ISSN No:-2456-2165

Analyzing the Cognitive and Non-Cognitive Skills, and Mathematics Performance of Stem Students

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Abstract:- The study aims to explore the cognitive and non-cognitive skills, and general mathematics performance of Grade 11 STEM students in Agusan National High School, Butuan City, Philippines. The study is quantitative in nature and used descriptive-correlational research design. The cognitive skills among Science, Technology, Engineering and Mathematics (STEM) students resulted to 3.490 indicates a very high level among students which implies that student/s has/have a very high level of cognitive skill which means that their thinking, remembering, and reasoning ability is very high as well. On the other hand, the non-cognitive skills a resulted to 3.479 also indicates a very high non-cognitive skills which means that the student/s has/have a very high level of non-cognitive skill which means that their motivation, integrity, and interpersonal interaction ability is very high. Meanwhile, the overall average grade of STEM students is 93.467. The study found out that r-value=0.065 of cognitive skills and general mathematics performance of STEM students has a strong and direct relationship which means that if cognitive skills increase, students' general mathematics performance also increase or if one decreases, the other one also moves at the same direction. The p-value of cognitive skills and general mathematics performance is 0.001 which implies a rejection of null hypothesis. This means that there is a significant relationship between cognitive skill and grade 11 students' general mathematics performance. The strength and direction of the relationship between non-cognitive skills and general mathematics performance of STEM students is the same with cognitive and general mathematics. The r-value between the two is equal to 0.623 and a p-value=0.000. The p-value indicates that there is a significant relationship between non-cognitive skill and grade 11 students' general mathematics performance.

I. INTRODUCTION

Twelve years of basic education is the best period for learning. The K-12 Curriculum program covers kindergarten and twelve years of basic education which gives enough time for concept and skill, mastery, develop lifelong learners and to give students more opportunities to specialize in their desired fields based on their interest and capabilities. Mathematics can be viewed as a system idea since it comprises a portion of the ideas identified with each other. In present time, Mathematics is considered an important skill because numerical abilities are getting significant for regular daily existence and work as education. Kusmaryono (2014) proclaimed that a person cannot survive in the 20th century without making use of mathematical skill. This justifies the importance and compulsion of the study of the subject by all students who go through secondary education.

Academic performance is predicted by cognitive abilities, so schools that enhance academic achievement may also enhance cognitive abilities. Cognitive development studies focused on processing speed, working memory ability and fluid reasoning as three interrelated cognitive skills that evolve significantly from childhood through adulthood and predict individual performance differences through various measures (Finn et al., 2014). A study of Ispas & Borman (2015) stated that cognitive skills are classified as a general mental ability that includes reasoning, problem solving, and planning, abstract thinking, understanding complicated ideas and learning from experience. Non-cognitive skills, on the other hand, comprise of personal traits, attitudes, and motivations. Furthermore, Farrington et al. (2012) indicated that non-cognitive skills are represented by the beliefs, policies, abilities, and actions of a student that are not evaluated through grading, scores, and standardized testing.

Globally, poor academic achievement in mathematics is a major concern. One study conducted by Kusmaryano (2014) in Indonesia states that facing lack of learning processes in education that must be addressed immediately. In the learning process, students are forced to memorize without understanding the concept and applying it to real life situations.in a study of Gilmore & Cragg (2019). In Nigeria, Ogan and George (2015) found out that mathematical concepts that are hard and that the difficulty varies from concept to concept as perceived by students. These problems occur due to lack of teachers to recognize, explore, and develop mathematical skills that exist in each student. A research study managed by Wei et.al (2011) in Beijing, spatial abilities and performance in advanced mathematics are significantly correlated with each other. Hence, Cognitive, and non-cognitive skill assessments each capture unique aspects of work-related competencies. Together, they provide a stronger, more comprehensive, and complete picture of an individual. (ACT Work Keys, 2014).

