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METACOGNITIVE SKILLS AND ACADEMIC PERFORMANCE OF GRADE 12 STEM LEARNERS AT THE UNIVERSITY OF BAGUIO

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ABSTRACT

Metacognitive skills are higher-order skills that control cognitive or motivational methods in various learning situations. This study aims to increase metacognitive awareness among learners by examining metacognitive skills and their relationship to science and math performance and recommending strategies to help learners improve their learning outcomes. The main objective of this study is to see the correlation between metacognitive skills and the academic performance of grade12 STEM learners in their math and science subjects. Two major parts of the metacognitive awareness inventory administered are knowledge about cognition and regulation of cognition. A descriptive survey using quantitative and correlational research is applied, with 87 participants. The results show that procedural knowledge, conditional knowledge, and debugging strategies are the most prevalent metacognitive skills of the learners, while declarative knowledge and information management systems are the lowest. The other metacognitive skills, planning, comprehension monitoring, and evaluation, are considered high, where most of the learners scored greater than 80 percent. No significant relationship was found between learners' metacognitive awareness and their performances in General Biology 1, Earth Science, General Math, Statistics and Probability, and Basic Calculus. A significant weak positive correlation between the knowledge of cognition and General Biology 2 performance of the learners exists. In contrast, a weak negative correlation between the regulation of knowledge and the Pre-calculus grades of the learners does exist. Thus, even under the same discipline, the learners' metacognitive awareness does not affect most of their academic performance. The grade 12 STEM learners have applied metacognitive skills as reflected in their academic performance except in the case of General Biology 2 and Precalculus. Thus, developing metacognitive skills allows the teacher to assist the learner in improving performance as applying these strategies applies to a unique learning situation.

INTRODUCTION

The technological age has consistently been a complex and constantly changing scene requiring Science, Technology, Engineering, and Mathematics (STEM) abilities to effectively explore this quickly developing space. Recent events have just made innovation abilities more significant. Philippine schools are gradually recognizing the significance of STEM in advancing and driving the country's future economic growth. To expand the number of graduates who try out science and math-related courses at the tertiary level, the K-12 program provides senior high school learners a choice to pursue STEM-related fields through the academic track. To this end, significant activities are underway to boost student engagement in these subject areas, including teacher quality.

As a result of globalization, education is forced to embrace metacognition to produce successful teacher training, student learning, and content development strategies. Mariano et al. (2017) expressed those researchers and practitioners use metacognition to investigate the principles of educational systems, learning environments, open content, and all potential processes. On the other hand, upskilling and reskilling will be a global requirement in the next five years, according to the World Economic Forum, where creativity is one of the most crucial abilities. In response to this trend, the PISA 2022 study will be established to measure the degree of creative thinking skills among 15-year-olds. It will focus on a person's changeable ability to develop new ideas, tying creativity and problem-solving skills together. Metacognition is one component of learning where learners are empowered to plan and set goals while monitoring their progress. When confronted with challenges, learners should put on their thinking caps and analyze the tasks, evaluate their strengths and shortcomings, and devise a strategy for moving forward. They participate in creative thinking and allow their ideas to flow while seeking alternatives to their learning practices. They get more creative as they gain more freedom and encouragement (Malinic, 2021).

This inquiry started from observations in the classroom, where teachers were seen applying a range of thinking tools but not regularly encouraging learners to engage in metacognitive thinking to help them learn more effectively. When learners seem unable to discern between what they know and do not know in a specific academic topic, they are not engaging in advanced metacognition and are not evaluating their knowledge. During the development of cognitive skills, many different types of experiences and input are required. These include opportunities to gain new skills as well as opportunities to put those skills to use. Learners must be able to self-regulate their learning by recognizing which solutions to apply and when.

As STEM learners, how can they learn by reflecting on what they know and do? How can educators help learners think about their thinking? Metacognition determines learning performances up to 40%. Metacognition is essential to the learning process than intelligence, social-economical background, and motivation (Veenman, 2015). He added that training and instruction could develop and improve metacognitive skills. Adequate metacognitive instruction and training enhance metacognitive skills and better learning performances (Veenman, 2013). A STEM approach necessitates a more student-centered teaching strategy because it does not merely teach learners about a particular curriculum area. Learners learn not by reading new material or listening to a teacher lecture but by exploring a complex real-world issue and discovering a solution.

Teachers must determine which skills must be taught and how they should be taught. However, participants in the study of Zohar and Lustov (2018) regard teachers' shaky understanding of metacognition as a barrier to their capacity to teach metacognition, even when they utilize learning materials that are expressly meant to teach metacognition and are quite straightforward. It's not always simple to break free from the constraints of traditional teaching methods. Educators can focus on teaching lessons rather than individual student thought processes by educating learners to think differently and recognize the reasons for their thoughts. Because metacognition is a crucial 21st-century talent, this strategy will help learners excel in your classroom and beyond.

Another topic of debate has been the intricate relationship between cognition and metacognition, which continues to perplex academics because it is difficult to discern between the two constructs because they rely on, influence, and share processes (Winne 2018). This illustrates the conundrum of a higher-order agent overseeing and directing the cognitive system yet being a part of it.

Exploring cognition further, Schraw et al. (2006) identified cognitive methods, problem-solving tactics, and critical thinking skills as part of cognition. Task-specific cognitive strategies (Weinstein et al. 2000) are conducive to rehearsing, organizing, and elaborating knowledge. They directly target specific types of information processing that must suit a given learning task. Donker et al. (2014) gave this example; a student will read a nonfiction text to grasp the topic as thoroughly as feasible. Text highlighting is one effective cognitive method for starting this activity, as it immediately addresses the type of information processing required, which is picking relevant information.

