

Executive function and mastery of science concept of grade 10 learners

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ABSTRACT

This survey – correlational research was conducted to determine the relationship between the executive function and mastery of science concept among grade 10 learners for the school year 2025 - 2026. The participants of this study were the 132 taken from the total population of 196 grade 10 students selected through stratified random sampling by lottery method using the Taro Yamane formula. To measure the level of executive function, a 30-item executive function questionnaire adapted from Baddeley and Diamond (2013) was used. To measure the level of mastery of science concept, a 29-item standardized test based on the Most Essential Learning Competencies (MELCS) was used. The two instruments were subjected to face and content validation by a panel of experts and were pilot-tested to 30 grade 10 students who were not included as participants of the study for reliability measures. The independent variable in this study was the executive function of grade 10 students. The dependent variable was the mastery of science concept of the grade 10 students. Frequency count, percentage, mean, and standard deviation as descriptive statistical tools were utilized for data analysis. Moreover, the Pearson was used as inferential statistical tool to determine the significant relationships. A two - tailed test was used at 5% level of significance for all inferential analysis. The results revealed that the overall level of executive function among the participants was found to be high, indicating that learners generally possessed strong cognitive flexibility and inhibitory control skills. Among its component, working memory was at a moderate level, suggesting some difficulty in handling complex or multi-step tasks, while cognitive flexibility and inhibitory control were both high, reflecting students' ability to adapt to changes and control their behavior effectively. Furthermore, the finding showed a significant relationship between executive function and mastery of science concept. This indicated that having well-developed executive function skills was important in fostering higher mastery of science concepts. The stronger the students' executive function abilities such as working memory, cognitive flexibility, and inhibitory control, the higher their level of understanding and mastery of science concepts was likely to be.

Keywords: Executive Function, Working Memory, Cognitive Flexibility, Inhibitory Control and Science Mastery.

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INTRODUCTION

There has been a greater emphasis on the relevance of cognitive processes in academic success, mostly in science education in the recent year. Science education plays a crucial role in nurturing students critical thinking, analyzing skills, sequencing and problem-solving abilities. Among these processes is the Executive function (EF) by Diamond, a collection of cognitive skills that is composed of working memory which concerned with information and task application, cognitive flexibility that can adapt to different task or new sets of information, and inhibitory control that helps in decision making and self-regulation which has been recognized as a key component impacting students' learning outcomes and development.

According to Diamond (2013) the author of the studies about executive functions, these skills are essential component for purposeful, goal-directed behavior and are crucial for success in academic landscape, particularly in tasks that demand problem-solving, reasoning, analyzing and critical thinking such as science learning. These cognitive abilities enable students to have mental flexibility in terms of planning and organizing, ability to hold and manipulate information, plan experiments that follow multistep procedures as science learning consist of complex concept and processes that required sustained attention. As noted by Blair and Raver (2015), strong executive functions are vital for self-regulated learning which encourages students to take control of their own unique learning journey and help students manage difficult cognitive tasks and adapt their thinking in dynamic classroom contexts like scientific education.

Recent studies further support this claim. Research indicates that executive function skills, particularly working memory, cognitive flexibility, and inhibitory control, are strong predictors of academic achievement and students' ability to perform complex learning tasks in school. Students with stronger executive function skills are more capable of organizing information, maintaining attention, and applying reasoning strategies necessary for learning scientific concepts (Pascual & Robres, 2019). Moreover, more recent research also highlights that executive functions play a significant role in students' academic performance because they support goal-directed learning behaviors, problem-solving processes, and effective cognitive regulation during challenging academic tasks (Perpiñà-Martí et al., 2023).

The mastery of science concepts, mainly at the secondary level, requires comprehensive approach which students need to analyze and synthesize information in various complex concept of science in Biology, Physics, Chemistry and Earth Science. These cognitive processes enable students to interpret scientific information, evaluate evidence, and apply scientific knowledge to real-world situations (OECD, 2019). Furthermore, research by Hattie (2020) highlighted that deep learning and conceptual understanding in science occur when students actively engage in analytical thinking and integrate new knowledge with prior understanding. Similarly, Osborne (2021) explained that science education should focus on developing students' reasoning and inquiry skills to help them better understand complex scientific ideas and processes.

