IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ≍ Peer-reviewed / Refereed journal ≍ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Conceptual Learning and Scientific Reasoning of the STEM Students as Influenced by Metacognitive Strategies

JENNIFER C. BAUTISTA, EdD

Science Teacher-II, Estefania Montemayor National High School, DepEd, Capiz Philippines

Abstract: This mixed method research aimed to determine the influence of metacognitive strategies to the conceptual learning and scientific reasoning of the STEM students. This was conducted to the 312 out of 1411 grade 12 STEM students of public schools in the province of Capiz for the school year 2023-2024. Stratified sampling were employed in the sample. The data were gathered using a 37- item Conceptual Learning Test where questions were adopted from the General Chemistry 1 Modules provided by the Department of Education was utilized for conceptual learning and 24-item adopted Scientific Reasoning Test from Lawson Scientific Reasoning Test was used for the scientific reasoning. An adopted 52 items Metacognitive Strategies Questionnaire from Schraw and Dennison (1994) was utilized to determine the metacognitive strategies employed by the students. In order to validate and verify detailed and relevant information, a Focus Group Discussion (FGD) was utilized for STEM students to gather data from Grade 11 STEM students of different schools for the Focus Group Discussion. The guide questions consist of 11 questions. The descriptive statistics used were the frequency count, mean, and standard deviation while One-way Analysis of Variance (ANOVA) and Pearson r were used for inferential statistics. All inferential tests were set at 0.05 alpha level of significance. The findings showed that the level metacognitive strategies of the STEM students was high. In terms of subcomponents under the knowledge about cognition, subdomain procedural knowledge was "high" and the highest among the three, followed by the declarative knowledge which was "high" and the conditional knowledge as "high" also. On the other hand, the highly utilized in the regulation of cognition subdomains was debugging which was "high", information management strategies was "high", and evaluation was "high". However, the planning was "moderate" and the comprehension monitoring was the lowest as "moderate also. The overall level of conceptual learning of the STEM students was moderate. The subcomponent concrete was "high", identity and classification were "moderate", and formalization was "low". The overall level of scientific reasoning of the STEM students was low. In terms of its subcomponents, conservation was "low", proportional reasoning was "low", identification and control of variables was "low", probabilistic and combinatorial reasoning was "low", and hypothetical-deductive was "high". There was no significant difference in scientific reasoning among the levels of metacognitive strategies of STEM students. There was a significant difference in scientific reasoning among the levels of conceptual learning of STEM students. Lastly, there was no significant relationship between metacognitive strategies and conceptual learning and between metacognitive strategies and scientific reasoning. On the other hand, there was a significant relationship between conceptual learning and scientific reasoning of the STEM students.

Keywords: Metacognitive strategies and scientific reasoning

I. INTRODUCTION

Science is a magnificent manifestation of humankind. Science is both a body of knowledge and an approach to acquiring and applying that knowledge. The techniques of investigation, or the "processes" of research, are a dynamic contrast to the gathered and organized body of knowledge, which is the "product" of science. According to Sheeba (2013), science is thus a combination of "processes" and "products" that are interrelated and dependent upon one another.

Students in the twenty-first century need to be able to reason scientifically. However, the two years of modular approach impacted greatly the learnings of the students. Level of understanding the concepts and improving the skills needed have been declined greatly. As a means of ensuring their survival, students must acquire critical skills for 21st-century learning objectives by using powerful scientific reasoning. Applying the 21st century learning paradigm as a pedagogical framework to the learning process requires a comprehension of it. Schools must include competences that foster a deeper comprehension of a subject matter in addition to subject-specific information, such scientific reasoning ability. And so, to improve the competencies, students must also employ the metacognitive strategies to be more globally competitive individual.

Ellis et al. (2013) cited that metacognition is a notion from cognitive psychology that emphasizes an individual's active involvement in their mental process. Numerous definitions and interpretations of "metacognition" have been generated since Flavell initially employed the word. The broader definition proposed by Flavell included cognitive, task, and strategy abilities. It is still believed that these three interrelated categories of metacognitive knowledge are crucial for learning.