Metacognition refers to higher-order thinking, which involves active control over the cognitive process when learning. For example, planning, approaching a given learning task, and evaluating progress towards completing a task are metacognitive in nature. Metacognition assumes a huge part in successful learning, so it is imperative to develop metacognition skills and apply them academically and socially (Hashmi et al., 2019). Flavell introduced in 1979 two aspects of metacognition which are reflection and self-regulation. Reflection is thinking about what we know, and self-regulation is managing how we go about learning. Learners can use metacognition to gain control over their own cognitive and motivational processes. According to Schraw et al. (2006), Metacognition is made up of two parts: metacognitive knowledge and metacognitive skills. The former contains declarative information about oneself as a learner, procedural strategies, and why and when to adopt a particular method in a given learning situation.

Metacognitive skills, also known as metacognitive strategies, are divided into three categories: planning, monitoring, and evaluating (Schuster et al., 2019). These abilities are higher-order strategies since they may be utilized to control cognitive or motivational methods in various learning situations. These abilities, which do not directly address information processing or motivational issues, ensure that learners use high-quality cognitive or motivational regulation mechanisms (Leopold & Leutner 2015).

Green (2021) mentioned that the best part about metacognitive skills is that they apply to everyone. They can be used in practically any subject, course, or situation when new information is required. He further added that metacognition is the practice of actively and consciously weighing the best possibilities for a given activity. What works in one context might not work in another. As a result, the greater the number of metacognitive skills learners may acquire, the better. The first step is to emphasize the importance of understanding and employing metacognitive skills. The second phase gives learners various metacognitive abilities to acquire and add to their toolbox of choices. He also enumerated planning, mental scripting, positive self-talk, self-questioning, self-monitoring, and various other learning and study practices, which are metacognitive skills.

Meanwhile, Kaur et al. (2018) indicated that if metacognitive skills and self-regulation approaches are promoted in individuals, they start to consider their own learning all the more unequivocally. Therefore, these learning-to-learn approaches, along with improved perceptions of one's own learning environment, can be helpful for low achieving learners, who could become skillful in managing their learning autonomously. Therefore, it is proposed that schools establish a metacognitive and supportive environment for the learners and focus on instilling self-regulatory skills. These interventions can assist learners with dealing with their motivation towards learning, improving their critical thinking skills and problem-solving abilities, and enhancing their academic performance.

The challenge for teachers is to utilize metacognitive strategies that will help learners become more efficient in finding information, evaluating resources, and understanding when to apply different approaches to problems. Improving student learning outcomes necessitates the use of metacognitive methods. Knowledge of cognition, or understanding one's own learning style, and cognition regulation, or how one applies what he has learned, go hand in hand. These cognitive ideas assist people in solving difficulties by helping them analyze information and apply it thoroughly. They can rearrange and improve their learning tactics by being conscious of their own learning process. They can mix and improve their learning methods. Not only does metacognition assist learners in understanding their mental strengths and shortcomings, but it also helps them become aware of anxiety and motivational variables that prevent them from learning correctly (Mariano et al., 2017). Furthermore, learners might benefit from metacognitive knowledge as they react to the changing situational demands of a specific learning assignment, directly addressing information processing.

Literature Review

Early ideas about metacognition involved John Dewey, the father of progressive education, who identified reflection as a focal piece of active learning. Piaget and Vygotsky, on the other hand, described the role of metacognition in cognitive development. Albeit, the idea of metacognition is currently utilized and examined in different fields of psychology and education.

The preliminary investigations on metacognition were formative in nature and started in the mid1970s by Ann Brown, John Flavell, and their colleagues (Shneider, 2015). To differentiate, cognitive skills are those necessary to perform a task, whereas metacognitive skills are needed to understand how it was performed. Metacognition refers to higher-order thinking, which involves active control over the cognitive processes engaged in learning. Psychologist John Flavell introduced the word metacognition which was commonly used in the 1970s. He described three kinds of metacognitive knowledge: 1) awareness of knowledge, 2) awareness of thinking, and 3) awareness of thinking strategies. On the other hand,

Metacognitive regulation is the ability to manage one's own thinking processes. Metacognition is considered necessary due to its effects on acquisition, comprehension, retaining and recalling the learning material, learning efficiency, critical thinking, and problem-solving.

The investigation of metacognition has allowed educational psychologists to understand the cognitive processes involved when learning and distinguish successful learners from their less successful peers. As learners become skillful at using metacognitive strategies, they become more independent and gain confidence. They become independent, pursue their own intellectual needs, and discover a universe of data readily available as they own their learning. In this rapidly evolving world, the challenge of teaching is to provide learners opportunities to develop lifelong skills which will enable learners to successfully cope with new situations (Chauhan & Singh, 2014).

Regarding specific subject areas, these are some studies relating to metacognition. Owo & Ikwut (2015) elaborated that learners' metacognition and attitude are important in improving academic achievement and learning in chemistry. Thus, parents, teachers, curriculum designers, and school heads should consider these factors as significant correlates of scholastic achievement and strive to develop them in learners. Di Camillo and Dawson's (2020) study using metacognitive strategies to support the application of mathematics skills of year 11 physics learners appeared to have more confidence in solving problems when they elicited a range of metacognitive strategies to support them and followed a structured approach. Results suggest that metacognitive instruction infused with active learning significantly affects student performance in General Chemistry, particularly on cognitively demanding chemistry concepts (Mulambuki et al., 2020). In 2018, Yen and colleagues studied 55 studies in 47 articles published from 1990 to 2016 investigating the effects of metacognition on science reading. They revealed that an e-based environment has the potential to support comprehensive and complicated measurement of metacognition. Their analysis revealed frequently applied methods such as self-report questionnaires for measuring metacognitive knowledge, event-based assessment for metacognitive skills, and questionnaires or interviews for metacognitive experiences. In another study on the analysis of the relationship between mathematics achievement, reflective thinking of problem-solving and metacognitive awareness (Toraman et al., 2020), it was determined that there was a strong positive significant correlation between learners' math achievement and reflective thinking towards problem-solving and metacognitive awareness. It was also determined that there was a strong positive significant correlation between reflective thinking towards problem-solving and metacognitive awareness.

