The Journal of Anatomical Sciences
Email: journalofanatomicalsciences@gmail.com

J. Anat Sci 17(2) June

Executive Function and Academic Performance among Medical Students at Enugu State University of Science and Technology, Nigeria: A Structural Equation Modelling Approach

Eric O. Aigbogun Jr[1*], Chidera Emekaisu[1,] Ibe M. Usman[2]

[1]Department of Anatomy, Enugu State University of Science and Technology, Enugu, Nigeria; [2]Department of Physiology, University of Rwanda, Huye, Rwanda.

***Corresponding Author:** Email: eric.aigbogun@esut.edu.ng; Tel: +2347031135557; **ORCID:** 0000-0001-8230-2771

ABSTRACT

Executive function (EF) comprises cognitive processes essential for academic success. This study assessed the relationship between executive function and self-assessed academic performance (AP) among medical students at Enugu State University of Science and Technology (ESUT). A cross-sectional design was used to examine the associations between EF components: inhibitory control (INC), cognitive flexibility (CF), and working memory (WM), and academic performance. A total of 314 medical students were selected through systematic sampling and completed an Open Data Kit (ODK) questionnaire with good internal consistency (Cronbach's $\alpha = 0.77$). Structural Equation Modeling using SPSS (SEM-GLS) and direct path analysis was employed to evaluate relationships among EF variables, AP, and sociodemographic factors. Inhibitory control correlated significantly with cognitive flexibility ($r = 0.389$, $p < 0.001$) and working memory ($r = 0.587$, $p < 0.001$), while cognitive flexibility and working memory were also strongly related ($r = 0.545$, $p < 0.001$). Cognitive flexibility showed a significant negative effect on academic performance ($\beta = -0.463$, $p < 0.001$). Regarding age, only inhibitory control demonstrated a significant association ($\beta = -0.248$, $p = 0.003$). Neither sex ($\beta = -0.019$, $p = 0.704$) nor age ($\beta = 0.069$, $p = 0.174$) significantly predicted academic performance. Among the ten reported academic challenges, the most common were being in classes students did not like (38.0%), difficulty communicating with lecturers (33.2%), and difficult courses (29.7%). The findings indicate that executive function components are significantly interrelated, suggesting close links among working memory, cognitive flexibility, and inhibitory control. Cognitive flexibility was negatively associated with academic performance. These results highlight the need to align curricula with student interests, strengthen faculty–student communication, and provide balanced academic challenges supported by adequate resources.

Keywords: executive function, academic performance, self-assessment, working memory, cognitive inhibition

INTRODUCTION

Structural equation modeling (SEM) is a powerful statistical technique that has gained popularity in sociobehavioral and educational research in recent times [1]. SEM allows researchers to test complex theoretical models by examining the relationships between multiple variables, including latent constructs, and accounting for measurement error [2]. This is particularly useful in fields where constructs like attitudes, behaviors, motivations, and executive function are abstract and cannot be directly observed. Hence, in the current study, SEM was used to examine the relation between academic performance and executive function.

Executive function can be seen as a set of mental skills or cognitive processes that are necessary for the cognitive control of behaviors.[3,4] These cognitive processes are further categorized into cognitive inhibition, inhibitory control, working memory, cognitive flexibility, planning, and problem solving.[5] Executive functions are controlled by the left prefrontal cortex of the cerebral cortex.[3] Executive function impairment is related to detrimental outcomes and constitutes a key feature of several psychiatric disorders, including attention deficit hyperactivity disorder (ADHD), schizophrenia, and bipolar disorder, which in the end could affect the ability of individuals to effectively carry out set tasks.[6] In medical school, the ability to effectively execute complex cognitive tasks is especially important and affects how the student will take care of their patients in the future. Medical students must be able to process and retain large amounts of information during lecture times, as it determines their success rate in their academic endeavor. These tasks could require the use of executive function processes such as working memory, inhibitory control, and cognitive flexibility.[7]

Academic performance is the sum of distinct and complex factors that act in a person who is learning.[8,9] It is also the ability to study and remember facts and to communicate one's knowledge verbally or in writing.[10] A study by Hania *et al.*[11] suggested a possible link or relationship between executive function and academic performance. They reported that executive dysfunction negatively impacted the academic performance of students in mathematics and science. An inversely proportional relationship between academic performance and working memory, and conscious supervision of behavior, respectively, was reported by Ramos-Galarza *et al.*[12] Despite the existing important relationship between executive function and academic performance, there are no reports on this subject matter from the South-Eastern part of Nigeria, hence the importance of the present study. The present study aimed to examine the relationship between executive function and academic performance among medical students at Enugu State University of Science and Technology (ESUT).

