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Metacognitive Awareness as a Correlate of Mathematics Achievement among Form Three Students in Makueni County, Kenya

By

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Abstract
The purpose of this study was to examine the relationship between metacognitive awareness, and mathematics achievement among form three students in Makueni County, Kenya. The research argued that mathematics success provides individuals with the necessary skills to be productive innovative and creative. In recent years, there has been a notable concern regarding poor mathematics, performance in Kenya, particularly in Makueni County. Poor mathematics achievement can result in suboptimal economic development by limiting the availability of skilled professionals across diverse industries. This study investigated the relationship between metacognitive awareness and mathematics achievement. This research was guided Brown's Metacognition model. The investigation employed a correlational research design. To choose the research area and target population, purposive sampling was used. To select the schools and research participants, stratified and simple random sampling were employed. Six public secondary schools were used to get a sample of 174 students. To increase the validity and reliability of the research instruments, a pilot study was carried out in one of the schools that did not take part in the main investigation. The research participants' data was gathered using the MAI Questionnaire. The research participants mean age was 17.01 years. A significant positive correlation was found between students' metacognitive awareness and their achievement in mathematics (r (170) =.73, $p < 0.05$). The study concluded that raising students' levels of metacognitive awareness is critical to raising their mathematics achievement. It was therefore advised that educators and parents support students' development of metacognitive awareness. This may lead to improved mathematics achievement.

Key Words: Metacognitive Awareness, Mathematics Achievement, Form Three Students, Makueni County

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Introduction

Across many disciplines, including engineering, medicine, computer science, business, biology, industry, economics, physics, and finance, mathematics is frequently used. In addition, it forms the basis for most science-based courses, which are essential for industrialization, enhancing the health sector, scientific research, technological innovation, and national development. Students gain from achieving high in mathematics because it opens up opportunity for them to improve their skills. They can acquire the essential knowledge and abilities required to make a meaningful contribution to the socio-economic development of the nation and county. Additionally, society possesses enough skilled labor to meet its need for the generation of wealth (Schukajlow, et al., 2023). Students who perform poorly in mathematics become frustrated since they are unable to pursue their intended occupations in universities and colleges (Hawes, 2022). This ultimately results in slow economic growth due to an increase in the number of unemployed people in the nation, a reduction in the number of qualified workers in various areas, and a higher dependency rate. These factors have compelled governments and scholars worldwide to dedicate their efforts to raising educational standards in their countries. Different nations have made significant financial investments in mathematics education by allocating enough money to guarantee that mathematical educational materials and teachers are available in schools. For instance, education received the largest allocation 656.6 (27.6 % of national budget) billion in Kenya's 2024–2025 budget.

Research indicates that low mathematics performance is now a cause for concern in several nations, including United States of America (Gökçe, and Guner, 2021), Philippines (Bernardo, 2022), Botswana (Bose, and Bäckman, 2020), South Africa (Khoza, and Biyela, 2020) and Kenya. Countries have claimed that student performance in mathematics falls short of both national and international mathematics educational norms. Dismally mathematics performance has persisted, according to the Kenya National Education System Plan (NESP) (2018–2022). Over three quarter of the students had a mean grade of C or lower for the past five years (2019–2023) country wide. Makueni County's students' mathematics means have been below 4 points out of possible 12 points. (KNEC KCSE statistics 2019, 2020, 2021, 2022, and 2023). This demonstrates unequivocally how low student success is.

The minimal grade in mathematics required for admission to higher learning institutions to pursue science-based courses is C+, which very few students achieve in Makueni County. Makindu sub-county, which is one of the nine sub-counties in Makueni, has exhibited the lowest performance in mathematics. The area has consistently produced lower-than-average mathematics results throughout the years, and this trend is expected to continue, if necessary, steps are not taken to remedy the situation.

Numerous factors that could explain the variance in mathematics achievement in Makueni County have been the subject of investigation by educational researchers. They include,–favorable attitude toward mathematics, regular attendance in class, appropriate teacher-student ratio, availability of learning tools, academic self-concept, and resilience

(Sila, 2019). Meanwhile, studies that have been done on metacognitive awareness have often focused more on; metacognitive experience and metacognitive strategy (Muema, 2021). These studies have produced inconsistent results. Therefore, there was a need to undertake the current study focusing on domains of metacognitive awareness with the main objective of establishing the relationship between metacognitive awareness, and mathematics achievement among form three students in Makueni County, Kenya. The key to understanding Mathematics achievement lies in the understanding of some of the domains of metacognitive awareness associated with it as studies have shown that these domains help students build suitable strategies for solving mathematical problems.