In the Philippines, the last stage of the K to 12 Program is the Senior High School (SHS). However, it is alarming that Filipino students have low excellence rate requiring higher order thinking skills and are lacking in the ability of basic mathematics. According to Antiporda (2014), this claim is evidently implied by the drop of performance during the year 2011 and 2012, from 50.7% to 46.3% of high schools in the country and its low rank of

ISSN No:-2456-2165

115th out of 142 participants in the Global Competitiveness Report, it was also identified that students from the Philippine Normal University have poor achievements and low performance related to Math Courses, both fundamental and contemporary mathematics. Ganal and Guiab (2014) studied the Bachelor of Elementary Education sophomore students in Philippine Normal University-Manila and found out that mathematics anxiety or shameful experiences with mathematics teachers resulted to the negative attitude of students towards math

Furthermore, Philippines ranked one of the lowest in an international test in Science and Mathematics learning areas such as the 2003 TIMSS (Trends in International Mathematics and Science Study) having ranked 34th out of 38 countries in HS II Math and 43rd out of 46 countries in HS II Science (Capate, 2015. According to Ferrer and Dela Cruz (2017), the grade 11 students have lowest average grade in mathematics mandated by the Department of Education, General Mathematics is a core subject in Senior High school curriculum which expects students to learn, to utilize their analytical reasoning skills. In addition, Andaya (2014), a professor in PNU-Isabela, determined that mathematics performance of a student is highly correlated to individual and instructional factors and classroom management.

In Butuan City, students are facing trouble when it comes to Mathematics despite the best efforts exerted in the discussion and activities, they regard mathematics as one of the stress contributors that can lead to anxiety and misconception to the subject. Inchoco (2005) studied the teaching practice of mathematics teacher at Agusan National High School and found out that the mathematics teachers and students had similar perceptions on the implementation of discussion, practical work, problem solving, and exposition as teaching strategies used by the mathematics teachers. However, she added that the mathematics teachers and students differ significantly in their perception of implementation of practice and consolidation; think, pair, share; and group mathematical investigation as teaching strategies used by the mathematics teachers. In the study of Lasco and Raganas (2016), Caraga State University Professors, stated that the performance-based learning in Mathematics of the students will depend also on the learning experiences, instructional materials, and activities in school. They further concluded that involving each student to do group activity with their peers and board work would help them perform better in learning mathematics.

Thus, this study will be exploring the cognitive and non-cognitive skills, and general mathematics performance of Grade 11 STEM students in Agusan National High School, Butuan City, Philippines. With the issues that educators are facing in General Mathematics Performances of the students in the Philippines or abroad, enhancing the curriculum guide in general mathematics according to cognitive and non-cognitive skills will provide an aid on the problem of teachers and students in teaching and learning mathematics especially on the least learned competencies and skills.

- *Theoretical Framework*

Both Cognitive and Non-cognitive skills are essential for growth and development of an individual. Students need to enhance these skills to better serve their nation and be the key to economic and social success. Such growth and development imply that students must be fully equipped with the necessary traits, critical thinking skills and experiences that are valued in the labor market, in school, and in many other domains (Heckman & Kautz, 2013). Stated by Eskafi (2016), cognitive abilities or hard-skills are related with an individual's knowledge, intelligence, and motor-functions that all jobs require for employees to have the said skills associated with obtaining information and completing tasks. Furthermore, it was stated by Cragg and Gilmore (2014) that successful learning and performance and the development of mathematics proficiency of an individual in mathematics depends on several factors such as monitoring and manipulating information in mind (working memory), suppressing distracting information and unwanted responses (inhibition), and flexible thinking (shifting).

This research paper is grounded on the theory of the domains of learning. According to Wilson (2019), these domains are cognitive (thinking), affective (emotion/feeling), and psychomotor (physical/kinesthetic). Wilson (2019) has also suggested to use a more holistic approach in teaching to facilitate deeper learning that can adhere to the three domains of learning. Furthermore, each domain is divided into taxonomy or types which each domain. Bloom (1956) has categorized the cognitive domain into six (6) taxonomies which are knowledge, comprehension, application, analysis, synthesis, and evaluation. A newer categorization for a modified Bloom's taxonomy has been established by Anderson and Krathwohl (2013) which are remembering, understanding, applying, analyzing, evaluation and creating.