According to the research of Best, Miller, and Naglieri (2015) executive function skills are significantly correlated with academic achievement especially in science education and Students with well-developed Executive Function skills tend to perform better in science because they can successfully plan and execute experiments, can organize their study materials and manage their time efficiently. In the context of junior high school, science education typically involves complex concept that require students to demonstrate higher-order thinking skills, which are closely tied to their executive functioning. Blair and Raver (2015) emphasized that executive function is crucially important during adolescence, a developmental stage when students face increasing academic demands in terms of the higher competency of the concepts and are expected to show independence in their learning style.

Recent research continues to highlight the significant role of executive function in students' academic achievement across various learning domains. A study by Park et al., (2023), found that executive function significantly contributes to adolescents' academic performance by supporting cognitive processes such as attention control, information processing, and problem solving. The study emphasized that executive function acts as a mediator between cognitive abilities and academic achievement, meaning that students with stronger executive function skills are more capable of performing well in school tasks that require reasoning and complex thinking. These findings further highlight the importance of developing executive function skills among students to improve learning outcomes in academic subjects, including science

In the current Philippine context, there are limited studies that can be found focusing specifically link between executive function and mastery of science concepts. The Philippine science education continues to promote scientific literacy and encourages inquiry-based learning among learners, yet there's still little attention given to the cognitive abilities that support such learning specifically the executive functions like planning and organizing. Given this gap in the present literature requires deep understanding through further study, particularly among Grade 10 students where their academic success and development become more critical and on crucial point as they prepare for bigger challenges and demands for Grade 11 and 12.

The study was based on the Executive Function Theory as cited in both the study of Kimbarow & Wallace (2024) that Executive functions is a complex neuropsychological construct that overlays but is different from attention and memory. This contributes to planning, organizing, initiating and adapting effectively and flexibly, as required by the situation.

Similar to this, the theory of learning, which is also called the Constructivist Theory of Learning, is a result of the works done by Jean Piaget and Jerome Bruner who claim that learners can synthesize their new understanding from the knowledge interaction and what they already know (Resnick & Glaser, 2016). In other words, when a student is engaging in scientific learning in a classroom that engages critical thinking, they are doing the work of inquiry, exploration, analysis and reflection, all of which involves executive functions. In Antonio and Prudente (2024) research shows that inquiry-based learning incorporates the principles of scientific inquiry into teaching. It also wants to enhance pupils' ability to think. Students are expected to be active participants everywhere throughout the process, from building hypotheses using data, observation, research, to question, and finally to conclude what can be drawn from available evidence. Consequently, they are actively seeking to master the scientific thinking techniques that enables them to interpret, and create their real ideas in the same way as scientists do. Therefore, individuals should continue to promote the use of science learning activities that focus on inquiry and problem solving to enhance students' executive functions.

Together, these ideas theories make a compelling point of view from which to understand how executive function abilities are related to science concept comprehension. Internal cognitive resources, executive functions, help the pupils to handle the demanding demands of scientific investigation and conceptual learning. Students lacking the executive functions may also struggle to integrate knowledge, alter their thinking, and face the scientific puzzles. On the other hand, active problem solving in science learning activities that focus on inquiry may enhance children's executive function even higher.

Accordingly, executive functions and scientific mastery are treated as one close phenomenon: effective executive functions facilitate in gaining scientific knowledge, and enhancing scientific skills such as observing, classifying and interpreting improves executive cognitive functions. In this theoretical framework, it directs to the research of how the components of executive functions impacts grade 10 students understanding in science subject.

Statement of the problem

This study aimed to determine the relationship between Executive function and Mastery of science concept among Grade 10 Students.