MATERIALS AND METHODS

Study design and setting

This is a cross-sectional descriptive study conducted among 314 students of anatomy, medical laboratory science, nursing science, and medicine at ESUT, Nigeria.

Sample size and inclusion

The sample size of 314 was determined using the Cochran formula[13] (confidence level of 95%, population size (P) = 5000, population proportion (p) = 7%, margin of error (e) = 2.73%). Only consenting 200 and 300-level students were included; critically ill students were excluded. The sample size was calculated online.[14]

Inclusion and exclusion criteria

Only students in their second (200-level) and third (300-level) year of study who consented to participate in the study were included. Critically ill students who were not available during the time of the study were excluded.

Research model and hypothesis

The model posits that achievement scores are a function of INC, CF, and WM. AP was measured based on the highest and lowest grades in core courses (Gross Anatomy, Biochemistry, Histology, Physiology, and Practical/Modeling). We hypothesized no significant relationships between EF components (H1-3), no direct effects on AP (H4-6).

1. **Executive function relationships:**
   - Hypothesis 1-3. There is no significant relationship between the executive functions: IC, CF, and WM.
2. **Direct effects on performance:**
   - Hypothesis 4 - 6. There are no significant effects of INC, CF, and WM on executive functions.
3. **Indirect/Demographic effects:**
   - Hypothesis 7 – 9. There is no significant relationship between INC, CF, and WM and sex.
   - Hypothesis 10 – 12. There is no significant relationship between INC, CF, and WM and age.
   - Hypothesis 13 – 14. There is no significant relationship between age, sex, and academic performance.

Study instrument

The instrument for this research is an ODK questionnaire developed and structured by the researcher following a thorough literature search. The questionnaire had two sections; Section A contained questions on socio-demographic characteristics (age and sex) of the respondents, while Section B contained questions on the executive function and academic performance. The executive function part of the questionnaire designed by Peg Dawson and Richard Guare in the year 2010 was used to determine executive skills and contains questions on working memory, inhibitory control, cognitive flexibility, planning, time management, and other categories of executive function.[15,16] The Academic performance part of the questionnaire contains questions about the highest grade on each medical course, like gross anatomy, histology, biochemistry, and physiology, and possible reasons they do not do well in their academics.

Statistical analysis

The internal consistency (Cronbach's α) was between 0.793 and 0.866 for the different sections of the questionnaire that evaluated INC, CF, and WM, suggesting that the validity and reliability of the scales were deemed adequate. The reliability of the scale items was as presented: inhibition control (INC; α=0.793 [4 items]), cognitive flexibility (CF; α=0.926 [4 items]), and working memory (WM; α=0.856 [4 items]).

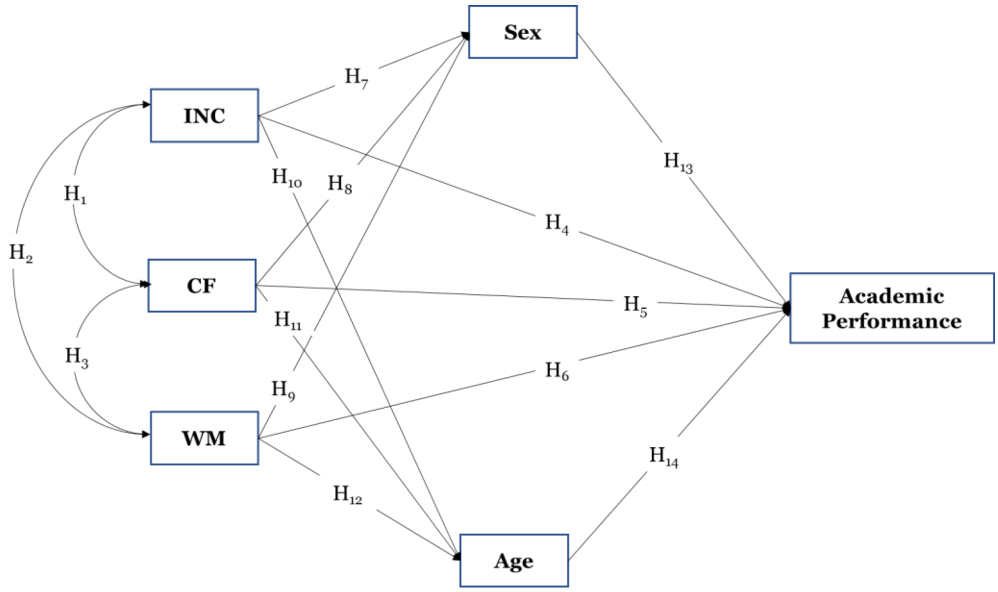

Figure 1: Path model of executive functions and academic performance. Latent constructs: inhibition control (INC), cognitive flexibility (CF), working memory (WM). Observed variables: Academic performance (AP), sex, and age. Arrows indicate hypothesized direct, indirect, and correlational paths.

