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Relationship Between Cognitive Control And Academic Achievement In Biology Among Form Three Students In Kitui County, Kenya

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Abstract: *Academic achievement in Biology among secondary school students in Kitui County has been below average over the years. Research efforts have been made but still the problem has continued to persist. This prompted the need for this study to examine the relationship between cognitive control and academic achievement in Biology among form three students in Kitui County in an effort to provide evidence that may be used to address this problem. The study was anchored on cognitive theory by Broadbent (1958). Concurrent embedded research design was used to examine the link between the variables. The target population was 30600 students in 300 public secondary schools located in Kitui County in the year 2024. Purposive sampling to select Kitui County and form three students. Stratified sampling was used to select the secondary schools from each school category. Simple random sampling technique was used to select students from each school. Slovin's (1960) formula was used to obtain a sample of 394 students. In order to account for non-response, the sample size was increased by 19% to 470 students. Data were collected using cognitive control scale, interview schedule and academic achievement in Biology Proforma. Both descriptive and inferential statistics were used to analyze quantitative data. Qualitative data were analyzed thematically. The results revealed existence of a moderate positive and significant relationship between cognitive control and academic achievement in Biology, $r\ (456) = .55,\ p < .05$. Qualitative data revealed that higher order cognitive processes work in relation to the student's academic achievement in comprehending difficult concepts in Biology. Based on the results, the study recommends that teachers should create an* interactive learning environments *that challenge students to think critically and adapt to new information in order to enhance students' cognitive control, including the subscales of cognitive flexibility, and emotional control in order to improve their academic achievement in Biology. This will go a long way in improving learning outcomes in the subject.*

Keywords: *Biology; Cognitive Control; Academic Achievement; Form Three Students*

I. INTRODUCTION

In Kenya, academic achievement in Biology has been consistently below average over the years. Kiilu et al. (2022) revealed that in Makueni County, secondary school students continue to post low academic achievement scores in Biology in national examinations. The low academic achievement in the subject was associated with negative attitude towards the subject, lack of teacher motivation and inadequate administration support. A similar study conducted by Jolif (2018) in Busia County revealed that performance in science subjects was below average among secondary school students. The study attributed this situation to a number of factors such as negative attitude and low morale among students, low school attendance among students, non-conducive home environment, and inadequate support from the family/guardian, inadequate learning materials, and poorly equipped laboratories.

Statistics obtained from the Ministry of Education indicate that the three counties in the lower Eastern part of Kenya; namely: Machakos, Makueni and Kitui posted below average academic achievement in Biology in KCSE. On the same note, Makueni County had academic achievement in Biology which was also below average between 2019 to 2023. The results show that in the four year period, a majority of the students scored grade D+ and below in Biology for the three counties. This indicates that majority of the students are performing way below average. It was therefore necessary to identify the factors that may be contributing to this kind of low academic achievement in Biology in an effort to find a lasting solution geared towards improving the quality of academic achievement in the subject.

Studies have been conducted globally, regionally, and locally to address this challenge and some of the factors that have been associated with below average academic achievement in Biology. According to Athanasia (2022), some of the factors contributing to dismal performance in Biology include negative attitude towards the subject and inadequate learning resources. On the same note, Bosco et al. (2023) indicated that huge workload among teachers contributes to low performance. Furthermore, Jolif (2018) argued that low qualification of teachers and inadequate practical lessons contribute to low performance in Biology. Kayan-Fadlelmula et al. (2022) revealed that lack of teacher and student motivation contribute immensely to poor performance in Biology. Similarly, Kiilu et al. (2022) revealed that poor academic achievement in Biology is as a result of limited professional development programs for the teachers. Lohay et al. (2022) also revealed that inadequate administrative support leads to dismal performance in Biology. Mapulanga (2019) indicated that absenteeism among students has also led to poor performance in Biology. United Nations (2022) report revealed that inadequate learning resources, absenteeism among students and inadequate support from the parents/guardians contributed to poor performance in Biology. Despite the research efforts that have been made to establish the factors associated with below average academic achievement in Biology, there are few studies that have been done in Kenya to determine the relationship between cognitive control and academic achievement in Biology as hypothesized in this study. Most of the studies have focused on factors outside the learners. Therefore, there was need to investigate the relationship between cognitive control and academic achievement in Biology.