Furthermore, as insisted by the ACT Inc. (2014), to provide a more comprehensive or complete picture of an individual, cognitive, and non-cognitive are fundamental skills to be assessed. It gives the person a perspective of its strengths and weaknesses that they need to improve to meet the demands of the society. Compared to using cognitive skill assessments alone, non-cognitive skill can also provide better understanding of one's potential outside academic performances.

Cognitive skills are intellectual efforts such as thinking, reasoning, and remembering that grant the students to establish their full capabilities. On the other hand, non-cognitive skills are related to the environmental factors such as motivation, integrity, and interpersonal interaction, these soft skills are associated to a student's temperament and attitude. Both play a major role in the aspect of academic related competencies which both provide a better and more comprehensive performance of the Grade 11 students in a certain subject, which in this case is General Mathematics.

ISSN No:-2456-2165

II. STATEMENT OF THE PROBLEM

This study was conducted to determine the relationship of cognitive and non-cognitive skill on general mathematics performance of grade 11 STEM students in Agusan National High School, Butuan City Division, Philippines.

➢ *Specifically, the Study Opted to Answer the following Questions:*

- *What is the Level of Students' Cognitive Skill According to the following*:

✓ Thinking;
✓ Reasoning; and
✓ Remembering?

- *What is the Level of Students' Noncognitive Skill According to the following:*

✓ Motivation;
✓ Integrity; and,
✓ Interpersonal Interaction?

- *What is the Rese*
- *Is there a significant relationship between cognitive skill and grade 11 students' general mathematics performance?*
- *Is there a significant relationship between non-cognitive skill and grade 11 students' general mathematics performance?*

➢ *Hypotheses*

- H_{o1}: There is no significant relationship between cognitive skill and grade 11 students' general mathematics performance.
- H_{o2}: There is no significant relationship between non-cognitive skill and grade 11 students' general mathematics performance.

III. DEFINITION OF TERMS

- **Cognitive Skill.** This term relates to the mental process involved in knowing, learning, and understanding or conscious intellectual activity. The cognitive skills of the students will be evaluated in this study by measuring their level of thinking, reasoning, and remembering.
- **General Mathematics Performance.** It is the final grade of the respondent in the subject General Mathematics. This subject aims to develop learners' understanding of concepts and techniques drawn from number and algebra, trigonometry and world geometry, sequences, finance, networks and decision mathematics and statistics, to solve applied problems
- **Integrity.** This is a quality of being honest and fair. This domain focuses on honesty of students in answering mathematical related question and problem.
- **Interpersonal Interaction.** this is a domain under the non-cognitive. This domain enables the student to interact with their peers. It is an important ability especially in group works that are related to mathematics it enables the students to interact and share ideas about math and problems that require group cooperation
- **Memory.** It is one of the domains in cognitive ability. Memory is an ability to process of reproducing or recalling what has been learned and retained especially through associative mechanisms. This is an ability of student to recall the formulas, discussion, and problems.
- **Motivation.** this is a domain under the non-cognitive skills this a process of giving someone a reason for doing something. This domain influences the students to persevere more in mathematics keeping them motivated in hard subjects boost their level of confidence in learning mathematics.
- **Non-cognitive Skill.** It relates to conscious intellectual activity or acquiring knowledge through the senses, experience, or reasoning. The non-cognitive skills of the students will be evaluated in this study by measuring their level of motivation, integrity, and Interpersonal Interaction.
- **Reasoning.** This is a process of thinking about something in a logical way to form a certain logical conclusion and judgement of a certain situation. This can be used in understanding problems and to formulate conclusion that can be used in solving.
- **Thinking.** This is one of the domains in cognitive skill. This is an action of students to use their mind to produce ideas and decisions. This is required in every student to create ideas that can help them to perform better in mathematics

IV. REVIEW OF RELATED LITERATURE

Cognitive abilities or hard-skills are associated with an individual's knowledge, intelligence, and motor-functions. All jobs require employees to have some cognitive skills associated with obtaining information and completing tasks. Mental skills or cognitive abilities consist of attributes such as perception, attention, motor, language, visual and spatial processing, and executive functions these cognitive skills associates are different in males and females. In most cases, females show advantages in verbal fluency, sensory activity speed, accuracy, and fine motor skills, whereas males outperform females in spatial, memory skills and mathematical abilities (Michelon, 2012).