Specifically, this study sought to answers to the following questions:

1. What is the level of executive function of grade 10 learners as a whole and in terms of: cognitive flexibility, working memory and inhibitory control?
2. What is the level of mastery of science concept among grade 10 learners?
3. Is there a significant relationship between the executive function and mastery of science concept of grade 10 learners?

METHODOLOGY

This study aimed to determine the relationship between executive function and mastery of science concept among grade 10 learners. A descriptive survey-correlational research design was employed, as this type of design is suited for studies that seek to provide static pictures of situations while simultaneously establishing the relationship between different variables (McBurney & White, 2009). According to Creswell (2012), research designs encompass the specific procedures involved in the research process, including data collection, data analysis, and report writing. Survey research provides an accurate and efficient means for describing people's thoughts, opinions, and feelings, and is used to describe the entire population of interest through the use of a predetermined set of questions (Research Methods in Psychology, 2015). Correlational research, on the other hand, provides an opportunity to predict scores and explain the relationship among variables. Cohen, Manion, and Marrison (2007) state that correlation involves the collection of two sets of data, one of which is retrospective, with a view to determining the relationship between them. In this study, the independent variable was executive function, while the dependent variable was mastery of science concept. The descriptive statistics employed were the mean, range, and standard deviation, while the inferential statistic utilized was the Pearson r , with the alpha level of significance set at 0.05. Data gathered were computer-processed using the Statistical Package for the Social Sciences (SPSS) Software.

The participants of this study were 132 grade 10 students drawn from the total population of 196 students enrolled at President Manuel Roxas Memorial Integrated School South during the school year 2025-2026. The participants were selected using the stratified random sampling technique, applying Taro Yamane's formula to determine the appropriate sample size. Stratified random sampling involves drawing samples from the population and then drawing separate random samples from each stratum (Sullivan, 2008). The school's grade 10 population was organized into four sections, namely Love, Hope, Kindness, and Faith, with population sizes of 48, 49, 49, and 49 students, respectively, yielding a corresponding sample size of 33 participants from each section, for a total of 132 participants across all four sections. The selection of individual participants from each section was carried out using the lottery technique, wherein all student names within each section were written on rolled slips of paper, placed in a box, and drawn without looking until the required number of participants per section was obtained. To ensure proportional representation across sections, the proportionate allocation formula was applied in determining the number of participants drawn from each group.

The data needed for this study were gathered using researcher-made questionnaires as primary data-gathering instruments. The first instrument was an Executive Function Questionnaire composed of 30 items adopted from Baddeley and Diamond (2013), covering

three components: 10 items for working memory, 10 items for cognitive flexibility, and 10 items for inhibitory control. Participants responded using a five-point Likert scale, with the following numerical weights assigned to each response: a score of 5 corresponded to Always, 4 to Often, 3 to Sometimes, 2 to Rarely, and 1 to Never. To interpret the level of executive function, the following scale was used: a mean range of 4.21 to 5.00 was described as Very High, 3.41 to 4.20 as High, 2.61 to 3.40 as Average, 1.81 to 2.60 as Low, and 1.00 to 1.80 as Very Low. This instrument underwent content validation by a panel of experts. Following face and content validation, it was pilot-tested on 30 grade 10 students who were not included as participants of the study. The results of the pilot-testing were used to determine the reliability of the instrument through Cronbach's Alpha. According to Fraenkel and Wallen as cited by Gonzaga (2013), a coefficient reliability of greater than or equal to .70 indicates high reliability.

The second instrument was a researcher-made 29-item standardized Science Concept Test based on the Most Essential Learning Competencies (MELCS) in science for the school year 2025-2026, constructed in multiple-choice format. Items that obtained a factor analysis value of 0.50 or higher were retained in the instrument, while those below 0.50 were removed. The following numerical scale was used for statistical interpretation: a score range of 23.41 to 29.00 was described as Very High, 17.01 to 23.40 as High, 11.61 to 17.40 as Average, 5.81 to 11.60 as Low, and 0.00 to 5.80 as Very Low. This instrument likewise underwent content validation by science teachers, research specialists, and assessment experts. After face and content validation, it was pilot-tested on 30 grade 10 students who were not included as participants, and the results were used to determine the reliability of the instrument through item analysis using the index of difficulty, which was set within the acceptable range of 0.20 to 0.80, and the index of discrimination, set within the range of 0.20 to 1.00.