Cognitive control refers to the ability of a student to mentally regulate their thoughts, emotions, and behaviors during learning (Sahneh & Zahra, 2023). It comprises of cognitive flexibility and emotional control. Cognitive flexibility refers to the capability of a student to interchange between thinking about two different ideas and concepts or think about multiple ideas and concepts at the same time (Kamiya, 2022). On the other hand, emotional control refers to the ability of students to exercise influence over their emotions by utilizing cognitive or behavioral tactics. The management of emotions, thoughts, and behaviors influence how students handle the academic tasks at hand (Lei, 2022). For instance, emotional management can help in alleviating a negative attitude towards a teacher due to encounter that may anger the student. Equally, by ensuring that they have their thoughts focused on the most important task at hand such as an ongoing lesson that requires grasping of the key concepts will have an influence on whether a student will succeed or not. Therefore, if students are able to manage or mentally regulate their thoughts, emotions, and behaviors it can result in good academic achievement in Biology subject. Cognitive control of students during learning may be linked to the value attached to the learning task. According to Snyder and Friedman (2021), cognitive control is an important aspect that contributes immensely to better performance among students. This sentiment was further echoed in a study that revealed that cognitive control equally motivates students towards academic achievement (Menon & Mark, 2022).

II. STATEMENT OF THE PROBLEM

The study of Biology helps students to understand living things and their surroundings and a lot of efforts have been made to improve performance in the subject. However, academic achievement in Biology in Kitui County in the years 2019, 2020, 2021, and 2022 was below average. During this period, the average mean grade for the county was a D plain where majority of the students scored a mean grade of D+ and below. This kind of academic achievement has raised concern among education stakeholders in the county. The over 70% of the students scoring a mean grade of D+ and below in KCSE every year will lead to a shortage of qualified and skilled personnel in the key sectors of the economy such as health and agriculture. This implies that the county will be relying on personnel from other counties to help them fill the deficit, which will negatively affect the socio-economic development of the county and the country at large.

Based on the background to the study, there are several factors associated with academic achievement in Biology globally, regionally and locally. However, there are limited studies that have been conducted to determine the influence of cognitive factors such as cognitive control on academic achievement in Biology in Kitui County. Studies conducted on factors that contribute to low academic achievement in Biology in the country have focused on other variables such as inadequacy of qualified teachers and facilities such as laboratories, inadequate support from school administration and parents, and lack of motivation among teachers and students. Most of these studies were conducted outside Kitui County and the samples used varied from college students to secondary school students. A few researchers have made efforts to investigate how cognitive control is related to academic achievement in Biology subject among secondary school students but the problem still persists. The present study therefore investigated whether cognitive control can be used to predict academic achievement in Biology among form three students in Kitui County, Kenya to fill the gaps.

III. OBJECTIVE OF THE STUDY

The study sought to achieve the following objective;

To find out the relationship between cognitive control and academic achievement in Biology among form three students in Kitui County.

IV. REVIEW OF RELATED LITERATURE

There is a scarcity of empirical literature on the relationship between cognitive control and academic achievement in Biology. Studies that have been carried out focused on cognitive control and academic achievement. A study by Shi and Qu (2021) was carried out in China to ascertain the relationship between students' academic achievement and their cognitive ability and self-management. The study involved 52 respondents, ranging in age from sixteen to eighteen, were chosen by the researcher. Using questionnaires, the chosen respondents provided the quantitative data. A hierarchical linear model was utilized for the analysis of the gathered data. The study found a favorable correlation between students' academic success and cognitive ability. Although the findings of this study help in explaining how cognitive abilities influence academic achievement, they may not be used to explain how cognitive control is related to academic achievement in Biology hence the need for the current study.

In yet another study conducted by Shi and Qu (2022) in China, the authors investigated the influence of students' cognitive ability, planning and self-discipline on academic achievement. The study sample comprised 572 secondary school students aged between 15–18 years. Data collection was done through questionnaires, while data were analyzed using descriptive and inferential means. The study results revealed that cognitive ability had a significant positive effect on students' academic achievement. The study was conducted in a context that differs from the environment in Kenyan schools and did not focus on academic achievement in Biology which limits the applicability of the findings to academic achievement in Biology among form three students in Kitui county, Kenya hence the need for the current study.

Another similar study was conducted by Luque and Morgan-Short (2021) to determine the association between cognitive control and the level of understanding of the second language of students in USA. The sample size for this study was 28 students. Questionnaires were used to collect quantitative data for this study. The study found a significant relationship between cognitive control and the level of understanding of the second language. This study investigated the relationship between cognitive learning and the level of understanding of the second language, presenting a knowledge gap on cognitive control and how it affects academic achievement in Biology that the present study filled. Furthermore, the sample size of 28 is prone to classical errors hence generalizability is limited. The present study used a relatively larger sample size which would enhance generalizability of the results.