The awareness of one's own cognitive processes and outputs, together with anything related to them, is what Flavell defines as metacognition. Metacognition includes being aware of one's own mental processes, managing cognitive processes, monitoring one's own mental processes, and using heuristics to structure problem-solving strategies. Metacognitive methods are employed in intentional inquiry. Thus, there is a great deal of hope that interventions that support student metacognition would lead to increases comparable to those in conceptual learning and science process abilities.

Irwan et al. (2023) cited that there are sources for the two subcategories of metacognition: knowledge of cognition and regulation of cognition. Furthermore, the definition of "knowledge of cognition" was an understanding of how humans generally process information and how they acquire new things. Then, the knowledge of cognition can be further classified into three distinct categories. Declarative knowledge is, first and foremost, the understanding of the learning process. Second, procedural knowledge—knowing which course of action is most suitable—is involved. Finally, knowing the conditions that are suitable for specific cognitive tasks is referred to as conditional knowledge. Using information management techniques during learning activities, as well as organizing and supervising prior to enrolling in a class or finishing a task, are examples of regulatory actions. Irwan et al. (2023) define "regulation of cognition" as the act of exerting control over one's own cognitive processing, such as by using a range of adaptable techniques according to the situation and intermediate learning objectives.

Consequently, it is possible to separate five distinct actions in the regulation of cognition. The process begins with setting objectives and allocating resources before learning. Information management techniques, or skills and strategies applied to the process of faster data comprehension, make up the second part. Thirdly, it is comprehension monitoring, which is the process of assessing an individual's level of knowledge or skill application. Debugging strategies, which include techniques to address understanding and performance problems, make up the fourth category. Evaluation is the process of analyzing performance and plan effectiveness after the learning process is over.Meanwhile, conceptual learning is the coherent understanding of important concepts. Knowledgeable learners are those who absorb topics more thoroughly than their counterparts who only understand theoretical ideas and methods. They understand the significance of an idea and its variety of uses. Their arrangement of the content facilitates their ability to assimilate and understand new concepts by relating them to concepts they are already familiar with. Because conceptual learning establishes connections between ideas and procedures learned through comprehension, it facilitates retention by making the material easier to recall, apply, and reconstruct in the event of forgetting

Concept learning is fast and flexible because newly learned information is adapted to new situations with little effort (Zeithamova et al., 2019). Tünkler (2020) cited that Klausmeier suggests that concepts are learned in a sequential order from the concrete level to the identity level, then to the classificatory level and finally to the formal level. According to him, the concepts learned up to a certain level can be used to solve problems, generalize positive examples and distinguish non-examples, and grasp hierarchical relationships.

Conversely, a complex construct, scientific reasoning competencies are defined as the ability to recognize scientific problems, formulate questions and hypotheses, classify and categorize entities, engage in probabilistic reasoning, generate evidence through modeling and experimentation, etc., and communicate, assess, and critically examine claims (NRC, 2012). These skills call for a variety of information, including procedural knowledge about scientific methods, content knowledge about scientific concepts, and epistemic knowledge about how scientific procedures support the claims made by scientists (Osborne, 2014).

Widodo et al., (2020) cited that there is a set of six dimensions for scientific reasoning. These include conservation of mass and volume, which calls for logical operations linked to students' experiential learning; proportional reasoning, a fundamental mathematical idea used to solve problems involving quantitative proportional relationships (Nelson et al., 2022); control of variables, which teaches students that altering the independent variable may have an impact on the dependent variable, either positively or negatively; and probability reasoning, which teaches students how probability is used in everyday life to make decisions when the results are uncertain (Ogbonnaya and Awuah, 2019). Students also learn about correlational reasoning, where they will realize that, first, correlation reasoning relates to the ability to determine the covariation of variables within a sample (Ogbonnaya, Awuah, 2019).