According to Azevedo (2020), metacognition is the capacity to control and regulate our own thoughts, including how we approach problems, choose solutions, and pose questions to ourselves. Metacognition is divided into metacognitive experience, metacognitive strategy and metacognitive awareness. This study focused on metacognitive awareness which refers to the individual's consciousness of their thinking and the techniques they employ when solving any given mathematical problem. Solving mathematical problems requires analysis of the presented problem, preparing the approach to be utilized to solve the problem, implementing the intended strategy, and determining whether the steps taken are proper.

Abdelrahman (2020), stated that in order for students to solve mathematical problems effectively, they must demonstrate the capacity to regulate their cognition that is; plan, assess, regulate, and control their learning. In order to solve mathematical difficulties, a student must first analyze the problem that is being given, plan the solution, carry out the intended strategy, and assess whether the steps performed are correct. This being the case therefore, understanding cognitive processes may go a long way in helping students build suitable strategies for solving mathematical problems, assess the implications and results, then modify the technique as necessary in light of prior knowledge (Akben, 2020). This argument is supported by Brown's Model of Metacognition (1987), which described metacognition as the process of reflecting on one's own experiences and ideas. Brown, explains that metacognition is responsible for optimizing one's cognitive actions in order to achieve mathematical goals.

According to this model, students who are aware of their own cognitive abilities, learning purposes, and tactics that can be used to achieve individual mathematics goals constantly assess their understanding, or lack thereof, and may be willing to employ tactics that have previously worked for them in solving mathematics-related problems, thereby improving their mathematics achievement. They must also understand learning tactics, including why and when to use them. Akben, (2020) added that in order for students to exercise efficient cognitive control when solving mathematical tasks, they must be able to organize, appraise, regulate, and govern their learning.

Literature Review

In order to better understand the impact of metacognitive awareness on mathematics achievement, Ajisuksmo and Saputri (2017) conducted a study with 103 university students in Tangerang, Indonesia as respondents. The study's findings showed that there was no significant correlation between metacognitive awareness and mathematics achievement ($r = 0.081$; $p > 0.05$). The evaluated research was carried out among an older cohort of university students who might have a higher level of metacognitive awareness than those of the current study, which involved secondary school students. As a result, the findings cannot be applied to a sample of secondary school students in Kenya.

In a sample of 263 Greek primary school students in fifth- and sixth-grade classrooms, Metallidou and Vlachou (2017) investigated the contextual differences in the patterns of relations among various metacognitive components of self-regulated learning and performance in language and mathematics. According to the study's findings, regulation of cognition was a better predictor of mathematical achievement than knowledge of cognition. An interaction influence between the two factors was also established in this investigation. Conclusions from the study may have been influenced by differences in metacognitive awareness between Greek and Kenyan secondary school students. Because learning contexts fluctuate, this necessitates the current investigation.

In order to investigate the link between students' metacognitive awareness and mathematical achievement, Fadlelmula et al. (2015) proposed and tested a structural model. In total 1,019 seventh graders from Ankara, Turkey participated. The findings showed a substantial relationship between students' proficiency in mathematics and their level of metacognitive awareness. This research was not carried out among secondary school students or in Kenya. This made the current investigation necessary. This is because there may have been differences in the two samples' mathematics achievement due to differences in their ages, educational backgrounds, and levels of their metacognitive awareness.

The relationship between pre-service primary school teachers' metacognitive awareness about solving mathematics problems was established by Yorulmaz et al. in 2021. The study comprised 284 pre-service primary school teachers enrolled in a university in the Aegean Region of Turkey. It was designed using the correlational survey approach. Consequently, it was discovered that the pre-service primary school teachers had medium views about solving mathematics problems and high metacognitive awareness. Additionally, it was discovered that 13% of the variance in solving mathematical problems was explained by metacognitive awareness. This study involved an older cohort of university students hence creating the need for the current study using a young population.

Methodology

Research Design

The design used in this study was correlational. This design is a non-experimental design and the aim was to find a relationship between variables with no intention of manipulation of the independent variables (Kothari, 2019). Consequently, this methodology was appropriate for the study's correlational analysis of mathematics achievement, and metacognitive awareness.