In 2019, Hashmi, Khalid, and Shoaib's study suggested that teacher educators adopt a teaching methodology that encourages metacognitive skills. In addition, assessments should provide practices for using such skills. On the other hand, policymakers may include metacognitive courses in teacher training programs for prospective teachers. Research shows that academic achievement and future teaching performance are empirically associated. Therefore, the Metacognitive Awareness Inventory (MAI) may be utilized to predict prospective teachers' performance as long as it is administered at entry-level in teacher education institutions.
With this, instructors are equipped with a solid and reliable tool to anticipate learners' low performance and remedy. Finally, future research may use experimentation to examine practical prospective learners' metacognitive skills that link to academic achievement.

Theoretical/Conceptual Framework

Emphasizing STEM education as a roadmap to innovation and the country's progress, the K to 12 Curriculum Guide for Science and Mathematics subjects is valuable for teachers planning their lessons. The core learning area standard in science states that the learners understand basic science concepts and apply science-inquiry skills. In addition, they exhibit scientific attitudes and values to solve problems critically, innovate beneficial products, protect the environment, conserve resources, enhance the integrity and wellness of people, make informed decisions, and engage in discussions of relevant issues that involve science, technology, and technology and environment. Similarly, the learning area standard in mathematics indicates that the learner demonstrates understanding and appreciation of key concepts and principles of mathematics as applied - using appropriate technology - in problem-solving, critical thinking, communicating, reasoning, making connections, representations, and decisions in real life (DepEd Resources, 2018).

Depending on the COVID-19 constraints and the individual context of the learners in the school or community, schools may use one or a mix of the following learning delivery modalities prescribed by DepEd, such as modular and online distance learning, blended learning, homeschooling, and other alternative delivery modes. However, a gap exists in studies involving learning modalities and metacognitive skills or awareness.

Meanwhile, Drew (2019) explored the metacognitive theory and explained that it is a theory of knowledge keen on actively monitoring and regulating their own thought processes. Flavell proposed in 1979 the four different classes of metacognition which acts as a framework for thinking about the theory: 1) Metacognitive knowledge is a person's beliefs or awareness about how they can affect their own cognition; 2) Metacognitive experiences are a person's own subjective application of their thinking to achieve tasks; 3) Tasks or goals are the outcomes you want to achieve when thinking about your own thinking; 4) Strategies or activities are those that you use to achieve your cognitive goals such as self-questioning, meditation, reflection, awareness of strengths and weaknesses, awareness of learning styles, use of mnemonic aids, and study skills.

Other theoretical links to the metacognitive theory that are closely connected to cognitive and social constructivist learning theories are 1) Vygotsky's Sociocultural theory, where children learn by talking through issues in their minds; 2) Piaget's Cognitive theory proposes that learning develops in stages and children develop cognitive strategies as they move through the stages. In higher stages, children use meta-thinking strategies to achieve abstract thought and reach conclusions on different topics; and 3) Jonassen's Cognitive tools theory argues that computers as cognitive tools can assist learners in pondering their reasoning and achieving higher-order cognition.

The Metacognitive Awareness Inventory (MAI) survey and scoring guide are attributed to Schraw and Dennison (1994). It is subdivided into two major components – knowledge about cognition and regulation of cognition. Subcomponents of knowledge about cognition include declarative, procedural, and conditional knowledge. The regulation of cognition includes planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation.

Breaking down further declarative knowledge refers to the learner's factual knowledge required before learners can process or apply critical thinking to the topic. There is awareness of one's talents, intellectual resources, and abilities as a learner. Presentations, demonstrations, and discussions are all ways for learners to gain knowledge. Items 5, 10, 12, 16, 17, 20, 32, & 46 are the survey statements that correspond to declarative knowledge. On the other hand, procedural knowledge is the knowledge that is put to use to complete a task or process. Understanding how to put learning techniques into action (e.g., strategies). Learners must understand the procedure and when to apply it in different scenarios. Learners can learn by doing research, cooperating with others, and solving problems. Items 3, 14, 27, & 33 falls under procedural knowledge. Conditional knowledge means determining when and how specific procedures or abilities should be transferred—understanding when and why to employ learning techniques. When certain situations are presented, declarative and procedural knowledge is applied. Learners can also gain knowledge through simulating situations. Items 15, 18, 26, 29, & 35 are the statements that are classified as conditional knowledge.

In the sub-category of regulation of cognition, specifically planning, learners should plan, create goals, and allocate resources to regulate cognition before learning. Items categorized under planning are #s 4, 6, 8, 22, 23, 42, & 45. As for information management strategies, the skills and strategy sequences are employed for more practical information processing (e.g., organizing, elaborating, summarizing, selective focusing). Items are 9, 13, 30, 31, 37, 39, 41, 43, 47, & 48. Regarding comprehension monitoring, where there is an evaluation of one's learning or strategy application, include items 1. 2. 11. 21. 28. 34. & 49. In debugging strategies where the methods for resolving comprehension and performance issues are applied are found in statements 25, 40, 44, 51, & 52. In the evaluation aspect of the regulation of cognition, where after a learning experience, one's performance and strategy effectiveness are evaluated is identified in statements 7, 19, 24, 36, 38, & 50.