DOI: 10.17148/IARJSET.2024.111204

This highlights the role of probabilistic concepts in the decision-making process. Students also learn that subjective probability may be used to make decisions that affect the selection of multiple options. Second, the covariation of continuous variables suggests that the dependent variable will either rise or decrease in proportion to a steady increase in the independent variable (Trzebinski and Marciniak, 2022). Thirdly, variables are referred to as non-variant if a change in one does not result in a change in another. Fourthly, an outcome may be simultaneously influenced by several variables. Fifth, multivariate variance frameworks presume causal consistency, or that same causes would have similar effects under the same circumstances (Suryadi, Yuliati, and Wisodo, 2021). Finally, hypothetical-deductive reasoning helps students understand that deductive reasoning is predicated on the given premise rather than facts. When a student uses hypothetical-deductive reasoning, they understand that if the premise is true, the conclusion must also be true (Khemlani, Byrne, andJohnson-Laird, 2018).

Therefore, metacognitive abilities may help students think more flexibly, reason more effectively, and solve problems more successfully. The best learners are those who have the ability to control their own learning, according to numerous research. Students may differ from one another in their conceptual learning and scientific reasoning because theyemploydistinctmetacognitivemethods. However, a lack of metacognitive techniques may make it harder to understand scientific concepts, which may further impair one's ability to reason and, ultimately, result in poorer academic performance. The researcher observed that some STEM students are having a hard time conceptualizing what they learned and reasoning scientifically. This situation makes it difficult for the students to understand better the lesson deeper especially in Science. The researcher acknowledges this situation as students take a lot of time understanding the lessons. Meanwhile, the researcher is very inquisitive in determining what metacognitive strategies the STEM students used to improve their learning. This situation drives the eagerness of the researcher to conduct this study.

This study tends to support Flavell's (1979) theory. He proposed a model of cognitive processes for regulation and monitoring that places an emphasis on the knowledge process and allows people to control and improve their own cognitive processes. This method includes goal or task knowledge, strategy knowledge, metacognitive experiences, and metacognitive knowledge. Two categories of metacognitive information were identified: (i) declarative knowledge about the individual, the task, and the strategy; and (ii) procedural knowledge about the regulation of the cognitive process as it is demonstrated in their planning, control, and evaluation. However, fostering scientific thinking throughout the educational process has brought up a variety of issues, including those pertaining to early developmental processes, particular science education teaching methodologies, scientific literacy assessment, and the effects of metacognitive tactics. Rather than focusing on "the result of one person thinking alone," a major focus of education has been on how various aspects of scientific cognition interact in a collaborative setting.

Constructivist education theory, which considered learning as an active process rather than a stand-alone technique of obtaining knowledge, was unusual in that it offered a perspective on the evolution of scientific reasoning. According to constructivist learning theory, getting students to align their opinions with the generally acknowledged scientific principles is the primary objective of assisting them in developing their scientific research skills. Constructivism is the intellectual foundation of the conceptual shift toward "building skills," which is also evident medical field.

A distinct approach to education that seeks to support students in developing their critical thinking skills is based on authentic learning settings. Students who actively participate in the learning process are more likely to learn, according to Lave's (1991) Situative Learning Theory, also referred to as Situated Learning Theory. The idea holds that procedural knowledge is learned through problem-solving; the newbies are focused to the setting where some individuals have previously addressed similar problems are also participating. Another important theoretical line of investigation that sought to create a foundation for the progression of scientific thought throughout the curriculum focused on the cognitive perspective. The Adaptive Character of Thought (ACT-R) theory was developed by Anderson (1996) and proposed that declarative and procedural knowledge interact to form cognition. Declarative knowledge is composed of facts organized into units called chunks that explain the "what," whereas procedural knowledge was composed of production rules that represented the "how to."