In another study, Kaur and Prajapati (2022) investigated the influence of cognitive ability among secondary school students in India. The study sampled 320 students from secondary schools in Amritsar district using stratified sampling. The study used a descriptive research design. Data were collected using questionnaires and then analyzed using descriptive and inferential statistics. The study results revealed that academic achievement was positively correlated with cognitive ability. Since the study was conducted in schools India which differ from Kenyan context, there was need for the current study to establish if similar results can be obtained in the Kenyan schools to enhance generalization of the results.

Ozawa et al. (2021) conducted a systematic review on the influence of cognitive ability on educational and economic returns. The authors conducted a systematic literature review and meta-analysis focusing on the association between educational outcomes and cognitive ability, and between economic outcomes and cognitive ability across Lower Middle Income Countries (LMICs). The researchers considered peer-reviewed studies since the year 2000 that quantitatively explored the stated relationships. From an initial search of 3,766 records, the researchers identified 14 appropriate studies. The study results revealed that higher cognitive ability increased both the school enrollment and academic achievement across the LMICs. The study also used a systematic review design, which presents a difficulty in identifying the shortcomings of each study used implying that the various gaps from the studies may be introduced into the systematic review thus limiting the reliability of the findings. The current study addressed the methodological gap by conducting the study amongst students undertaking normal classroom learning.

In another study carried out in Turkey, Toroman and Ozdemir (2020) explored the relationships between cognitive flexibility and academic achievement. The study sample comprised 1573 undergraduate students at a university in Ankara. The researcher collected the study data using cognitive flexibility scale. The study data were analyzed using structural equation modeling. The study results showed that, cognitive flexibility was significantly correlated with academic achievement. The study focused on university students who were older and more experienced in learning compared to secondary school students. The current study focused on secondary school students in Kenya to fill the gap.

Bayley (2021) examined cognitive flexibility amongst primary school pupils in Rwanda who were undergoing competence-based curriculum. The study adopted mixed methods research design and sampled 306 pupils who were randomly selected. The study data were collected through interviews, pupils' assessment, and observations. Statistical analyses revealed that cognitive flexibility was significantly correlated with academic achievement. This study was conducted among primary school learners who are at a different level of cognitive development compared to secondary school students. The results may therefore not be generalized to secondary school students hence the need for the current study to fill the gap.

Ekatushabe et al. (2022) carried out a study in Uganda to ascertain the relationship between students enrolled in Biology classes and their cognitive initiation, self-management, emotional regulation, and metacognition. Using a simple random sample technique, 587 secondary school students participated in the study. Utilizing questionnaires, quantitative data were gathered and utilized to draw conclusions for the study. SPSS Version 24 was used for the analysis of the gathered data. It was shown that metacognition and cognitive start were significantly correlated. Self-management served as a mediator in this connection. Cognitive initiation was primarily used at the beginning of new learning while cognitive control was used to sustain learning process. Therefore, the results may not be generalized to explain the relationship between cognitive control and academic achievement in Biology hence the need for the present study.

A similar study was carried out in Kenya by Amukune and Józsa (2021) to ascertain the connection between first-grade students' academic achievement and cognitive control. 526 students participated in the study, having been chosen with their professors' help. Simple random selection was used to choose the students, whereas stratified and purposive sampling techniques were used to choose the schools. The study investigated the study factors on cognitive control using exploratory and confirmatory factor analysis, and the students' academic achievement was assessed by a sitting exam. The first-graders' academic achievement and cognitive control were found to be significantly correlated in the study. These results may not be generalized to secondary school students because cognitive control varies with age hence the need for the current study.

Another similar study was conducted by Nübler et al. (2020) in Kenya to determine whether climate change and cognitive development influence academic outcomes among students. The researchers assumed that rainfall shocks that comes due to the impact of climate change can influence the households and availability of resources, especially for those coming from dry areas. The study established that rainfall shocks and cognitive development influences academic outcomes among students. The study focused on the effects of climate change and cognitive development among the students which may not applicable in all parts of the country, presenting a knowledge gap on cognitive control that the current study filled.

V. METHODOLOGY

A. RESEARCH DESIGN AND TARGET POPULATION

The study used concurrent embedded research design to examine the link between the variables. In this design both quantitative and qualitative data are gathered concurrently and incorporated into the same study (Sharon & Halcomb, 2009). In this study, the quantitative approach was given more weight than the other methods. This was appropriate because the researcher aimed to test research hypothesis which is done using quantitative data. The quantitative data were gathered using the cognitive control scale while the qualitative data were gathered using an interview schedule. Research hypotheses were tested with quantitative data, and the results were supplemented with qualitative data. In line with the recommendations of Creswell and Creswell (2018), qualitative findings were integrated with quantitative results. The design enhanced the reliability of the study findings through provision of multiple types of evidence which also helped to reduce potential biases. It also gave the researcher deeper understanding of the connection between cognitive control as a predictor of students' academic achievement in Biology. It offered a more comprehensive view point on the variables that could be connected to students' below average achievement in Biology.