Measures

Metacognitive awareness was measured with an adapted MAI scale. Adaptation was accomplished by selecting only question items in the metacognitive awareness category that were relevant to the current investigation. The researcher modified the questionnaire's language to make it appropriate for the current research respondents, since it was meant to assess mathematical achievement among secondary school students. For example, in the original questionnaire, the term "*academic achievement"* was replaced with *"mathematics achievement*". The scale has 32 items divided into two categories: knowledge of cognition (12 items) and regulation of cognition (20 items). A Likert scale was used to rate the items. The Likert scale used for the MAI question items ranged from 1 (strongly disagree) to 5 (strongly agree). Each research respondent's score was totaled to determine the students' level of metacognitive awareness. Metacognitive awareness scores varied from the lowest of 32 to the highest of 160. Low metacognitive awareness was indicated by a score between 32 and 78, whereas moderate metacognitive awareness was indicated by a score between 79 and 125. High metacognitive awareness was indicated by a score between 126 and 160.

Participants and Procedure

The research included all form three students in Makueni County's public secondary schools in 2024. The accessible population consisted of 1322 students from 18 public secondary schools in Makindu Sub-County, Makueni County. This is because public secondary schools had higher rates of low math achievement than private secondary schools. Form three students were given precedence for involvement in the study because they had attended secondary school for a longer amount of time than form one and form two students. More importantly, form three students have already decided on their preferred examination subjects, making them more focused and goal-oriented. Furthermore, it was considered that they had a higher level of metacognitive awareness. Using simple random sampling, ninety girls and eight four boys were selected to participate in the study. The study's participants mean age was 17.01 years.

Logistical Considerations

Kenyatta University's Graduate School provided the researcher a letter authorizing data collection. The researcher received a research authorization from the National Council for Technology and Innovation (NACOSTI). Furthermore, the researcher requested permission from the county director of education in Makueni County, followed by the sub-county director of education in Makindu Sub-County, to perform the study in the selected schools. The schools were then visited for familiarization and to schedule appointments with the principals. The researcher administered questionnaires to the students, with aid from the teachers.

Data Collection Techniques

Data was gathered using questionnaires given to students in form three. The researcher provided the students with instructions, clarified the questions, and explained why the study was being conducted in order to guarantee the respondents' anonymity of the information they provided. After receiving the completed questionnaires, the researcher thanked the participants for their time. The examination department provided the participants with their mid of-term one 2024 mathematics exam results.

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Results of the Study

Descriptive Statistics for the Respondents' Metacognitive Awareness

The mean, standard deviation, skewness, kurtosis, range, minimum, and maximum scores of the students' metacognitive awareness scores were calculated. Table 1. summarizes the results.

Table 1: Descriptive of Students' Metacognitive Awareness Scores

	Metacognitive Awareness
Sample Size	170
Mean	120.23
Std. Deviation	10.70
Skewness	-.34
Kurtosis	.25
Range	110.00
Minimum	35.00
Maximum	145.00

Source: Field Data 2024

According to the findings of the analysis, the mean score for metacognitive awareness was 120.23 (SD=10.70), as shown in Table 1. Furthermore, the projected maximum score for metacognitive awareness was 160, with a minimum score of 32. The lowest score was 35, and the maximum score was 145. Metacognitive awareness scores appeared to be approximately symmetric, as indicated by the coefficient of skewness, which was -.34. Because the Kurtosis coefficient, which was.25, was less than 1, the score distribution was platykurtic. Table 2 show Descriptive Statistics for the Scores on the Sub Scales of Metacognitive Awareness.

Table 2: Descriptive Statistics for the Scores on the Sub Scales of Metacognitive Awareness

	Regulation of Cognition	Knowledge of Cognition
N	170	170
Mean	50.11	70.12
Std. Deviation	2.07	3.10
Skewness	.111	-.12
Kurtosis	-.39	-.07
Minimum	13.00	22.00
Maximum	55.00	90.00

Source: Field Data 2024
Note. N- Sample size

Table 2 shows that the average score for regulation of cognition was 50.11, with maximum and minimum values of 55 and 13, respectively. The mean knowledge of cognition score was 70.12, with a range of 90 to 22. The kurtosis and skewness coefficients for all subscales indicate that the score distribution was approximately normal. Table 3 displays the respondents' statistics for the three levels of metacognitive awareness.

Table 3: Respondents' Levels of Metacognitive Awareness

Level of Metacognitive Awareness	Frequency	Percentage
Low	1	0.8
Average	134	78.7
High	35	20.5
Total	170	100

Source: Field Data 2024

Over three-quarters of the respondents demonstrated an average level of metacognitive awareness, as indicated by the data in Table 3. Approximately twenty percent of respondents demonstrated a high level of metacognitive awareness, whereas only 0.8% reported having a low level.

Hypothesis Testing

H_{01}: There was no significant relationship between metacognitive awareness, and mathematics achievement.