Each item was measured on a five-point Likert scale, ranging from ‘‘strongly disagree’’ (1) to ‘‘strongly agree’’ (5). The perceived, self-rated academic performance for low and high performance was determined by the lowest and highest grade achieved for Gross Anatomy, Biochemistry, Histology/Embryology, Physiology, and Practical/Modelling. The subjects were graded A to F, which represented a score of 5 to 0.

To test these proposed hypotheses, data were collected and analyzed using the Statistics Package for Social Science (IBM® Amos V21.0.0, USA) structural equation modelling, which combined multiple regression with a series of interrelated dependence relationships. In evaluating model fit within Structural Equation Modeling (SEM) using AMOS, several key indices guide analytical decisions. The study considered the Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI), which assesses the overall model fit, with values above 0.60 indicating acceptable fit and above 0.95 reflecting excellent fit. The Root Mean Square Error of Approximation (RMSEA) was used to evaluate how well the model would fit the population, where a value below 0.08 suggests a reasonable fit and a value below 0.05 indicates a close fit. The Standardized Root Mean Square Residual (SRMR) was used to measure the difference between observed and predicted correlations, with a value less than 0.08 considered good. The study also determined the standardized and unstandardized direct effects of the exogenous variables on the manifest variable and presented the results as path and relation diagrams.

Ethical consideration

Approval for the study was sought and granted by the Research and Ethics Committee of the Faculty of Basic Medical Sciences, Enugu State University of Science and Technology (Reference Number: ESUT/ANA/2024/1026). The researcher provided a consent form to the participants and allowed them to give written informed consent to take part in the study. The participant was made very aware of their right to withdraw from responding to any of the research questions at any time if they felt uncomfortable doing any more of the questions.

RESULTS

As described in Table 1, of the total study participants, 122 (38.9%) were males, and 192 (61.1%%) were females. The mean age was 22.02±1.077, with student in the age group 19 – 23 years (295; 93.9%) being more than their older counterparts aged 24 and above (19; 6.1%). More Medicine students (123; 39.2%) participated in the survey compared to their Anatomy (61; 19.5%), Med Lab science (66: 21%), and Nursing (64; 20.4%) counterparts. Most students were not in any relationship (311; 99.0%) and not employed (304; 96.8%).

Table 1: Study demographic characteristics of participants in the survey

Category	Sub-categories	Frequency (n=314)	Mean±S.D
Sex	Male (%)	122 (38.9)	N/A
	Female (%)	192 (61.1)	
Age	19 – 23 Years (%)	295 (93.9)	22.02±1.077
	24 and above (%)	19 (6.1)	
Course	Anatomy (%)	61 (19.4)	N/A
	Med Lab Science (%)	66 (21.0)	
	Medicine (%)	123 (39.2)	
	Nursing (%)	64 (20.4)	
Course level	200L (%)	73 (23.2)	N/A
	300L (%)	241 (76.8)	
Relationship status	Not in relationship (%)	311 (99.0)	N/A
	In a relationship (%)	3 (1.0)	
Employment status	Not employed (%)	304 (96.8)	N/A
	Employed (%)	10 (3.2)	

Note: n=distribution, N/A=Not applicable, 200 L = Second year of study, 300 L = third year of study

Construct and model fit

From the correlation matrix, the items within each executive function domain were strongly interrelated. Working memory items (WC1–4) exhibited particularly high intercorrelations, with several coefficients exceeding 0.80, indicating strong internal consistency (Table 2). Cognitive flexibility items (CF1–4) also demonstrated robust positive correlations, all above 0.78. However, inhibition control items (IC1, IC3, & IC4) were moderately to strongly correlated, with values above 0.60, while IC2 showed weaker associations with other inhibition measures. This implies that IC2 may require revision or reconsideration in future measurement models. Cross-domain correlations were generally lower but still positive, suggesting that while the constructs are related, they remain distinct. However, they contributed meaningfully to the factor structure. Bartlett's test of sphericity was significant ($P < 0.01$), and the determinant value was low, confirming the data's suitability for principal component analysis.

Varimax rotation produced a clear and interpretable factor structure. Component 1 was defined by strong loadings from all cognitive flexibility items (C1-4, all > 0.78; with communality slightly above 0.70). Component 2 was characterized by high loadings from all working memory items (W1-4, all > 0.62; with communality above 0.75). Component 3 was defined by inhibition items (C1, C3, C4, all > 0.69; with the lowest communality of 0.23), except for IC2, which did not load strongly on any component, consistent with its low communality. The distinct clustering of items suggests that the theoretical separation of executive function into cognitive flexibility, working memory, and inhibition control domains is valid.