In gathering the needed data, the researcher followed a series of procedural steps to ensure proper authorization and ethical compliance. Permission was first sought from the Dean of the Graduate School of Filamer Christian University, followed by permission from the Schools Division Superintendent of Roxas City, Capiz to conduct the study. Subsequently, permission was secured from the principal of the school where the study was to be conducted. Upon approval, the researcher sought consent from the parents or guardians and the students themselves to participate in the study. Informed consents were secured from both parents and students prior to data collection. The researcher also ensured that data privacy was strictly observed by maintaining the confidentiality of all information and data gathered from the participants, in adherence to the provisions of Republic Act 10173, also known as the Data Privacy Act of 2012, which ensures the protection of individual personal information and communication systems in both government and private sectors. All data obtained from the instruments were subsequently processed, encoded, and analyzed using the appropriate statistical tools.

The following statistical tools were employed in the analysis of the gathered data. Frequency count was used to determine the number of student responses in each of the two instruments. The mean was used to determine the level of executive function and mastery of science concept among the participants. Standard deviation was used to determine the homogeneity and heterogeneity of responses of the respondents across both instruments. Pearson r was used to determine the relationship between executive function and mastery of science concept. All inferential tests were set at the 5% alpha level of significance.

RESULTS AND DISCUSSION

This chapter presents the results and discussion of the study examining the relationship between executive function and mastery of science concepts among Grade 10 learners. The study employed a descriptive survey-correlational research design involving Grade 10 learners as participants. Data were gathered using researcher-made instruments measuring executive function across three components, namely cognitive flexibility, working memory, and inhibitory control, as well as a science test measuring mastery of science concepts. The gathered data were analyzed using descriptive statistics, including the mean and standard deviation, and inferential statistics using Pearson r to determine the significance of the relationship between the two variables. The results are interpreted in direct relation to the objectives of the study and are discussed in conjunction with relevant scholarly literature to contextualize the findings within the broader field of educational research.

The overall level of executive function of Grade 10 learners was found to be "High" ($M = 3.51$, $SD = 0.64$). Among the three components, working memory obtained a "Moderate" level ($M = 3.38$, $SD = 0.69$), while cognitive flexibility was described as "High" ($M = 3.48$, $SD = 0.78$), and inhibitory control likewise obtained a "High" level ($M = 3.67$, $SD = 0.70$). These results were interpreted using a five-point arbitrary scale wherein a mean range of 4.21–5.00 was described as Very High, 3.41–4.20 as High, 2.61–3.40 as Moderate, 1.81–2.60 as Low, and 1.00–1.80 as Very Low. The significantly high overall level of executive function indicates that learners demonstrated strong cognitive abilities in managing academic tasks, regulating behavior, and processing information. This implies that Grade 10 students are capable of handling learning activities that require attention, organization, planning, and problem-solving skills.

Among the three components, working memory obtained the lowest rating at the Moderate level ($M = 3.38$, $SD = 0.69$). This means that while learners are able to temporarily store and process information, they may still encounter difficulties when dealing with complex tasks that require holding multiple ideas at once, such as solving multi-step science problems, recalling procedures in laboratory activities, and integrating different scientific concepts. Working memory plays an essential role particularly in academic comprehension and problem-solving ability. This is supported by Allan Baddeley (2017), who explained that working memory is one of the components of executive function that plays a crucial role in holding and manipulating information that is essential for learning and comprehension. The moderate performance in this domain suggests that while learners possess foundational cognitive processing capacity, targeted instructional support may still be needed to strengthen their ability to manage cognitively demanding tasks.