The predictive validity of cognitive ability relies on the complexity of the job with the highest validity coefficients for extremely complicated employment (Ones et al., 2012). Heckman & Kautz (2012) infer that this new understanding of cognition isn't generally accepted, some use IQ tests, standardized achievement tests, and even grades as interchangeable "cognitive capacity" or intelligence measures. Individual differences in cognitive skills of Cattell-Horn-Carroll (CHC) are linked to individual differences in the resolution of math problems. Whether cognitive abilities are associated with math issue solving directly or indirectly through math component skills is less evident, however, and whether these relationships vary

ISSN No:-2456-2165

across grade levels. The Crystallized Ability, Visual Processing, and Short-Term Memory constructs had direct and indirect relationships with math issue solving in the higher-order model, whereas the constructs of Learning Efficiency and Retrieval Fluency had only indirect relationships with math issue solving through mathematical computing. Integrated cognitive ability and mathematical achievement relationships across CHC intelligence models were usually consistent (Hajovsky, Lewno, Mason & Villenueve, 2019).

Bandura (2010) reviewed the different manners by which self-viability contributes to cognitive development and functioning and found out that self-adequacy applies its impact through four major processes which include cognitive, motivational, affective, and selection processes. Teachers' beliefs in their own adequacy to persuade and advance learning influence the sorts of learning conditions they make and the dimension of scholastic advancement.

Non-cognitive aptitudes cannot be instructed the same way cognitive abilities are instructed (Kryssov, 2016). Math incapacities, in any case, are as common as perusing which may have numerous causes and measurements. Additionally, as the math educational programs and curriculum changes, more accentuation has been set on communicating math thoughts, deciphering information from charts and figures, and evaluating. Whether or not other learning incapacities are show, in any case, there's developing prove that fundamental cognitive forms play a critical part in math execution (Brainware, 2017).

There has been constant questioning with regards to the quality of Philippine Education due to the poor performance of students in Science and Mathematics tests despite the amount of attention given towards the two major subjects. The results of implementing the K-12 curriculum were not able to change the current status quo (Imam, 2016) and in fact, the Mathematics teachers of Old Damulog National High School (ODNHS) were faced with the actuality of students having a negative attitude towards mathematics and they certainly did not fully grasp the mathematical concepts and procedures that were introduced.

Cognitive skills cover intelligence which refers to the capacity to process, learn, think, and reason, hence, it is essential knowledge as reflected in indicators of academic and mathematical achievement while, non-cognitive skills develops student's achievement and lessen student's behavioral-related problems.(Bauer, Mumford, Breitweiser, & Schanzenbach, 2016). According to Cirino, Tammy Tolar, & Fuchs (2015), it was found out that there is a strong research base underlying in concomitants on math skills that are early developing. The study found out that later developing skills have fewer studies and added that the results controlling for age showed that cognitive, number, and arithmetic variables have a combination accounted cumulatively for 38% to 44% of the fraction variances. Other studies like Karbach, Gottschling, Spengler, Hegewald, and Spinath (2013) used another medium via general cognitive ability (GCA). Some studies showed general cognitive ability (GCA) is a predictor of academic achievement. In early adolescence parental involvement in their children's academic importance is needed.