Three components (1-3) met the eigenvalue-greater-than-one criterion. Component 1 accounted for 43.75% of the total variance, Component 2 for 17.98%, and Component 3 for 10.53%, yielding a cumulative variance explained of 72.26%. This high cumulative percentage indicates that the three-component solution captured the majority of the variance in the dataset, supporting the adequacy of the model for summarizing the underlying structure of executive function measures.

The model demonstrated an adequate fit: $\chi^2/df = 2.30$ (acceptable), RMSEA = 0.064 (reasonable fit), GFI = 0.923, and AGFI = 0.883. However, CFI = 0.754 and TLI = 0.673 were below the 0.90 threshold, indicating that while the model fits moderately well, some improvements may be needed. The squared multiple correlations indicated that the model accounted for 38.4% of the variance in academic performance, suggesting a moderate explanatory power of the executive function and demographic predictors combined (Figure 2).

Table 2: Mean and standard deviation of the executive function measurement constructs and items

Constructs and Items	Mean	SD	Constructs and Items	Mean	SD
INC	2.05	0.48	WM	2.28	0.75
INC1	2.09	0.65	WM1	2.44	0.88
INC2	1.76	0.64	WM2	2.42	0.89
INC3	2.09	0.65	WM3	2.38	0.82
INC4	2.27	0.80	WM4	1.87	0.87
CF	3.18	0.75			
CF1	2.82	0.55			
CF2	3.23	0.90			
CF3	3.26	0.90			
CF4	3.41	1.04			

Note: N = 314, IC - Inhibition control, WM - Working memory, CF – Cognitive function, SD – Standard deviation

Table 3: Mean and standard deviation of the academic performance measurement constructs and items

Constructs and Items	Mean	SD	Constructs and Items	Mean	SD
Academic Performance (High)	4.05	0.42	Academic Performance (Low)	2.81	0.62
Gross Anatomy	4.07	0.38	Gross Anatomy	2.97	0.34
Biochemistry	3.87	0.36	Biochemistry	2.54	0.61
Histology/Embryology	4.16	0.40	Histology/Embryology	3.15	0.38
Physiology	3.93	0.40	Physiology	2.67	0.62
Practical/Modelling	4.2	0.47	Practical/Modelling	2.74	0.83

Note: SD – Standard deviation, N = 314

Academic performance

The mean score (±S.D) for the highest academic performance score was 4.05±0.42, highest academic performance score was 2.74±0.83 (Table 3).

Executive function relationships

Consistent with expectations, the three executive function constructs were significantly correlated. Inhibition control correlated with cognitive flexibility ($r = 0.389$, $p < 0.001$) and working memory ($r = 0.587$, $p < 0.001$), while cognitive flexibility and working memory were also strongly related ($r = .545$, $p < .001$). These findings indicate substantial overlap among executive functions, while still representing distinct constructs (Figure 2).

Direct effects on academic performance

The hypothesized direct effects of executive functions on academic performance yielded mixed results. Inhibition control ($\beta = –0.130$, $p = 0.067$) and working memory ($\beta = –0.101$, $p = 0.145$) were not significantly associated with academic performance. By contrast, cognitive flexibility demonstrated a strong and statistically significant effect ($\beta = –0.463$, $p < .001$), though in a negative direction, contrary to theoretical expectations. This suggests that higher levels of cognitive flexibility were associated with lower academic performance (Figure 3).

Effects of executive functions on sociodemographic variables

The relationships between executive functions and sex were nonsignificant across all paths (IC: $\beta = –0.138$, $p = 0.122$; WM: $\beta = 0.128$, $p = 0.155$; CF: $\beta = 0.021$, $p = 0.787$), indicating no evidence of sex differences in executive function performance. Regarding age, only inhibition control showed a significant effect ($\beta = –0.248$, $p = 0.003$), suggesting that inhibition control decreases with increasing age. Working memory ($\beta = –0.034$, $p = 0.687$) and cognitive flexibility ($\beta = –0.109$, $p = 0.130$) were not significantly related to age (Figure 3).

Demographic effects on academic performance

Neither sex ($\beta = –0.019$, $p = 0.704$) nor age ($\beta = 0.069$, $p = 0.174$) significantly predicted academic performance, indicating that demographic characteristics did not play a substantial role in explaining performance outcomes within this model (Figure 3).