Cognitive flexibility, on the other hand, obtained a High level ($M = 3.48$, $SD = 0.78$), indicating that learners are capable of adjusting their thinking, shifting between tasks, and adapting to new or changing learning situations. Such ability is essential in science education, where students are often required to interpret data, modify strategies, and consider alternative explanations. Cognitive flexibility is instrumental in learning as this skill allows students the ability to accept feedback, criticism, and incorporate corrections in their learning. Similarly, Gathercole, Dunning, and Holmes (2019) emphasize that learners with high cognitive flexibility demonstrate a greater ability to adjust their thinking when faced with challenges in academic settings, as these learners are capable of shifting tasks and providing alternative strategies when solving problems. The high level of cognitive flexibility among the participants therefore reflects a meaningful capacity for adaptive thinking that supports engagement with the varied and dynamic demands of science learning.

Inhibitory control also obtained a High level ($M = 3.67$, $SD = 0.70$), indicating that learners are able to regulate their impulses, maintain focus, and control distractions during

academic activities. This skill is particularly important in classroom and laboratory settings, where sustained attention and careful adherence to instructions are required to complete tasks accurately and effectively. Inhibitory control plays a significant role in emotional regulation, as learners with high inhibitory control tend to manage frustration when tasks become difficult, maintain composure in stressful situations, and avoid reacting impulsively to multiple distractions. In the Philippine context, inhibitory control is especially essential given the dynamic and challenging learning environment in schools. Learners with well-developed inhibitory control are equipped with skills that enable them to stay focused, make thoughtful decisions, disregard distractions, maintain academic persistence, and sustain emotional resiliency despite environmental or social pressures. According to Alloway (2017), learners with strong inhibitory control demonstrate not only better concentration but also self-regulation and emotional stability. The findings on executive function as a whole align with the work of Diamond (2013), who emphasized that executive function is crucial for academic achievement and cognitive development of learners in the classroom setting, noting that learners who demonstrate strong executive function skills are most likely to perform academically because they are more capable of managing their emotions, solving problems, and controlling their attention when faced with distractions and challenges.

The level of mastery of science concepts of Grade 10 learners was found to be "High" ($M = 20.23$, $SD = 6.11$), as interpreted using the following scale: a mean range of 23.41–29.00 was described as Very High, 17.41–23.40 as High, 11.61–17.40 as Moderate, 5.81–11.60 as Low, and 0.00–5.80 as Very Low. This high level of mastery indicates that learners demonstrated a good understanding of key science concepts in Earth Science and Physical Science. Specifically, several items on Earth Science tested the capacity of learners' deeper comprehension of geological and theoretical processes and their ability to relate scientific concepts to real-world phenomena, allowing learners to not only utilize remembering but also to analyze situations, interpret scientific principles, and apply information in practical contexts. Items in Physical Science likewise required learners to analyze scenarios, consider alternative solutions, and apply logical reasoning to provide accurate answers. The high level of mastery therefore shows that learners were not only able to recall scientific facts but also apply conceptual understanding to different situations, interpret scientific phenomena, solve problems, and relate scientific concepts to real-life situations such as natural disasters, optical instruments, and environmental processes. This is consistent with the study of Doyan et al. (2024), who claim that the ability of students to apply theoretical information to real-world situations and solve cognitively demanding tasks, especially in science, is an indication of science mastery. Furthermore, this high level of mastery is necessary for promoting science proficiency, fostering higher-order abilities, and allowing students to make knowledgeable judgments about environmental, societal, and technological issues in everyday settings.

To determine the relationship between executive function and mastery of science concepts, Pearson r was employed at a 0.05 alpha level of significance. The results revealed a significant relationship between the level of executive function and mastery of science concepts of Grade 10 learners ($r = 0.234$, $p = 0.007$). The obtained correlation coefficient indicates a positive relationship, meaning that learners with high executive function tend to demonstrate mastery and understanding of scientific concepts. The relationship is statistically significant at the 5% alpha level, indicating that executive function highly contributes to the science learning of students. Accordingly, the null hypothesis stating that there is no significant relationship between executive function and mastery of science concepts of Grade 10 learners is hereby rejected.