B. SAMPLING TECHNIQUES AND SAMPLE SIZE

The researcher used purposive sampling to select Kitui County and form three students. Data were collected from National Schools, County schools, and Sub County secondary schools. Stratified sampling was used to select the secondary schools from each school category. This allowed analysis of potential differences in cognitive control in learning Biology across the different categories of school. This technique was appropriate because Kitui County and form three students have unique characteristics with regard to academic achievement in Biology and therefore considered appropriate (Palinkas et al., 2015).

Simple random sampling was used to pick one stream in the event that the sampled schools have more than one stream of students taking Biology. Depending on the number of streams, the researcher wrote the word yes on one piece of paper and the rest were left blank. All the pieces of paper were then folded and put in a small container. From each stream, one student was selected to pick one piece of paper and the student who picked "yes" was used to select the stream from which the sample of students would be obtained. By utilizing proportionate sampling, a sample of students from each school category was obtained. Simple random sampling was used to choose the participating students for the schools where the pupils were of the same gender. Adopting simple random sampling guaranteed that the sample size was selected without bias, improving the generalizability of the findings (Bhardwaj, 2019).

The sample of students for this study was obtained using Slovin's (1960) formula.

$n = \frac{N}{1+N(e)^2}$ where N is the target population and e is the margin of error (0.05).

$$n = \frac{30600}{1+30600(0.05)^2} = 394$$

In order to account for non-response, the sample size was expanded by 19% to 470 students as suggested by Anokye's (2020). The sample of students from each school category was selected using proportionate sampling. There was a 10% increase in the sample size for each type of institution.

C. RESEARCH INSTRUMENTS

a. *COGNITIVE CONTROL SCALE*

This scale was be adapted from the cognitive control scale developed by Gabrysl et al. (2018) with initial reliability coefficient of .91. It consists of 17 items that measure cognitive control of students. The cognitive control scale was modified and sub-divided into two sections which focused on the objectives of the current study. Its Likert scales points was further modified to suit the current study with the domains of focus being cognitive flexibility and emotional control.

In the adapted scale, the domains were measured using a five point Likert scale ranging from 1 = not true, 2 = a little true, 3 = rather true, 4 = true and 5 = very true. The first section with items 1-9 measured cognitive flexibility and items 10-17 measured emotional control. Scoring involved adding the scores and the expected lowest score was 17 while the expected highest score was 85. A score of 17-34 indicated below average cognitive control, 35-67 indicate average, while a score of 68-85 indicated a high level of cognitive control.

b. *INTERVIEW SCHEDULE*

The researcher used interview schedule to collect qualitative data that was used to complement quantitative data. With the knowledge and skills gained together with guidance from the university supervisors, the researcher developed the interview schedule to measure cognitive control and academic achievement in Biology. The interview schedule was developed from short questions which were specific and required short answers. The interview questions also captured the levels of scale of measurements of the study variables.

c. *ACADEMIC ACHIEVEMENT IN BIOLOGY PROFORMA*

The researcher used academic achievement in Biology proforma to obtain academic achievement scores in Biology. The researcher filled the academic achievement proforma using student's end of the term examination 2024 scores. The researcher analyzed the results of the end of the term examination in Biology using academic proforma.

D. DATA COLLECTION PROCEDURES, ANALYSIS AND PRESENTATION

Data were collected using cognitive control scale, academic achievement results in Biology and interview schedules. These techniques of data collection were the most appropriate for this study because they enabled the researcher to collect adequate data within limited time. The researcher trained three research assistants to assist in data collection. Collection of quantitative data was done first and then was followed by collection of qualitative data. The sampled students were given questionnaires by the researcher and research assistants. The sampled form three students in each school were given a 20-minute explanation of the study's goal by the researcher, and once they indicated that they understand it, they were allowed to fill out the questionnaires.

This enhanced the reliability of the responses that were provided. Filling the questionnaire took about 30 minutes. Before the questionnaires were collected, the respondents were requested to countercheck to ensure all the questions were answered. Thereafter, the students involved in the collection of qualitative data were randomly selected from the sample of the students involved in filling the questionnaires. The students were randomly sampled from selected schools. The students were provided with the interview schedules and their individual responses were recorded using a mobile phone.