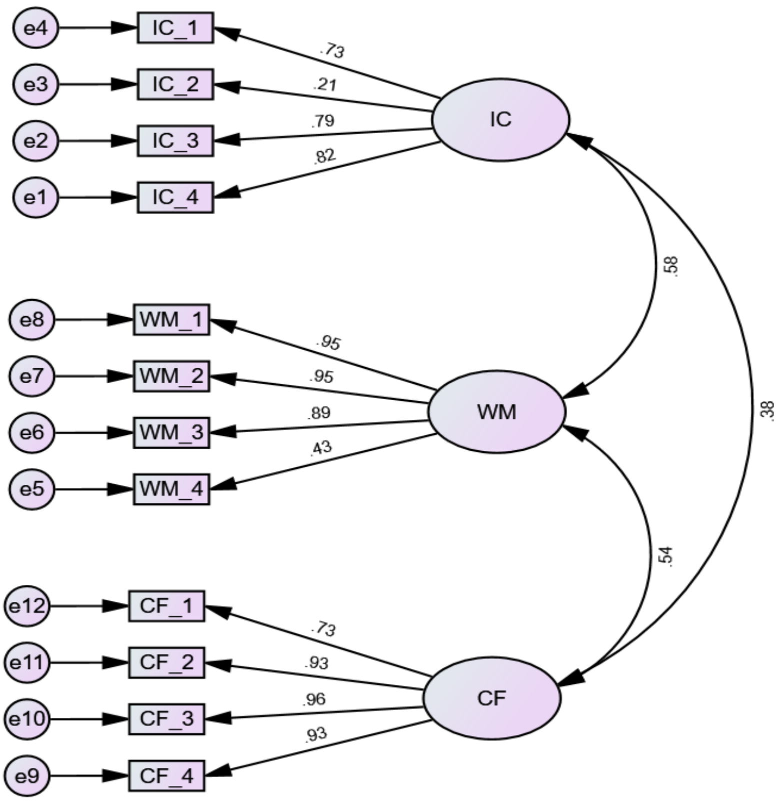

Figure 2: Factor loading of construct variables for inhibition control (IC), working memory (WM), and cognitive flexibility.

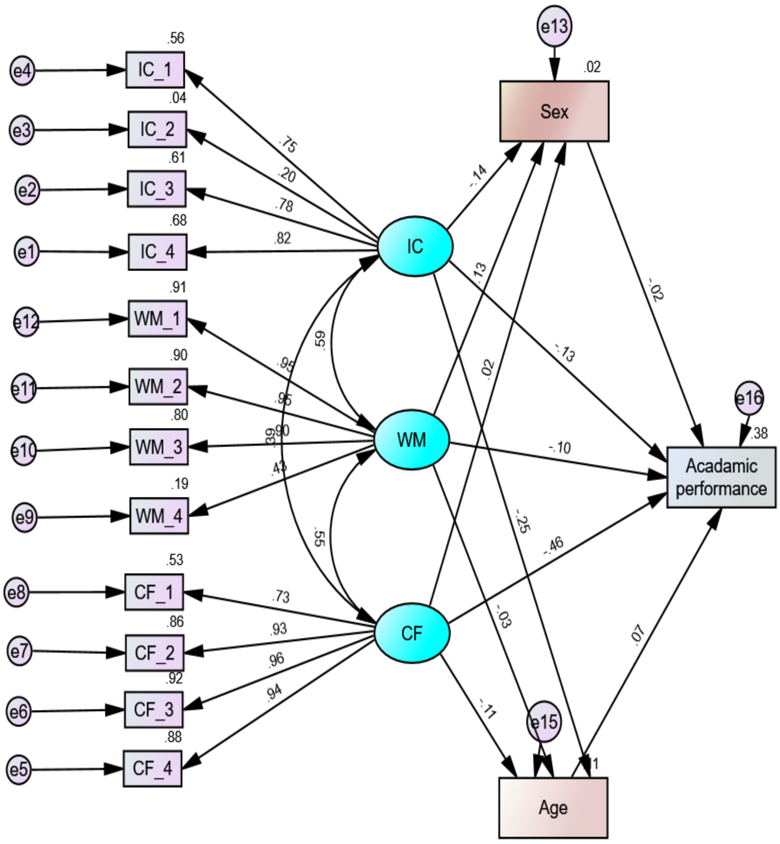

Figure 3: Model for executive functions, academic performance, and sociodemographics; inhibition control (IC), cognitive flexibility (CF), and working memory (WM).

Perceived factors influencing academic performance

In Figure 4, the study graphically described the perceived factors influencing academic performance among medical students. Out of ten (10) suggested issues with academic performance, three (3) stood out: being in classes they didn't like (38.0%), difficulty communicating with lecturers/professors 33.2%), and difficult courses (29.7%).