The positive and significant relationship between executive function and science mastery is theoretically grounded and empirically supported. Science, at its core, employs a methodology characterized by analyzation, observation, and experimentation, and uses complex cognitive processes such as problem-solving, logical reasoning, and understanding of abstract concepts, all of which require students to utilize their executive function skills. Working memory enables learners to retain essential information, recall instructions, retrieve appropriate scientific terms, keep ideas in mind simultaneously, and understand complex concepts. Cognitive flexibility allows learners to shift between different concepts, try new ways to solve problems, use varied ideas across different situations, accept corrections, analyze new concepts from different perspectives, and adapt to new activities or learning tasks. Inhibitory control helps learners resist or ignore distractions, maintain attentiveness during discussions, and manage frustration when tasks become complex. These findings are consistent with the research of Zalazo and Carlson (2020), who emphasized that executive function supports goal-directed behavior and higher-order thinking skills, and who noted that working memory, cognitive flexibility, and inhibitory control enhance learners' ability to solve problems, stay engaged in school activities, and improve their capacity to understand complex concepts. Similarly, Pascual (2019) noted that executive function is an essential indicator of learners' academic achievement, as learners with higher executive functioning skills tend to perform better academically because they are able to organize their thoughts, use effective learning techniques, and regulate their behavior. This finding is further supported by a recent meta-analysis by Fidalgo et al. (2024), which highlighted the favorable connection between executive function skills and academic success, demonstrating that learners with stronger executive function abilities are more inclined to excel academically, with this association remaining consistent across a variety of cultural contexts, thereby indicating the global importance of executive function in the realm of education.

Taken together, the findings of this study affirm that executive function is a significant cognitive factor that supports science learning among Grade 10 learners. The significantly high overall level of executive function, the high level of mastery of science concepts, and the statistically significant positive relationship between the two variables collectively reinforce the central premise of this investigation. These results contribute to the growing body of evidence emphasizing the role of cognitive regulatory skills in academic achievement, particularly in the context of science education in the Philippines. The findings further suggest that strengthening executive function skills through effective and efficient teaching strategies can help enhance students' ability to master science concepts. By incorporating activities that promote working memory, cognitive flexibility, and inhibitory control, teachers can support learners in organizing information, adapting to new tasks, and maintaining focus. These implications provide a meaningful foundation for the recommendations and proposed interventions to be presented in the succeeding chapter of this manuscript.

CONCLUSION

This study investigated the relationship between executive function and mastery of science concept among grade 10 learners at President Manuel Roxas Memorial Integrated School South during the school year 2025-2026. Employing a descriptive survey-correlational research design, the study involved 132 participants selected through stratified random sampling using Taro Yamane's formula. Data were gathered using a researcher-developed 30-item adapted questionnaire from Baddeley and Diamond (2013) to assess executive function, and a 29-item standardized Science Concept Test based on the Most Essential Learning Competencies (MELCS) to measure mastery of science concept. Descriptive statistics including mean and standard deviation were used to determine the levels of each variable,

while Pearson r was employed to determine the significant relationship between the two variables at the 0.05 alpha level of significance. The findings of the study yielded three major conclusions, each of which carries important implications for students, teachers, schools, and future researchers.

The first conclusion drawn from the study is that the level of executive function of grade 10 learners was high overall, with working memory at a moderate level and both cognitive flexibility and inhibitory control at high levels. Grade 10 students possessed well-developed cognitive and task management skills, including the ability to initiate tasks, adjust to changes in plans, maintain self-awareness, and demonstrate emotional stability. This high level of executive functioning enabled learners to solve problems, plan strategies, and make sound decisions. Working memory helped students retain and recall information when performing tasks, cognitive flexibility allowed them to manage their work effectively and shift strategies when necessary, and inhibitory control enabled them to ignore distractions and maintain focus throughout class hours. These skills are particularly important in helping learners understand complex concepts in science, a subject that requires analyzation, deep comprehension, and critical thinking. As a result, strong executive functioning skills contribute positively to academic achievement. It is therefore recommended that students continuously develop and strengthen these skills by practicing task organization, academic planning, and self-regulation strategies. Teachers are further encouraged to integrate creative instructional methods such as project-based learning, inquiry-based learning, and structured metacognitive activities into their lessons. Regular assessment of executive function skills is also advisable so that teachers can identify learners who need support and provide timely interventions. Schools, on their part, can advocate for and promote learning activities that cultivate working memory, cognitive flexibility, and inhibitory control as part of a broader effort to build a conducive learning environment where students can work independently and meet academic demands. Future researchers are likewise encouraged to investigate how advanced cognitive skills influence other areas of academic performance beyond science, and to explore additional variables such as student motivation, learning strategies, and classroom environment to better understand their interaction with executive function.