The data were cleaned once the collection procedure was finished so that they were ready for a thorough analysis. Questionnaires that did not fulfill the predetermined standards were discarded during the cleaning procedure. Data coding in accordance with the study variables followed after data cleaning. SPSS version 25 was used for data analysis. This was done in order to record any study assumptions, look for data mixing, and eliminate any outliers. Both descriptive and inferential statistics were used to analyze quantitative data. Qualitative data were analyzed thematically. The researcher developed a code book for categorizing obtained responses into themes. The themes were identified using a deductive approach on one hand, identifying the issues the sampled students raised in their responses, and on the other hand, using an explicit approach that focused on the objective responses to the various issues raised under the study variables.

VI. RESULTS AND DISCUSSIONS

Table 1 presents the descriptive data of gender and type of school cross tabulation.

		Type of your school			Total
		National School	County school	Sub County Schools	
Gender	Male	16(3.51%)	53(11.62%)	154(33.77%)	223(48.90%)
	Female	20(4.39%)	38(8.33%)	175(38.38%)	233(51.10%)
Total		36(7.89%)	91(19.96%)	329(72.15%)	456(100.00%)

Table 1: Gender and Type of School Crosstabulation

Table 1 shows that the respondents constituted a majority of 233 (51.10%) female students of whom 175(38.38%) were from sub county schools, 38(8.33%) were from county schools, and 20(4.39%) were from national schools. On the other hand, there were 223(48.90%) male students of whom 154(33.77%) were from sub county schools, 53(11.62%) were from county schools, and 16(3.51%) were from national schools.

The researcher also obtained the descriptive statistics of cognitive control based on gender as presented in Table 2.

Gender	N	Min	Max	R	*M*	*SD*	*Kur*	*Sk*
Male	223	29.00	85.00	56.00	56.67	11.82	-.22	.22
Female	233	21.00	86.00	65.00	59.37	12.90	-.35	-.06
Total	456	21.00	86.00	65.00	58.05	12.45	-.34	.08

Note. N=456; Min – Minimum; Max – Maximum; R-Range; SD – Standard deviation; Sk – Skewness; Kur- Kurtosis

Table 2: Descriptive Statistics of Cognitive Control by Gender

As seen in Table 2, the female students obtained a higher mean of 59.37 (*SD* = 12.90). They obtained a minimum score of 21, and a maximum score of 86. On the other hand, male students obtained a mean of 56.67 (*SD* = 11.82). They also obtained a minimum score of 29, and a maximum 85.

The descriptive statistics of cognitive control were also obtained based on sub scales by gender as presented in Table 3.

		N	R	Min	Max	*M*	*SD*	*Sk*	*Kur*
Cognitive Flexibility	Male	223	31.00	14.00	45.00	29.13	6.31	-.12	.25
	Female	233	36.00	9.00	45.00	30.18	7.25	-.19	-.06
Emotional control	Male	223	28.00	12.00	40.00	27.53	5.88	-.21	.41
	Female	233	29.00	12.00	41.00	29.19	6.35	.10	-.54

Note. N=456; Min – Minimum; Max – Maximum; R – Range, M-Mean; SD – Standard deviation; Sk – Skewness; Kur-Kurtosis

Table 3: Descriptive Statistics of Cognitive Control Scores in Sub Scales by Gender

Table 3 shows that on the sub scale of cognitive flexibility, the female students obtained a higher mean of 30.18 (*SD*=7.25). Their minimum score was 9, and a maximum 45, giving a range of 36. The values of skewness coefficient was -.19 indicating that the data was near normal distribution. The coefficient of kurtosis was -.06 indicating that the distribution shape was platykurtic. The results indicate gender differences in cognitive flexibility in favor of female students, implying that female students had higher cognitive flexibility compared to their male counterparts.

On emotional control sub scale, the female students again obtained a higher mean of 29.19 (*SD*=6.35). Their minimum score was 12, and a maximum 41, giving a range of 29. The value of skewness coefficient was .10 indicating that the data was near normal distribution. The coefficient of kurtosis was -.54 indicating that the distribution shape was platykurtic. The results indicate gender differences in emotional control still in favor of female students, implying that female students had higher emotional control compared to their male counterparts.

The researcher run Pearson product moment correlation test on the following null hypothesis:

H_{01}: There is no significant relationship between cognitive control and academic achievement in Biology among form three students in Kitui County.

The results of the test are presented in Table 4.

		Biology score
Cognitive Control	Pearson Correlation	.55**
	Sig. (2-tailed)	.00
	N	456
Cognitive Flexibility	Pearson Correlation	.57**
	Sig. (2-tailed)	.00
	N	456
Emotional Control	Pearson Correlation	.47**
	Sig. (2-tailed)	.00
	N	456

Correlation is significant at the 0.01 level (2-tailed).

Table 4: Correlation between Cognitive Control and Academic Achievement in Biology

From Table 4, the results revealed existence of a moderate positive and significant relationship between cognitive control and academic achievement in Biology, r (456) = .55, $p < .05$. The results imply that the higher the cognitive control among the form three students, the higher the academic achievement in Biology.