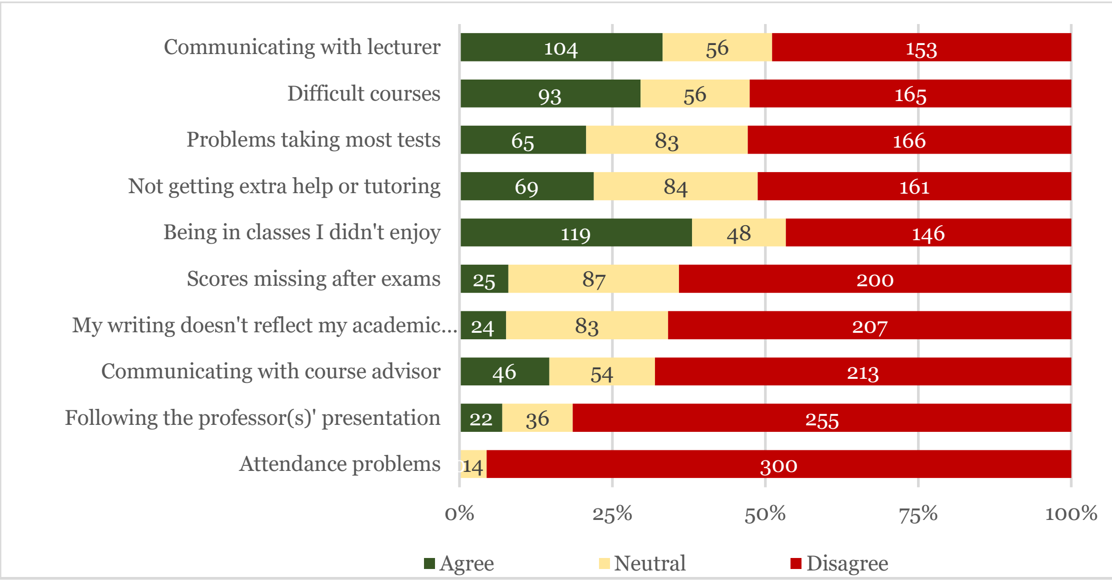

Figure 4: The issues associated with high and low academic performance

DISCUSSION

While the incremental fit indices fall below the traditional 0.90 threshold, the model is considered statistically acceptable due to its reasonable absolute fit indices.[17] The lower TLI and CFI values can be attributed to model complexity and the relatively specific sample size.[18] Nonetheless, the model is statistically acceptable and shows reasonable fit in absolute terms. Research suggests that strict adherence to universal cutoffs is often based on intuition rather than absolute statistical necessity;[18] thus, the current model remains a valid framework for explaining 38.4% of the variance in performance.

Executive function variables are significantly related to each other in the present study. The fact that all executive function variables are significantly related suggests that working memory, cognitive flexibility, and inhibitory control are closely tied together and do not work alone in most instances.[19] This interaction could help to promote higher-order thinking and goal-oriented behavior and consequently improve academic performance. Our findings support the idea that executive functions form a unified but complex system, where strengths or weaknesses in one area can affect performance in others.[3] For example: Good inhibitory control can improve working memory by minimizing distractions from irrelevant information. A strong working memory can enhance cognitive flexibility by allowing the retention and manipulation of different task rules or viewpoints.[20] Cognitive flexibility can help manage behavior effectively, which then supports inhibitory control. However, excessive flexibility may lead to strategy-switching, inconsistency, and reduced persistence, traits less rewarded in structured medical education. Consequently, improving one area of executive function through training or educational methods can lead to benefits across the entire executive function spectrum.

Traditional models of executive functions often predict that inhibition, control, and working memory are crucial for academic success [21]. The lack of significant effects in the present study challenges this assumption. The unexpected negative effect of cognitive flexibility suggests that the relationship between executive functions and academic performance may be more complex than linear models assume. This observation is in contrast with the finding of Gathercole *et al.*[22] who reportedly suggested a link between cognitive flexibility and positive learning outcomes. The possible explanation for the observation in our study may be linked with the fact that highly flexible students may switch strategies too often, leading to inconsistency and reduced efficiency in academic tasks[23]. A lot of time, academic performance often rewards persistence, rule-following, and sustained focus; excessive flexibility might conflict with these demands, leading to possible low academic performance.[24] Consequently, when developing programs aimed at boosting executive functions should consider that not all components equally predict academic success.

The study also found that cognitive flexibility is related to the age of our respondents, suggesting that an increase in age was linked with increased ability to think from various angles to find a problem. Our observation is in line with the findings of Chen *et al.*[25], who suggested that the older people get the better they get at problem solving. However, not all the executive function variables are related to either age or gender, which implies that regardless of the student’s age or the student’s gender, a student’s working memory and inhibitory control can function individually based on how each student developed their skills. The observation that not all executive function variables are significantly related to age or gender suggests that key components like working memory, cognitive flexibility, and inhibitory control may function independently of demographic factors. What this means is that development and use of executive processes are more influenced by personal experiences, external environments, and cognitive strategies than by one's age or biological sex.[26] These results are significant for questioning the assumption that there are uniform executive function developmental pathways for all ages and explicit gender differences[6]. Our findings support an emphasis on the individual in a cognitive developmental framework; each student's executive profile represents a unique combination of brain development, encounters with academic learning, practice and reinforcement of self-regulation skills, and socio-emotional and contextual stimuli.