A bivariate correlation study was conducted to determine the Pearson product moment correlation coefficient in order to test the null hypothesis, which states that there is no significant association between metacognitive awareness and mathematical achievement. The results were shown in Table 4.

Table 4: Correlation between metacognitive awareness and mathematics Achievement

		Mathematics Achievement
Metacognitive Awareness	Pearson correlation	0.73**
	Sig (2-tailed)	000

Note. *N*=170

Source: Field Data 2024

The results presented in Table 4 demonstrate a substantial and positive relationship between students' mathematical achievement and their metacognitive awareness (r (170) =.73, $p < 0.05$). As a result, the null hypothesis was rejected. The findings suggest that students' performance in mathematics improves as their metacognitive awareness rises.

The relationship between two types of metacognitive awareness (knowledge of cognition and regulation of cognition) and mathematical achievement was explored. This was done individually to test for linearity using bivariate correlation. The results are presented in Table 5

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Table 5: Relationship between Domains of metacognitive awareness and Mathematics Achievement.

Domains of Metacognitive Awareness	Mathematics Achievement
Regulation of cognition	.11**
Knowledge of cognition	.11**

Note. **Correlation significant at p<0.01

Source: Field Data 2024

Table 5 shows that the two metacognitive awareness domains have a weak positive link with mathematics achievement (r (170) =.11; p<0.01 for all associations). The findings reveal that regulation of cognition and knowledge of cognition independently contribute less to mathematics achievement than when the two aspects are combined.

Discussion of the Results

The current study's findings are consistent with those of previous research that used a sample of secondary school pupils. According to Akben (2020), all dimensions of metacognitive awareness (knowledge of cognition and regulation of cognition) were positively associated with mathematics achievement in a sample of university students. The positive association could be attributed to the fact that when students comprehend and govern their cognition, they can successfully navigate mathematics problem-solving tasks. Sari and Sumilah (2021) observed similar outcomes among South Korean college students.

Arum et al. (2019) found that students' metacognitive awareness substantially predicted their level of mathematics achievement, whether they were low, average, or high. The findings of this analysis and those of Arum et al. (2019) are consistent. These findings show that students with high levels of metacognitive awareness are better positioned to study more and get higher results in mathematics than their peers whose metacognitive awareness is still growing.

Toraman et al. (2020) reported similar findings in India, employing a sample of undergraduate students from several universities. The study showed a correlation between diverse levels of metacognitive awareness and varying levels of mathematical achievement. The favorable correlation could be attributed to the fact that students who are aware of and regulate their cognition can plan, control, evaluate, and monitor their learning processes. As a result, these children can increase their mathematical ability, leading to better learning outcomes.

Numerous studies have shown a connection between math achievement and metacognitive awareness, which suggests that one of the key areas to focus on when attempting to explain students' math achievement is metacognitive awareness. This is corroborated by the theoretical explanation that students with higher levels of metacognitive awareness are better able to recognize the parts of the math problem that pose challenges for them and modify the available strategies to concentrate more on those regions. Additionally, they have the ability to organize their time efficiently for the given mathematics assignments, carry out the necessary procedures, keep track of their development, consider the finished mathematical solutions, and, if necessary, modify the methods used in the future to solve any mathematical problem (Brown, 1987).

The results of the current study contradict those of a study conducted in 2017 by Rahman and Hassan, which revealed no significant correlation between mathematical achievement and metacognitive awareness. This discrepancy in outcomes could have a potential explanation. It can be due to disparities in the educational backgrounds and study locations of the pupils. The current study's findings suggest that low levels of metacognitive awareness may be responsible for of pupils' poor math performance.

Conclusion and Recommendations

The two variables have a strong positive association, according to the findings. The findings show that the achievement score in mathematics increases with increased metacognitive awareness, and vice versa. These results suggest that teaching secondary school students to organize, oversee, evaluate, and manage their own mathematical learning can help them improve on their mathematics achievement. In addition, it's important to teach students how to identify and use the most relevant approaches when solving mathematical problems. This study therefore made recommendations for educators and education stakeholders. The study results revealed a substantial association between metacognitive awareness mathematical achievements. Educators and other education stakeholder's ought to develop training initiatives that improve students' metacognitive awareness with the aim of improving students' performance in mathematics. This study however, had some limitations. The sample only included form three students from Makueni County and this may restrict the results' generalizability beyond this group. Secondly, questionnaires were utilized in this study to gather information on metacognitive awareness as a correlation with mathematical achievement and therefore some degree of subjectivity may not be ruled out in the results. Finally, this study used correlational research design consequently causation may not be implied.

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