Significance of the Study

Being aware of how you think is known as metacognitive awareness. Metacognition is the ability to recognize one's own thoughts and strategies. It helps learners be more aware of what they're doing, why they're doing it, and how their acquiring abilities might be applied differently in different settings. Furthermore, learners can be more aware of their own control over their success at tasks. They may also adjust their thinking strategies as they go about their tasks to ensure optimum outcomes. When learners "think about their thinking," they are more capable of self-improvement. Metacognitive strategies can be learned, practiced, and made into habits to improve future learning, studying, and thinking skills. The justification for focusing on metacognition as a particular pedagogical practice is due to various investigations that make solid cases that when learners are viably shown metacognitive skills, they will generally gain better progress than children who are not taught such skills (Perry et al., 2018).

When a student has knowledge of his own thinking, he can utilize that knowledge to direct or manage his learning. "Executive control" is another term for this type of metacognition. When it comes to learning, successful learners frequently employ metacognitive tactics. They may, however, fail to employ the most appropriate method for each sort of learning environment. Each learner can use the following metacognitive skills presented by Jaleel & Premachandran (2016): 1) knowing the limits of one's own memory for a specific activity and putting in place a backup plan; 2) self-monitoring one's learning technique, such as idea mapping, and then modifying it if it isn't working; 3) determining whether or not one understands what one has just read and, if not, altering one's approach; 4) skimming through unnecessary subheadings to get at the information needed; 5) rehearsing a skill many times to master it, and 6) taking self-tests to check how well you've learned something regularly.

Learners rarely know what they're doing when they're doing it, but it isn't easy to enhance a process if they don't know what they're doing right now. If one of the goals of education is to prepare learners to be lifelong learners, it is critical to assist learners in being aware of themselves as learners and taking charge of their own actions. Most learners spontaneously pick up metacognitive knowledge and skills from their parents, peers, and especially their educators to some level. Learners' metacognitive ability, on the other hand, varies greatly. When learners develop metacognitive skills, they typically demonstrate a gain in self-confidence.

Given the importance of metacognitive skills in learning, teachers need to understand how metacognition may be developed as a culture in the classroom. Teachers should be able to promote metacognitive instruction in the school context. Identifying the strengths and weaknesses of the Grade 12 STEM learners of UB will help the teachers select an appropriate strategy according to the problems faced and monitor the learning progress and correct any mistakes that occur during concept understanding and analyze the effectiveness of the chosen strategy. Subject teachers, subject heads, and their immediate heads may then put their heads together during their professional learning community (PLC) meetings and suggest activities/ strategies/ techniques/ assessments that may cater to the student body's learning needs with the goal of developing metacognitive skills and hope that they turn out to be lifelong learners.

Objectives of the Study

This study aims to identify the correlation between metacognitive skills and academic performance of Grade 12 Science, Technology, Engineering, and Mathematics (STEM) learners at the University of Baguio. Specifically, it seeks to answer the following problems:

1. What metacognitive skills are prevalent among Grade 12 STEM learners of UB?
2. Is there a significant relationship between the metacognitive awareness and the academic performance of Grade 12 STEM learners of UB in the different subjects:
    a. General Biology (SPGBIO1 and SPGBIO2)
    b. Earth Science (CORSCI1)
    c. General Mathematics (CORMAT1 & CORMAT2)
    d. Pre- and Basic Calculus (SPCALC1 & SPCALC2)
3. What metacognitive teaching-learning strategies are recommended for Grade 12 STEM learners?

METHODOLOGY

The following section explores details of the proposed study design, sample population, data gathering tools, and procedures with the corresponding treatment of data, including ethical considerations in doing this study.

Study Design

This study is of quantitative design. Specifically, descriptive research utilizes descriptive statistics to summarize and interpret the metacognitive awareness inventory of the learners. In addition, since the MAI relationship and the student's GPA were taken, this study is also correlational research.

Sample/Population of the Study

The participants in the study are the officially enrolled grade 12 STEM learners for the first semester of the academic year 2021-2022. As of August 30, 2021, the enrollment data include 379 learners of the University of Baguio High School (UBHS) and 130 learners of the University of Baguio Science High School (UBSHS). A total of 509 respondents. However, 87 learners participated in this study.

Data Gathering Tools

Measures were obtained from a self-administered Metacognitive Awareness Inventory (MAI) form. The inventory has been widely used in different languages assessing metacognitive knowledge and skills developed by Schraw and Dennison (1994). Up till now, the tool has been translated into various languages and validated. This inventory comprises the "Knowledge of cognition" scale and the "Regulation of cognition" scale. The first scale measures declarative, procedural, and conditional knowledge, while the second measures knowledge about planning, implementing, monitoring, and evaluating strategy use. The instrument consisted of 52 statements assessed on a yes or no categorical measure. The participants were asked to answer the items of MAI, taking into account their learning experiences. Academic performance will be measured using the learners' grade point average (GPA) in the Math & Science subjects during Grade 11, specifically General Biology, Earth Science, General Mathematics, and Pre-and Basic Calculus.

Many versions of the English MAI were translated into different languages and were repeatedly tested for their validity and reliability. One Turkish study identified that the internal consistency of the entire inventory was 0.95. The item-total correlations ranged from 0.35 to 0.65, and the test-retest reliability coefficient was 0.95. According to these findings, the MAI is a valid and reliable instrument that can be used in education (Akin et al., 2007). Another Indonesian MAI complies with construct validity criteria, content validity, and internal consistency. Therefore, MAI is useful for assessing metacognitive ability in the academic stage of undergraduate medical education, according to Soemantri & Abdullah (2018). Another proof of its use is the research whose aim was to translate, adapt and validate Junior Metacognitive Awareness Inventory for its use in Brazil. The validity evidence of the translated and adapted version of the instrument was found, suggesting its adequacy for evaluating metacognition in Brazilian adolescents (Teotonio et al., 2019). Assessing through a self-report scale is one of the limits of this research.