On the sub scales of cognitive control, the cognitive flexibility sub scale had a moderate positive and significant relationship with academic achievement in Biology, r (456) = .57, $p < .05$. The results indicate that the higher the cognitive flexibility among the form three students, the higher the academic achievement in Biology and vice versa. On emotional control, the results revealed that that there was a moderate positive and significant relationship with academic achievement in Biology, r (456) = .47, $p < .05$. The results indicate that the higher the emotional control among the form three students, the higher the academic achievement in Biology and vice versa.

The researcher carried out further analysis on the prediction of academic achievement in Biology from cognitive control. The results are presented in Table 5.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.58[a]	.33	.33	8.20
2	.58[b]	.33	.33	8.21

a. Predictors: (Constant), Emotional control, cognitive flexibility

b. Predictors: (Constant), Emotional control, cognitive flexibility, gender

Table 5: Model Summary Prediction of Academic Achievement in Biology from Cognitive Control

The results in Table 5 it can be seen that R square value for model 1 was .33 indicating that 33% of the variance in academic achievement in Biology among form three students in Kitui County, Kenya is influenced by emotional control. On the other hand, R square value for model 2 was also .33, indicating that 33% of the variance in academic achievement in Biology among the students is influenced by cognitive flexibility.

ANOVA test was conducted to confirm if the predictive values for academic achievement in Biology from cognitive control were significant. The results are presented in Table 6.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15027.84	2	7513.92	111.70	.00[b]
	Residual	30472.16	453	67.27		
	Total	45500.00	455			
2	Regression	15029.37	3	5009.79	74.32	.00[c]
	Residual	30470.63	452	67.41		
	Total	45500.00	455			

a. Dependent Variable: Biology score

b. Predictors: (Constant), Emotional control, cognitive flexibility

c. Predictors: (Constant), Emotional control, cognitive flexibility, gender

Table 6: ANOVA Test for the Prediction of Academic Achievement in Biology from Cognitive Control

The results in Table 6 reveal that both emotional control and cognitive flexibility had a joint significant relationship with academic achievement in Biology, F (2, 453) = 111.70, $p < .05$ and F (2, 452) = 74.32, $p < .05$ Therefore, the null hypothesis was rejected implying that emotional control and cognitive flexibility significantly predict academic achievement in Biology.

The researcher carried out regression analysis to establish the predictive values for both emotional control and cognitive flexibility as shown in Table 7.

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	25.48	1.84		13.82	.00
	Cognitive Flexibility	.90	.10	.61	8.79	.00
	Emotional Control	.08	.11	.05	-.68	.50
2	(Constant)	25.62	2.08		12.32	.00
	Cognitive Flexibility	.90	.10	.61	8.75	.00
	Emotional Control	.07	.11	.05	-.65	.52
	Gender	.12	.78	.01	-.15	.88

a. Dependent Variable: Biology score

Table 7: Regression Coefficients for Prediction of Academic achievement in Biology from Emotional Control and Cognitive Flexibility

Table 7 indicates that in the first model, cognitive flexibility had a positive and significant relationship with academic achievement in Biology, β = .90, t (455) = 8.79, p < .05. This implies that by holding emotional control constant, a unit change in cognitive flexibility leads to .90 change in academic achievement in Biology. Secondly, emotional control had a positive and non-significant relationship with academic achievement in Biology, β = .08, t (455) = -.68, p =.50. This implies that by holding cognitive flexibility constant, a unit change in emotion control leads to -.08 change in academic achievement in Biology.

In the second model, cognitive flexibility had a positive and significant relationship with academic achievement in Biology, β = .90, t (455) = 8.75, p < .05. This implies that by holding emotional control constant, a unit change in cognitive flexibility leads to .90 change in academic achievement in Biology. Secondly, emotional control had a positive and non-significant relationship with academic achievement in Biology, β = .07, t (455) = -.65, p =.52. This implies that by holding cognitive flexibility constant, a unit change in emotion control leads to .07 change in academic achievement in Biology.

Table 7 indicates that in the first model, cognitive flexibility had a positive and significant relationship with academic achievement in Biology, β = .90, t (455) = 8.79, p < .05. This implies that by holding emotional control constant, a unit change in cognitive flexibility leads to .90 change in academic achievement in Biology. Secondly, emotional control had a positive and significant relationship with academic achievement in Biology, β = .08, t (455) = -.68, p <.05. This implies that by holding cognitive flexibility constant, a unit change in emotion control leads to -.08 change in academic achievement in Biology. Thirdly, the model incorporated gender which had a non-significant relationship with academic achievement in Biology β = .12, t (455) = -.15, p = .88.