A study conducted by Farrington and a few others in 2012, mentioned that school performance was shaped by various factors essential to students and their external environment but, in addition to academic skills, they must develop non-cognitive skills that are vital to academic performance and whose values might not be shown in cognitive tests. According to Garcia (2014) non-cognitive skills is represented as the "Patterns of thought, feelings and behaviors of an individual that may continue to develop throughout their lives, and that play some role in the education process". Extensively, these abilities include those qualities that are not directly represented by cognitive skills, but rather by socio-emotional or behavioral characteristics that are not fixed attributes of the character, and are linked to the instructive procedure, either by being nurtured in the school years or by contributing to the development of cognitive skills during those years (Lipnevich et. al., 2013).

According to Gabrieli et al, (2015) students with stronger non-cognitive skills we're able to exhibit superior academic achievement throughout their academic careers compared to students who had poor non-cognitive skills or students who only exhibited good cognitive aptitudes. This is in line with the conclusions drawn by Barett (2014) who stated that non-cognitive skills and aptitudes we're similarly or was indeed more critical in value than cognitive skills in educative handling and work potential in individuals and that the increasing attempts to investigate the role of non-cognitive factors and how it associates to academic and personal achievement is increasing the collective knowledge of these factors in current literature and academia which affects the overall view of individuals towards the importance of non-cognitive factors in general.

V. METHOD

The study was quantitative in nature using descriptive-correlational study design. It has a fact-finding method in which processes of descriptive is utilized. There will be two different skills that will be correlated to the General Mathematics Grades of Grade 11 STEM students in Agusan National High School, Butuan City, Philippines. The first skill correlated to General Mathematics Grade is Cognitive skill which relates to the mental process involved in thinking, remembering and reasoning. Second to Cognitive Skill is non-cognitive skill which involves Motivation, Integrity and Interpersonal Interaction.

- *Research Participants*

There were 350 grade 11 students in Agusan National High School. There were 180 systematic and randomly selected students who participate the study. Participant answered the research-made survey questionnaire which measured their cognitive and non-cognitive skills. Subsequently, the researcher recorded the data in general mathematic performance from their general mathematics

teachers. The data collected were analyzed after the collection using the SPSS software.

➢ *Research Instruments*

A self-developed 60-item survey questionnaire was administered in the data gathering by the researcher. The 60-item survey questionnaire use a 4-point Likert's scale where 4 is strongly agree, 3 for agree, 2 for disagree and 1 for strongly disagree. The questionnaire has two parts. The first part is Cognitive skill test where it is divided into 3 domains: Thinking, Reasoning and Remembering. Every domain is consisting of ten (10) questions. The second part is non-cognitive skill test where it is also divided into 3 domains: Motivation, Integrity, and Interpersonal Interaction. All domains consist of ten (10) questions as well.

The instruments underwent two kinds of validation. The first validation is content validity where 3 experts in cognitive and non-cognitive skills will examine the content of the questionnaire. Second validation is the reliability which will be done after pilot testing.

➢ *Data Gathering Procedure*

For data analysis, the mean of both cognitive and non-cognitive skills was computed in the study. The level and interpretation of cognitive and noncognitive skills were based on the following:

Table 1 Scale for the Level of Cognitive Skill

Mean Range	Level	Interpretation
3.26-4.00	Very High	The student/s has/have a very high level of cognitive skill which means that their thinking, remembering, and reasoning ability is very high as well.
2.51-3.25	High	The student/s has/have a high level of cognitive skill which means that their thinking, remembering, and reasoning ability is high as well.
1.76-2.50	Low	The student/s has/have a very low level of cognitive skill which means that their thinking, remembering, and reasoning ability is low as well.
1.00-1.75	Very Low	The student/s has/have a very low level of cognitive skill which means that their thinking, remembering, and reasoning ability is very low as well.

Table 2 Scale for the Level of Non-Cognitive Skill

Mean Range	Level	Interpretation
3.26-4.00	Very High	The student/s has/have a very high level of non-cognitive skill which means that their motivation, integrity, and interpersonal interaction ability is very high as well.
2.51-3.25	High	The student/s has/have a high level of cognitive skill which means that their motivation, integrity, and interpersonal interaction ability is high as well.
1.76-2.50	Low	The student/s has/have a very low level of cognitive skill which means that their motivation, integrity, and interpersonal interaction ability is low as well.
1.00-1.75	Very Low	The student/s has/have a very low level of cognitive skill which means that their motivation, integrity, and interpersonal interaction ability is very low as well.