Data Gathering Procedures

A letter addressed to the school principals asking permission to conduct research and administer a survey to their first semester

Grade 12 STEM learners was submitted before scheduling with the respondent's research teacher or adviser. The learners were given an assent form for their parents to sign a consent form if they agreed. For 18 years and older learners, the consent was asked at the beginning of the created google forms. The survey forms' link was sent to the research teacher or adviser to share with their respective learners during their classes via google classroom. The researchers explained the purpose and why their participation is important during these classes. The researchers then requested the learners to click the google forms link shared with them via their subject's google classroom. They were guided throughout, answering clarifications during the process. Those who did not consent were not required to answer the survey and continue with their subject requirement quietly. The online survey forms remained open if the respondents could not participate during the assigned schedule but gave their consent just the same.

Treatment of Data

In this study, the researchers utilized descriptive statistics in summarizing and presenting the data. A descriptive analysis was done to see the prevalent metacognitive skills of the grade 12 learners. Specifically, percentage was used to convert the raw scores of the respondents in the different metacognitive skills, then median and mean were used to summarize the scores of the metacognitive skills of the respondents. As for the interpretation of the metacognitive scores, the higher score yields to having the skill while the lower tends not to have the skill. Since the data for the metacognitive awareness inventory of the learners are categorical and discrete in nature, a non-parametric test, the Spearman rank correlation, was utilized to see if there is a significant relationship between the learners' metacognitive skills and their academic performance in the subjects exists. The table below was used to interpret the computed correlation coefficient.

Table 1
Interpretation of the computed correlation coefficient

Range	Interpretation
0	No correlation
0.01 – 0.19	Very weak correlation
0.20 – 0.39	Weak correlation
0.40 – 0.59	Moderate correlation
0.60 – 0.79	Strong correlation

A t-test was used to test the significance of the computed correlation coefficient. The said tests utilized a 0.05 level of significance for all the subjects. A path analysis was then done to see the percent of variability of the academic performance as affected by their metacognitive skills.

Ethical Considerations

A preliminary request in the Google forms was made to gather information essential for the study to acquire voluntary informed consent. They then proceed to complete the survey if they agree. They were not required to complete the survey if they chose not to. Added to the consent forms is their permission to gather their previous academic performance or grades in Math and Science required for the study. If the learners agreed, their grades were requested and confirmed by their separate Principal's offices. Before the survey results are used and the study's findings are disseminated, their approval was sought as well in the same Google forms before they click submit.

Participating in the study has only minor risks and inconveniences, such as discomfort due to exposure to their computer screens when answering the online survey and time spent taken from their classes. Participation in the study is entirely voluntary. The respondents may choose not to participate, withdraw at any time without incurring any penalties, not have their grades affected, or be treated unfairly. All learner responses will be confidential. All information gathered will only be used in this study and will not be divulged to others without the respondent's permission in ways inconsistent with the initial disclosure's understanding.

The following measures were taken to minimize these risks and inconveniences: The questions were clarified when participants wanted more information while doing the survey. Participants could respond to the survey via Google Forms even beyond the adviser's or research teacher's schedule. Their responses will remain secure, and any personal information obtained will be viewed only by the researchers undertaking the study. The findings of this study may be included in reports, presentations, or publications, but the participants' names will not be mentioned. Only the aggregated results will be provided. In addition, the data was stored on a password-protected computer that only the researchers will have access to. The data is kept for three years after the project is over and properly disposed of, the digital files wiped, and the paper records shredded.

Exposure to some research procedures that may aid them in their research subjects is one of the advantages of participating in this study. The grade 12 STEM learners participating in this study may not see any immediate benefits. Still, it will help researchers figure out what learners need to promote metacognitive awareness in Science and Mathematics classes and contribute to educational research.

Suppose the participants have questions about the study or want to be informed of the results. In that case, the researcher's office phone number and email will be provided, and a copy of their responses will be sent back to them as proof of their participation should they wish to have a copy. Finally, the study's outcomes may be published in the University research journal or, if applicable, presented in In-Service Training (InSeT) proceedings.

RESULTS AND DISCUSSION

This section presents the different tests, analyses, interpretations, generalizations, and discussions about the gathered data results. Descriptive and inferential statistics were utilized in the presentation, organization, and data analysis. Also, implications are presented to support the said results of the study.

Prevalent Metacognitive Skills among grade 12 STEM learners of UB

The learners' metacognitive awareness is subdivided into two main categories: knowledge of cognition and regulation of cognition. Knowledge of cognition corresponds to what learners know about themselves, strategies, and conditions under which strategies are most useful. In contrast, regulation of cognition corresponds to knowledge about how learners plan, implement strategies, monitor, correct comprehension errors, and evaluate their learning. Under these two categories are the metacognitive skills.

Table 2 shows the prevalent metacognitive skills of grade 12 STEM learners of the University of Baguio. The table shows both the mean and median of the learners' scores under each category and each skill. For the knowledge of cognition of learners, it can be seen that the median of both procedural and conditional knowledge is 100. This means that more than or equal to 50% of the learners have a 100 score on these skills. Having a 100 score means that all the stated indicators for the said skills are true for all the learners. Since Schraw and Dennison did not provide any level of interpretation for the scores, the researchers can only establish that the grade 12 STEM learners are seen to be having the skills in the application of knowledge to complete a procedure or process about how to implement learning procedures, knowing the process as well as when to apply the process in various situations, and can obtain knowledge through discovery, cooperative learning, and problem-solving. This is not surprising since UB Science high school (UBSHS) and UB high school (UBHS) adopt learning phases where learners have time to do explore activities and then use the acquired knowledge to understand the firm-up and deepen part of the lesson.