Out of ten (10) suggested issues with academic performance, three stood out: being in classes they didn’t like (38.0%), difficulty communicating with lecturers/professors 33.2%), and difficult courses (29.7%). This pattern shows that emotional, social, and mental barriers significantly shape students' academic experiences. The high level of disinterest in classes indicates the strong impact of intrinsic motivation and subject relevance.[27] When students take courses they find boring or not aligned with their interests, their effort and persistence may drop.[28] The second issue, difficulty communicating with lecturers, emphasizes the importance of interaction between students and instructors for academic success. Poor communication can limit students’ ability to ask questions, get feedback, or feel supported, which can harm learning outcomes and confidence[29]. Finally, the challenge of tough courses reflects the mental demands of students. While academic rigor is important, too much difficulty without proper support may lead to frustration, disengagement, or burnout. These findings highlight the need for: a curriculum that matches student interests, better communication between faculty and students, and a balanced academic challenge with proper support. Tackling these areas can improve student engagement, satisfaction, and overall academic performance.

The study recognizes the results may not reflect those of the general population of Nigerian students, as it sampled a single school from the Eastern part of the country. The self-reported nature of the participants' responses could result in exaggeration or underreporting responses and recall bias. However, the present study brings to bear key issues that could possibly help improve student academic performance if given proper attention. The relatively low incremental indices weaken the strength; hence, our model explains variance only moderately well compared to simpler alternatives. However, the model is statistically acceptable and shows a reasonable fit in absolute terms.

CONCLUSION

Executive function components: working memory, cognitive flexibility, and inhibitory control, were significantly interrelated, indicating that these cognitive processes operate closely together among medical students. While only cognitive flexibility showed a significant negative association with academic performance, the findings highlight the importance of fostering curricula aligned with student interests, strengthening faculty–student communication, and providing appropriate academic support to enhance student engagement and academic outcomes.

Conflict of interests: The authors have no conflicts of interest to declare

Acknowledgements: The authors wish to express their sincere gratitude to the students and staff of the College of Medicine for their valuable participation and steadfast support of this study.

Authors' contribution: EOA Jr: conceptualization, methodology, formal analysis, writing – original draft, writing – review & editing; CE.: data curation, investigation, formal analysis, writing – original draft, visualization; IMU: conceptualization, validation, resources, supervision, writing – review & editing.

REFERENCES

1. Kline RB. Principles and practice of structural equation modeling. 5th ed. New York (NY): Guilford Press; 2023. Available from: https://www.guilford.com/books/Principles-and-Practice-of-Structural-Equation-Modeling/Rex-Kline/9781462551910
2. Bollen KA, Noble MD. Structural equation models and the quantification of behavior. Proc Natl Acad Sci U S A. 2011;108(Suppl 3):15639-15646. doi:10.1073/pnas.1010661108.
3. Friedman NP, Miyake A. Unity and diversity of executive functions: Individual differences as a window on cognitive structure. Cortex. 2017;86:186-204. doi:10.1016/j.cortex.2016.04.023.
4. Friedman NP, Robbins TW. The role of the prefrontal cortex in cognitive control and executive function. Neuropsychopharmacology. 2022;47(1):72-89. doi:10.1038/s41386-021-01132-0.
5. Gross RG, Grossman M. Executive resources. Continuum (Minneap Minn). 2010;16(4):140-152. doi:10.1212/01.CON.0000368266.46038.0E.
6. Grissom NM, Reyes TM. Let's call the whole thing off: Evaluating gender and sex differences in executive function. Neuropsychopharmacology. 2019;44(1):86-96. doi:10.1038/s41386-018-0179-5.
7. Escobar JP, Espinoza V. Direct and indirect effects of inhibition, working memory, and cognitive flexibility on reading comprehension of narrative and expository texts: Same or different effects? Read Writ Q. 2024;41(1):1-17. doi:10.1080/10573569.2024.2400993.
8. Enyoojo SF, Ijah CE, Etukudo EM, Usman IM, Ezeonuogu CS, Adaramati T, *et al.* Satisfaction and learning experience of students using online learning platforms for medical education. BMC Med Educ. 2024;24:1398. doi:10.1186/s12909-024-06411-0.
9. Mwabaleke J, Usman I, Tito A, Obeten KE, Isyaku MU, Etukudo E, *et al.* Perceptions and challenges faced by undergraduate medical students in studying anatomy: A case study at Kampala International University–Western Campus, Uganda. Adv Med Educ Pract. 2023;14:1129-1135. doi:10.2147/AMEP.S427136.
10. Pascual AC, Muñoz NM, Robres AQ. The relationship between executive functions and academic performance in primary education: Review and meta-analysis. Front Psychol. 2019;10:1582. doi:10.3389/fpsyg.2019.01582.
11. Hania A, Orcullo DJC, Salim AZ. The impact of executive functioning on the academic performance of students in mathematics and science. Malays J Soc Sci Humanit. 2019;4(1):15-21.
12. Ramos-Galarza C, Acosta-Rodas P, Bolaños-Pasquel M, Lepe-Martínez N. The role of executive functions in academic performance and behaviour of university students. J Appl Res High Educ. 2020;12(3):444-455. doi:10.1108/JARHE-10-2018-0221.
13. Ahmed SK. How to choose a sampling technique and determine sample size for research: A simplified guide for researchers. Oral Oncol Rep. 2024;12:100662. doi:10.1016/j.oor.2024.100662.
14. Calculator.net. Sample size calculator [Internet].