The second conclusion is that the level of mastery of science concepts among grade 10 learners was high. Students demonstrated a strong grasp of the fundamental ideas, theories, and processes covered in the scientific concepts assessed. A high level of science mastery indicated that learners were able to apply their scientific knowledge in various contexts, comprehend scientific ideas accurately, solve problems using scientific reasoning, use evidence to support scientific explanations, draw conclusions from research, evaluate information logically, and analyze scientific procedures and instructions. The high mastery level further reflected that learners were capable of engaging in higher scientific thinking and inquiry-based learning, moving beyond mere recall of knowledge to formulating hypotheses, conducting investigations, and interpreting data. Instructional materials, teaching strategies, and learning approaches used in science education played a key role in developing these competencies, as approaches such as audio-visual learning, hands-on experiments, real-world connections, integration of technology, and differentiated instruction supported learners in developing strong critical thinking, inquiry skills, and greater interest in science. It is therefore recommended that students continue to deepen their understanding by actively engaging in problem-solving and inquiry-based tasks, practicing the analysis and interpretation of data, and applying scientific reasoning to real-life situations. Teachers are encouraged to integrate varied tasks and activities that challenge learners to plan, analyze, and interpret data, and to make use of diverse educational resources that effectively facilitate science learning. Schools may further

provide enrichment activities such as science fairs, research projects, science clubs, laboratory experiments, STEM challenges, and science exhibits where students can apply their knowledge, use scientific reasoning, and develop critical thinking skills. Future researchers may also explore other factors that contribute to high science mastery, such as teaching strategies, learning environments, and student motivation, and may conduct studies focusing on intervention programs that further enhance scientific skills and critical thinking.

The third and final conclusion is that there was a significant relationship between executive function and mastery of science concepts among grade 10 learners ($r = 0.234$, $p = 0.007$), leading to the rejection of the null hypothesis. Executive function skills, specifically working memory, cognitive flexibility, and inhibitory control, were found to be fundamental in the learners' ability to analyze, comprehend, plan, and process knowledge scientifically. Since science is a cognitively demanding subject that requires deep comprehension, structured reasoning, evidence-based conclusions, and critical thinking, learners with strong executive function skills were more likely to master science concepts, grasp ideas effectively, and achieve their academic goals. The findings further suggested that students who can effectively regulate their emotions, recall information, and manage their impulses and behaviors are better equipped to understand complex topics in science, apply knowledge to real-world phenomena, and perform efficiently during instruction. It is therefore recommended that students practice strategies such as organizing tasks, managing time, and reflecting on their own learning processes to support their comprehension and application of scientific ideas. Teachers may consider incorporating inquiry-based learning, problem-solving tasks, and reflective activities within science instruction to enhance higher-order thinking and metacognitive skills. Schools may support these efforts by providing professional development opportunities related to executive function and its role in academic success, and by ensuring that adequate learning resources are available to help teachers integrate cognitive development strategies into their lessons. Future researchers are encouraged to further explore the relationship between executive function and mastery of science concepts across different grade levels, subject areas, and cultural contexts to provide broader comparative evidence, and to evaluate the effectiveness of specific intervention programs and instructional strategies designed to enhance executive function skills and improve learners' mastery of science concepts.

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