Also, the learners have knowledge in determining under what circumstances specific processes or skills should transfer, when and why to use learning procedures, application of declarative and procedural knowledge with certain conditions presented, and can obtain knowledge through simulation. This again is supported by the phases of learning of the UBSHS and UBHS. After the deepen part of the lesson and some guided generalization, the “transfer” takes place where the competencies acquired by the learners are to be used appropriately in real-life scenarios. Thus, the determination of necessary skills or procedures to be done is needed and carefully selected by the learners. Also, the performance tasks given to learners are considered a simulation since they are to put themselves in the role of a certain profession, making the application of declarative and procedural knowledge more meaningful.

As for the declarative knowledge of the learners, it is seen that the median is 75, which implies that more than 50% of the learners have scores of 75 or more. With this, it can still be said that learners have incomparable skills in procedural and conditional knowledge. Thus, learners can be said to have factual knowledge the learner needs before being able to process or use critical thinking related to the topic, knowledge of one’s skills, intellectual resources, and abilities as a learner, and can obtain knowledge through presentations, demonstrations, discussions. This scenario might be supported by the understanding that the phases of learning are geared more towards developing the critical thinking skills of the learners than factual knowledge. This can also be seen in the quarterly assessments, where 10% to 20% of the items are allotted only in addressing the learners' factual knowledge, which is associated with declarative knowledge.

Table 2
Prevalent Metacognitive Skills of Grade 12 STEM learners of UB

Category	Skills	Median Score %	Mean
Knowledge of Cognition	Declarative Knowledge	75	70.11
	Procedural Knowledge	100	83.91
	Conditional Knowledge	100	85.75
Regulation of Cognition	Planning	85.71	76.31
	Information Management Strategies	80	78.85
	Comprehension Monitoring	85.71	77.01
	Debugging Strategies	100	93.79
	Evaluation	83.33	69.35

Under the regulation of cognition, the debugging strategies of learners are the most prevalent metacognitive awareness skill, with a very high median and mean. With this, most of the learners can be seen to have the skills in strategizing to correct comprehension and performance errors. This might be an effect of introducing formative assessments before giving the summative assessments. Thus, the learners learn about their mistakes and how to address or correct them before having the summative assessments. The learners then gain the skills in identifying errors and are adopted in any situation. As for the other skills, it can be seen that the medians are at least 80, which means that half of the learners’ scores are more than 80. With this, it can still be said that learners have these skills. Thus, learners can be seen to have good planning, goal setting, and allocating resources prior to learning, skills and strategy sequences used to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing), assessment of one’s learning or strategy use, and analysis of performance and strategy effectiveness after a learning episode.

Significant relationship between the metacognitive skills and the academic performance of Grade 12 STEM learners of UB in the different subjects

Table 3 shows the relationship between the metacognitive awareness inventory scores and the different academic subject grades of learners from grade 12 STEM of the University of Baguio. The two major areas of metacognitive awareness, knowledge of cognition and regulation of cognition, were considered. Most of the correlation coefficients can be seen to be very weak or weak. Still, most of the computed correlation coefficients are also said to be not significant. With this, most of the subject performance of the learners can be said to have no significant relationship with their metacognitive awareness. This contrasts with Toraman et al.'s (2020) study, where a strong correlation was found between learners' metacognitive awareness and mathematics achievement. The biggest factor in these findings can be seen in the difference in learning modality. Toraman et al. (2020) study was done in a face-to-face scenario, while the present study was done during online distance learning. Since online learning was just implemented because of the pandemic last March 2020, it is natural that the learning and teaching were greatly affected. The transition from a face-to-face setting to an online modality was not planned properly due to a lack of time and resources. Teachers’ teaching strategies and learners’ learning strategies need to adapt also with the new modality, making it a new experience for both teachers and learners. Thus, effective teaching strategies, assessments of academic performances, learning styles, and pedagogies during a face-to-face may not be effective in online learning. With this, the learning modality may affect the learners’ performance more than their metacognitive awareness.

However, in the study of Kaur et al. (2018) using regression analysis, only the declarative knowledge and knowledge about cognition have a significant effect on the academic achievement of adolescents. This supports the findings of the present study that most of the academic performances of the grade 12 STEM learners are not affected by their metacognitive awareness.

Table 3

Spearman’s Rank Correlation Test on the relationship between metacognitive skills and the academic performance of Grade 12 STEM learners of UB

Metacognitive Skills	Subject	Correlation Coefficient	Descriptive Equivalent	p-value	Interpretation
Knowledge of Cognition	SPGBIO1	0.17	Very Weak	0.178	Not Significant
	SPGBIO2	0.25	Weak	0.045	Significant
	Earth Science	0.07	Very Weak	0.504	Not Significant
	General Math	-0.04	Very Weak	0.744	Not Significant
	Statistics and Probability	0.17	Very Weak	0.123	Not Significant
	Pre-calculus	0.00	No Correlation	0.997	Not Significant
	Basic Calculus	0.23	Weak	0.070	Not Significant
Regulation of Cognition	SPGBIO1	0.05	Very Weak	0.706	Not Significant
	SPGBIO2	0.21	Weak	0.098	Not Significant
	Earth Science	0.05	Very Weak	0.667	Not Significant
	General Math	0.05	Very Weak	0.620	Not Significant
	Statistics and Probability	0.14	Very Weak	0.211	Not Significant
	Pre-calculus	-0.27	Weak	0.03	Significant
	Basic Calculus	0.05	Very Weak	0.672	Not Significant
Metacognitive Skills	SPGBIO1	0.10	Very Weak	0.428	Not Significant
	SPGBIO2	0.23	Weak	0.068	Not Significant
	Earth Science	0.06	Very Weak	0.563	Not Significant
	General Math	0.02	Very Weak	0.887	Not Significant
	Statistics and Probability	0.16	Very Weak	0.132	Not Significant
	Pre-calculus	-0.19	Very Weak	0.127	Not Significant
	Basic Calculus	0.12	Very Weak	0.356	Not Significant