Available from: https://www.calculator.net/sample-size-calculator.html
15. Nasir H, Tan CS, Pheh KS. The Executive Skills Questionnaire-Revised: Adaptation and psychometric properties in the working context of Malaysia. Int J Environ Res Public Health. 2021;18(17):8978. doi:10.3390/ijerph18178978.
16. Virginia Family Special Education Connection. Executive Skills Questionnaire—Peg Dawson & Richard Guare (Embrace Autism). Available from: https://vafamilysped.org/Resource/JWHaEa5BS77bw_uCRU4ozQ/Resource-executive-skills-questionnaire--peg-dawson--richard-guare-embrace-autism
17. Goretzko D, Siemund K, Sterner P. Evaluating model fit of measurement models in confirmatory factor analysis. Educ Psychol Meas. 2023;84(1):123-144. doi:10.1177/00131644231163813.
18. Xia Y, Yang Y. RMSEA, CFI, and TLI in structural equation modeling with ordered categorical data: The story they tell depends on the estimation methods. Behav Res Methods. 2019;51(1):409-428. doi:10.3758/s13428-018-1055-2.
19. Nweze T, Nwani W. Contributions of working memory and inhibition to cognitive flexibility in Nigerian adolescents. Dev Neuropsychol. 2020;45(3):118-128. doi:10.1080/87565641.2020.1765169.
20. Van Stockum CA, DeCaro MS. When working memory mechanisms compete: Predicting cognitive flexibility versus mental set. Cognition. 2020;201:104313. doi:10.1016/j.cognition.2020.104313.
21. Ma C, Song M, Zhao X. The impact of executive functions on English academic performance among Chinese primary school students: A network analysis. Learn Instr. 2025;99:102174. doi:10.1016/j.learninstruc.2025.102174.
22. Gathercole SE, Team C, Woolgar F, Kievit RA, Astle D, Manly T, *et al.* How common are WM deficits in children with difficulties in reading and mathematics? J Appl Res Mem Cogn. 2016;5(4):384-394. doi:10.1016/j.jarmac.2016.07.013.
23. Gökçe S, Güner P. Pathways from cognitive flexibility to academic achievement: Mediating roles of critical thinking disposition and mathematics anxiety. Curr Psychol. 2024;43(20):18192-18206. doi:10.1007/s12144-024-05642-0.
24. Duckworth AL, Taxer JL, Eskreis-Winkler L, Galla BM, Gross JJ. Self-control and academic achievement. Annu Rev Psychol. 2019;70(1):373-399. doi:10.1146/annurev-psych-010418-103230.
25. Chen X, Hertzog C, Park DC. Cognitive predictors of everyday problem solving across the lifespan. Gerontology. 2017;63(4):372-384. doi:10.1159/000459622.
26. Hatoum AS. The etiology of executive functioning is nature and nurture. Biol Psychiatry. 2023;94(2). doi:10.1016/j.biopsych.2023.05.009.
27. Gottfried AE. Academic intrinsic motivation: Theory, assessment, and longitudinal research. In: Advances in motivation science. Vol. 5. San Diego (CA): Elsevier; 2018; 71-109. doi:10.1016/BS.ADMS.2018.11.001.
28. Saeed S, Zyngier D. How motivation influences student engagement: A qualitative case study. J Educ Learn. 2012;1(2):252-267. doi:10.5539/jel.v1n2p252.
29. Gao D, Nacional RB. Students' interactions and communication skills towards their maximum learning. Int J Educ Humanit. 2024;16(3):305-309. doi:10.54097/t68pye09.