The prediction equation for model 1 is as below:

$\hat{Y} = 25.48 + 0.90X_1 + 0.08X_2 + \acute{\varepsilon}$

Where $\hat{Y}$ = Predicts academic achievement in Biology; X_1 = Cognitive Flexibility, X_2 = Emotional Control, and $\acute{\varepsilon}$ = standard error.

The prediction equation for model 2 is as below:

$\hat{Y} = 25.62 + 0.90\, X_1 + 0.07X_2 + 0.12X_3 + \acute{\varepsilon}$

Where $\hat{Y}$ = Predicts academic achievement; X_1 = Cognitive Flexibility, X_2 = Emotional Control, X_3 = Gender Term, and $\acute{\varepsilon}$ = standard error.

Qualitative Data Results Report On Cognitive Control

The researcher intended to establish the level of self-regulation among students' learning in Biology with emphasis being placed in the areas of cognitive flexibility and emotional control. From student interviews, the researcher gathered qualitative data on various approaches that the students adopted whenever they encountered challenging questions in Biology. The data was collected from 40 students and then analyzed using NVIVO software. Two major themes namely changes in thinking and emotion control caused variability in students' behavior in learning biology.

Changes In Thinking

Changes in thinking, an aspect of cognitive flexibility is the ability of the students to alter their thinking approaches depending on the context to achieve learning goals. This was the most prominent theme identified in the study. Some students described a lot of difficulties in comprehending complex concepts in Biology. Nevertheless, the observed behaviors covered a range of strategies used to overcome these difficulties, which according to this study is cognitive flexibility of the students.

Student 1, for instance said,

> *"The most difficult task was trying to classify the living organisms. I was able to overcome this by using a chart of classification, group discussions, and flashcards and other symbols.* The student also said that *"This I believe improved my knowledge and marks,"*

As an example of how cognitive flexibility helped the student to get to understand complex learning tasks in biology.

Like other learners, Student 4 also faced some challenges in Ecology which were overcome using field experiences and ecosystem concepts. This also showed the importance of different perspectives in choosing proper learning strategies as well as interaction with examples that helped them enhance their knowledge and contribute to their performance improvement.

Student 8 did this differently from the others when faced with a problem of understanding photosynthesis. The student said,

> *"Inclusion of simple experiments alongside the use of diagrams and other online resources helped me to become more curious and switched to more experimental work for better understanding."*

From their experience, cognitive flexibility helps in promoting creativity as well as interest in the concepts being taught.

All these accounts reflect the cognitive flexibility with which the students approached their learning. Whether it involved designing something, talking and sharing ideas, testing or applying learned theory in practice, the students demonstrated the ability to think in more than one way. This versatility contributed to more comprehension and better test scores in Biology.

Capacity To Regulate Emotions

Regulation of emotions is another aspect of cognitive flexibility, which enables students to regulate their emotional responses depending on different situations. It is the capacity to regulate emotions so as to allow room for maintaining on-task behavior and sustained effort in the learning process. This was another theme identified in the qualitative data.

For instance, Student 6 stated that,

> *"I struggled a lot in reconstructing the concept of skeletal system. I encouraged myself by employing such practices as interactive 3D models and practicing throughout the lessons."*

This demonstrates flexibility in thoughts and also in coping with feelings. This enables the student to overcome first-try-failure and frustration when they are solving the problem. Through this regulation of emotions, students are able to develop better practical skill and test performance.

Likewise, Student 3 demonstrated emotional regulation through the struggle experience with plant nutrition. By following carefully following step by step explanations, utilizing mind maps, and engaging in discussion with friends, the student was able to control anxiety level by compartmentalizing information.

Thus, through emotional control, students demonstrated ability to grasp challenging content from different angles though thinking flexibly. Emotional control allows to keep studying material, looking forward to finding a solution.

The data has elaborated how high order cognitive processes work in relation to the student's academic achievement in comprehending difficult concepts in Biology. In their problem solving strategies, both cognitive flexibility and emotional control played a significant role. The effects of their interrelationships was evident in the enhanced performance and enhanced understanding of concepts as described by the students. The students learnt to switch and engage various modes of learning. These include using technology, markers, experiments or group discussions to enhance their study habits.

Thus, cognitive control which includes one's ability to change thinking patterns and manage emotions, contributed to achievement in Biology. This is relevant as a foundation for educational practices since students' potential for developing such skills reflects their problem-solving potential or their performance at school. If these aspects of self-awareness are cultivated within a student it will enable them to perform better in complex areas and improve the quality of their learning.