The only significant relationship can be seen between the knowledge of cognition and SPGBIO2 grades of learners and between the regulation of cognition and their Pre-calculus grades. The learners' metacognitive skills have a very weak positive relationship with their SPGBIO2 grade. This implies that higher metacognitive skills tend to result in a higher grade in the said subject. This is logical since the subject SPGBIO2 is dependent on the learners' declarative, procedural, and conditional knowledge skills. The metacognitive ability of learners affected the learners' cognitive thinking ability. One of the factors is implementing lesson learning methods like a lecture that is less empowering the student's metacognitive ability, according to Erlin and Fitriani (2019). In addition, teacher feedback can positively increase learners' ability to self-monitor and generate internal feedback. Another recommendation from Mynlieff et al. (2014) is that one of the elements that lead to learners' future academic accomplishment is their usage of metacognitive awareness reading strategies while reading academic content. Siegesmund (2016) also explained that self-assessment in the classroom would assist learners in developing a regular self, lifelong learning, and independence in the face of diverse challenges.

It is uncommon that the regulation of cognition has a weak negative correlation with their Pre-calculus performance. It implies that lower metacognitive skills tend to higher academic performance in this subject. This scenario is unusual since Toraman et al. (2020) found that the learners' metacognitive awareness has a strong positive correlation with their mathematics achievement. In the same study, the learner's metacognitive awareness has a very strong positive correlation with their reflective thinking towards problem-solving, which is necessary for a good performance in any math subject.

To summarize the given significant relationships between the metacognitive skills and the academic performance and to present the percent of variability of the learners' academic performance as affected by the metacognitive skills, figure 1 shows the model.

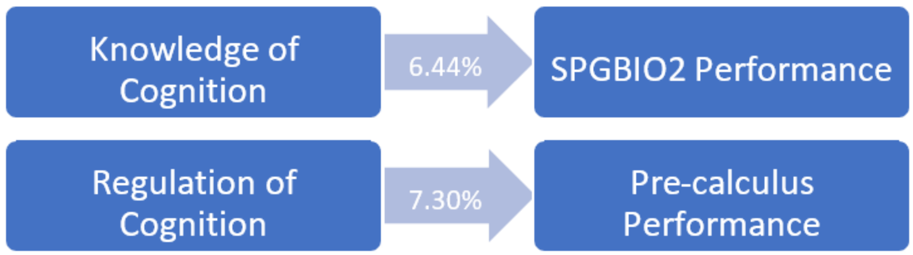

Figure 1. Metacognitive skills and subject performance model

Figure 1 reveals that the knowledge of cognition of learners affects 6.44% of the variability of their SPGBIO2 performance. Also, the regulation of cognition of the learners affects 7.30% of their Pre-calculus performance.

Metacognitive Teaching-Learning Strategies

Teaching metacognitive skills to all learners in all subject areas can considerably improve their learning. This offers suggestions to help school administrators and teachers integrate metacognitive concepts into their daily lessons. It also gives examples of how schools might use metacognitive strategies to help learners develop self-regulation and a strong feeling of autonomy in their learning.

The following metacognitive strategies from different sources are suggested for use in various teaching-learning areas:

Education and Endowment Foundation (2021) recommends the seven metacognition and self-regulated learning. It includes the seven-step model of metacognition, where scaffolding is shifted from the teacher to the learner. Also, a seven-step model-planning worksheet is added as a guide, including an independent sample behavior, teacher assessment, and the four metacognitive learner template levels. All of which can be found in the appendices. It provided a sample that may be used to develop metacognitive skills in learners.

Some of the most common strategies used in everyday teaching to foster the learning and internalization of metacognitive strategies recommended by Education State Victoria are:

1. Explicit instruction focuses on activating past information, introducing new knowledge and abilities, modeling the application of knowledge and skills, and offering adequate opportunities for autonomous practice and reflection.

2. Assisting learners in the planning, monitoring, and evaluating of their work/learning. Learners will eventually internalize these approaches and use them to take charge of their own learning if level-appropriate skills are explicitly taught and work is structured around these phases.

3. Creating rubrics (and, if possible, co-designing them with learners) to help learners keep track of their own progress and set personal learning goals that are specific, measurable, achievable, realistic, and timely (SMART).

4. Model thinking by verbalizing the intellectual processes used to consider, analyze, and solve problems. It could be as simple as 'thinking out loud.

5. By utilizing questions to engage learners, assess their progress, stimulate their thinking and recognize student inquiries as a form of feedback and an opportunity for clarification/extension of learning, questioning is a powerful tool.

To add, Du Toit et al. (2009) investigated how much metacognitive strategies are used by math learners and teachers in the classroom. Twelve of the thirteen metacognitive approaches described were used to compile the survey data: planning strategy, generating questions, choosing consciously, setting and pursuing goals, evaluating the way of thinking and acting, identifying the difficulty, paraphrasing, elaborating and reflecting ideas, clarifying terminology, problem-solving activities, thinking aloud, journal-keeping, cooperative learning, and modeling. The study's findings demonstrated that learners used the most evaluating ways of thinking and action, preparing solutions, deliberately deciding, and acknowledging the challenge. Cooperative learning, thinking aloud, and journaling, on the other hand, were used to the greatest extent possible. Du Toit (2009) stated that learners looked to be well-organized and aware of their strengths and shortcomings, despite the need to be encouraged to orally express their opinions in a group context to explain the disparities in performance.