➢ *Statistical Treatment*

The following statistical tools will be utilized to interpret the gathered data which are the following:

- **Frequency.** It is a statistical tool that identifies the number of times the data value occurs. This will be used to describe the number of learner-respondent's response on the survey questionnaire.
- **Percentage.** It is a number or ratio expressed as a fraction of 100 which is denoted using the percent sign or %. This will be used to represent the frequencies into its percentage.
- **Mean.** It is also called as average which is computed as the sum of a collection of numbers divided by the count of numbers in the collection. This will be used to identify the level of cognitive and non-cognitive skill.
- **Pearson Correlation Rho.** This will be used to determine the relationship value between the variables. This will be used as will to get the significant relationship between cognitive skill and general mathematics performance, and between non-cognitive skill and general mathematics performance.

VI. RESULT

Table 3 Cognitive and Non-cognitive skills of STEM Students

Skills	Average	Level
Thinking	3.765	Very High
Reasoning	3.251	Very High
Remembering	3.462	Very High
Cognitive	**3.490**	**Very High**
Motivation	3.863	Very High

Integrity	3.456	Very High
Interpersonal Interaction	3.119	High
Non-cognitive	**3.479**	**Very High**

Table 3 shows the level of cognitive and non-cognitive skills of STEM students. The constructs under cognitive skills obtained averages which lie to the same level or very high. The overall average of the constructs of cognitive skills resulted to 3.490 which indicates a very high level among students which implies that student/s has/have a very high level of cognitive skill which means that their thinking, remembering, and reasoning ability is very high as well.

On the other hand, motivation and integrity of non-cognitive skills measured at the very high level while interpersonal interaction with an average of 3.119 lies on the high level. Overall, the non-cognitive skills among STEM students resulted to 3.479 still indicates a very high non-cognitive skills which means that the student/s has/have a very high level of non-cognitive skill which means that their motivation, integrity, and interpersonal interaction ability is very high as well.

Table 4 General Mathematics Performance of STEM Students

Average Grade	**SD**
93.467	2.669.

General mathematics performance of students is shown in table 4. It was shown that the overall average grade of STEM students is 93.467. The SD of 2.669 indicates that the data set are not so dispersed, or the grades of the student are not so far from the mean.

Table 5 The Relation between Cognitive and Non-cognitive Skills, and General Mathematics Performance of STEM Students

Null	**R-Value**	**P-Value**	**Decision**
There is no significant relationship between cognitive skill and grade 11 students' general mathematics performance.	0.651	0.001	Reject Null
There is no significant relationship between non-cognitive skill and grade 11 students' general mathematics performance.	0.623	0.000	Reject Null

Table 5 shows the relationship between the cognitive and non-cognitive skills, and general mathematics performance of STEM students. It was found out that r-value (r-value=0.065) of cognitive skills and general mathematics performance of STEM students has strong and direct relationship which means that if cognitive skills increase, students' general mathematics performance also increase or if one decreases, the other one also moves at the same direction. Since the p-value of cognitive skills and general mathematics performance is 0.001, we will reject the null hypothesis which means that there is statistical evidence found that there is a significant relationship between cognitive skill and grade 11 students' general mathematics performance.

Similarly, the strength and direction of the relationship between non-cognitive skills and general mathematics performance of STEM students is the same with cognitive and general mathematics. The r-value between the two is equal to 0.623 and a p-value=0.000. The p-value indicates that there is a significant relationship between non-cognitive skill and grade 11 students' general mathematics performance.

VII. CONCLUSION

Based on the findings, both cognitive and non-cognitive skills are essential for the growth and development of students in mathematics. Cognitive and noncognitive skills equally statistically plays a crucial role towards student's mathematics performance. To improve the mathematics performance of students, cognitive and noncognitive skills should be developed at the same time.

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