C. DISCUSSION OF THE RESULTS

The first objective of this study was to find out the relationship between cognitive control and academic achievement in Biology. The quantitative study results revealed existence of a moderate, positive and significant relationship between cognitive control and academic achievement in Biology. The results imply that the higher the cognitive control among the students, the higher the academic achievement in Biology. This was also true for the cognitive control sub scales whereby cognitive flexibility sub scale had a moderate, positive and significant relationship with academic achievement in Biology. The results indicate that the higher the cognitive flexibility among the students, the higher the academic achievement in Biology and vice versa. On emotional control sub scale, results revealed that that there was a moderate positive and significant relationship with academic achievement in Biology. The results indicate that the higher the emotional control among the students, the higher the academic achievement in Biology.

These results are consistent with Cognitive Theory by Broadbent (1958) that explains how humans apply selective attention as a cognitive process whereby an individual deals with one or a few sensory inputs and ignores the others. It is this cognitive process that allows students to have cognitive flexibility, which is the ability to shift from one way of thinking to another to achieve desired learning outcomes in a subject like Biology. Cognitive theory has been demonstrated successfully in Biology performance in several studies such as by Kercood et al. (2017), whereby it was used to explain the relationship between cognitive flexibility and academic performance. Kostromina et al. (2017) also utilized this theory to explain how cognitive control influences academic achievement among students where it was established that there existed a relationship between cognitive control and academic achievement.

The current study's findings are also consistent with the results of Shi and Qu (2021); and Shi and Qu (2022) who carried out a study in China to ascertain the relationship between students' academic achievement and their cognitive ability. The studies found a favorable correlation between students' academic success and cognitive ability. Luque and Morgan-Short (2021) also conducted a study to determine the association between cognitive control and the level of understanding of the second language of students in USA, and found similar results. The study found a significant relationship between cognitive control and the level of understanding of the second language.

The current study also agrees with the findings of Kaur and Prajapati (2022) who found that academic achievement was positively correlated with cognitive ability among secondary school students in Amritsar district, India. In a systematic review conducted by Ozawa et al. (2021), the researchers found out that higher cognitive ability increased student's academic achievement across the LMICs. These results are consistent with those of the current study. Toroman and Ozdemir (2020) also carried out a study in Turkey that revealed that cognitive flexibility was significantly correlated with academic achievement.

Similarly, Bayley (2021) carried out a study amongst primary school pupils in Rwanda and found out that cognitive flexibility was significant correlated with academic achievement. These results are consistent with those of the current study. On the same note, Amukune and Józsa (2021) carried out a study in Kenya to ascertain the connection between first-grade students' academic achievement and cognitive control. The study results revealed that the first-graders' academic achievement and cognitive control were found to be significantly correlated in the study, results which are consistent with the findings of the current study. The results show that cognitive control is an important factor in students' academic achievement in Biology. It is therefore imperative to make development of cognitive skills as part of learning process to enhance students' academic performance in Biology.

The researcher also collected and analyzed qualitative data that sought to find out the challenges that students had encountered in learning Biology, and how they approached it in order to assess their cognitive control. The analysis of results revealed that through various aspects of cognitive flexibility, students were able to surmount various challenges in learning Biology which led to improved scores in the subject. This supports the findings received from the quantitative data and those from other researchers such as Kercood et al. (2017); Toroman and Ozdemir (2020); and Bayley (2021) whose studies revealed a positive relationship between cognitive flexibility and students' academic performance. The findings imply that, strengthening students' cognitive control enhances academic achievement in Biology. This underscores the importance of incorporating cognitive skills training in the process of learning to improve students' Biology performance.

VII. CONCLUSIONS

The objective of this study was to find out the relationship between cognitive control and academic achievement in Biology. The study concludes that there exists a moderate, positive and significant relationship between cognitive control and academic achievement in Biology. The results indicate that the higher the cognitive control among the students, the higher the academic achievement in Biology and vice versa. Based on the findings from the sub scales of cognitive control, the researcher concludes that there exists a moderate, positive and significant relationship between cognitive flexibility academic achievement in Biology. The results indicate that the higher the cognitive flexibility among the students, the higher the academic achievement in Biology. The study further concludes that there exists a moderate positive and significant relationship between emotional control and academic achievement in Biology. The results indicate that the higher the emotional control among the students, the higher the academic achievement in Biology.

IX. RECOMMENDATIONS

- ✓ Teachers should create an interactive learning environments that challenge students to think critically and adapt to new information in order to enhance students' cognitive control, including the sub scales of cognitive flexibility, and emotional control in order to improve students' academic achievement in Biology.
- ✓ The government should give policy direction to curriculum developers and TSC to ensure that all teachers are trained on how to foster cognitive control in their students. This can be done through workshops, seminars and collaborative teaching models.

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