Another study by Parlan et al. (2018) where they conducted an experiment to assess the scientific explanation quality of prospective chemistry teachers. Expository learning was used to teach the first set of 62 learners in a chemistry education program, while metacognitive strategies were used to teach the experimental class. The following strategies were used in the training sessions:

1. Preparation: Examine your skills to teach. Establish a learning goal, select a learning technique, and plan a study timetable. Finally, develop a question list based on the important goals, relevant prior knowledge, and topics comprehended.
2. Doing: Engage in the learning activity
3. Checking: Monitor the planning, evaluate the learning, analyze the method's effectiveness, and reflect on the learning process.
4. Assessing and following-up: Provide feedback and monitor the learning outcome.

Furthermore, Kisac et al. (2014) investigated the relationship between metacognitive methods and levels of learning self-confidence. Four hundred university learners from various schools and departments were given the Managing Metacognition Inventory. The findings revealed that note-taking, summarizing, outlining, and reflecting were the most popular strategies while reciting and reviewing were averages, showing that learners prefer less recalling and repeating. Metacognitive strategies were also found to be associated with higher levels of self-confidence. The research looked at three key skills (planning, monitoring, and evaluation) as well as the following metacognitive strategies:

1. Note-taking: Before deciding what to write, write down the important points.
2. Summarizing: Make concise statements that summarize the essential points.
3. Outlining the material's essential points in a hierarchical style.
4. Reflecting: Relate prior knowledge to current facts.
5. Reciting: State points out loud, asking and answering questions.
6. Reviewing: Self-examination and repetition of learning

Another study by Heidari et al. (2016) where they conducted an experiment to assess the impact of learning cognitive and metacognitive strategies on nursing learners' academic performance. The study included 40 nursing learners who were split into two groups: control and experimental. The last group received ten sessions of cognitive and metacognitive learning techniques training. A pre-test, post-test, and follow-up academic achievement test were done after the course. The study found that the instruction of metacognitive learning strategies significantly improved academic achievement. The learners were taught the following metacognitive methods (skills for monitoring, guiding, and adjusting cognitive strategies as needed) after the sixth session:

1. Planning: Determine the study's goal. Estimate how much time the study will take. Determine the study speed and choose a cognitive strategy.
2. Control and Monitoring: Evaluate the study's progress. Track the learning and attention.
3. Pose self-questions when studying, keep track of time and speed, and anticipate exam questions.
4. Regulation: Adjust the study speed and duration. Modify or change the study strategy.

A 2019 Global Metacognition Institute's metacognition worksheet collection contains a wide range of metacognitive reflection worksheets that teachers can use in conjunction with MAI's collection of over 30 worksheets, giving learners plenty of choice throughout the academic year.

The classification of metacognitive strategies presented differs based on the definitions used and the various associations and connotations associated with different study topics. Despite extensive research efforts on metacognition and related learning processes, there are still fundamental issues concerning their precise structure, functions in learning self-knowledge, and relationship to academic performance. The list provided in this study may be used as a guide to developing metacognitive skills to improve the academic performance of grade 12 STEM learners at UB.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The scope of the current study was on metacognitive skills and academic performance of grade 12 STEM learners in UB. Based on the findings, most learners need help developing their declarative knowledge and information management strategies. For declarative knowledge, this might be the effect of focusing too much on learners' critical thinking skills and too little emphasis on building the foundation of factual knowledge they need in process or critical thinking topics. This also directly affects their information management strategies since factual knowledge is also used in organizing, elaborating, and summarizing information.

Since the learners' metacognitive skills have no significant relationship with most of the learners' academic performance in most subjects except for pre-calculus and SPGBIO2, it can be concluded that the learners' performance in their science and math subjects may be affected by the online learning modality. Even if the subjects are in the same discipline, the learners' metacognitive awareness has a varied effect on each of their performances.

The list of metacognitive teaching-learning strategies provided in this study can be used as a reference to assist UB grade 12 STEM students in developing metacognitive skills to improve their academic performance.

Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. Authors are strongly encouraged not to call out multiple figures or tables in the conclusion—these should be referenced in the body of the paper.

Recommendations

As stated in the conclusion that learners need to develop their declarative knowledge and information management system, it is then recommended that the school should implement programs addressing these concerns. Thus, more time should be spent on the acquisition aspect of math and science subjects leading to the explore and firm-up phases of learning to gradually develop. Also, building the foundation of factual knowledge for every subject must not be neglected since it affects the other metacognitive skills of learners. With this, a study on effective explore and firm-up activities can be done to see if it addresses the declarative knowledge of learners.

Since the modality of learning might have an effect on the learners' performance in their academic performance and metacognitive awareness, a further study is recommended in this area. Also, since a negative correlation was found between the metacognitive awareness of learners and their Pre-calculus performance, an in-depth study might be done to determine the factors affecting this trend. Focusing too much on the learners' metacognitive awareness is not recommended since most of the subject performances of the learners are not affected by their metacognitive awareness. The metacognitive awareness is recommended to be integrated with planning activities for SPGBIO2.

The strategy of teachers in teaching should be anchored in the learners' strengths, which are obtaining knowledge through discovery, cooperative learning, problem-solving, and simulation. Also, self-assessment of comprehension and performance errors can be integrated with the activities as part of learning.

It is also recommended to consider applying the metacognitive teaching-learning strategies to improve the higher-order cognitive abilities of Grade 12 STEM learners and other grade levels to improve their academic performance in any subject.

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