The individual pieces were formed by encoding items in chunks or transforming production rules. "Human cognition depends on the amount of knowledge encoded and the effective deployment of the encoded knowledge," according to the ACT-R theory. In STEM (science, technology, engineering, and mathematics) education, the emphasis is shifting from topic knowledge to the development of skills connected to the knowledge required for practical science, such scientific reasoning. Scientific literacy is today viewed as one of the primary goals for the development of 21st-century citizens, and scientific reasoning ability is generally found to be a vital component supporting student performance in science study.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed / Refereed journal ⋇ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Furthermore, students' conceptual learning and scientific reasoning may be influenced by metacognitive strategies, which are hidden variables. Thus, tracing the students' conceptual learning and scientific reasoning proficiency may be helpful in identifying areas in which they struggle with learning and reasoning, as well as informing the development of appropriate strategies for enhancing the students' metacognitive skills.

II. METHODOLOGY

Participants in this study were the 312 Grade 12 Science, Technology, Engineering, and Mathematics (STEM) students from the public schools in the province of Capiz. To determine the sample, Slovin's formula was used. The probability sampling technique known as stratified random sampling was used by the researcher. Using stratified random sampling, the researcher separates the sample into several subgroups, or strata, and then proportionately chooses the final individuals at random from each stratum. A total of 312 Grade 12 sample size were the respondents of the study out of 1411 students in public schools in the province of Capiz. Meanwhile, there was a Focus Group Discussion (FGD) which was participated by eleven (11) STEM students of different schools.

The table below provides the sample size distribution for each school:

Table 1
Distribution of Participants

Schools	*Number of Population*	*Sample Size*
Capiz National High School	213	47
Casanayan National High School	20	4
Col. Patrocinio Artuz NHS	45	10
Comsr. Luis R. Asis NHS	52	11
Cuartero NHS	36	8
Dao NHS	32	7
Dumalag Central NHS	39	9
Estefania Montemayor NHS	42	9
Feliciano Yusay Consing NHS	94	21
Florentina B. Degala NHS	21	5
Ivisan NHS	60	13
Jose Diva Avelino Jr. NHS	37	8
Maayon NHS	38	8
Maindang NHS	27	6
Mambusao East NHS	38	8
Mambusao NHS	43	10
Marciano M. Patricio (Pilar)	33	7
Panitan National High School	80	18
Pontevedra NHS	43	10
Sapian NHS	76	17
Tapaz NHS	39	9
Tuburan NHS	25	6
Vicente Andaya Sr. NHS	109	24
Congressman Ramon A. Arnaldo Sr. NHS	55	12
Tanque National High School	67	15
Roxas City School for Philippine Craftsmen	47	10
Total	1411	312

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⪤ Peer-reviewed / Refereed journal ⪤ Vol. 11, Issue 12, December 2024
DOI: 10.17148/IARJSET.2024.111204

Data-gathering Instruments

An adopted questionnaire was used as an instrument to gather the necessary data to analyse the metacognitive strategies of the students. Meanwhile, questions from General Chemistry 1 modules of the Department of Education were adopted and utilized to gather the level of conceptual learning while an adopted test was used for the scientific reasoning of the students. Additionally, an FGD guide served as instrument for triangulation.

Metacognitive Strategies Questionnaire. A 52- item adopted questionnaire from Schraw and Dennison (1994) was used in this study. The researcher utilized a likert scale with a five point scoring. Fifty-two (52) items divided into components: Knowledge about Cognition with three sub-components of Declarative Knowledge, Procedural Knowledge, and Conditional Knowledge and the Regulation of Cognition with five sub-components namely: Planning, Comprehension Monitoring, Information Management Strategies, Debugging Strategies, and Evaluation was set to assess the metacognitive strategies in which the students utilized.

To describe the metacognitive strategies of students, the scale below was used:

Scale	Description
4.21-5.00	Very High
3.41-4.20	High
2.61-3.40	Moderately High
1.81-2.60	Low
1.00-1.80	Very Low

The adopted questionnaire was subjected to face and content validation, with the approval of the research adviser. All necessary adjustments and recommendations were integrated into the evaluation tool.

After the validation test, the 52-item adopted questionnaire was pilot tested to 30 STEM students of Estefania Montemayor National High School who were not part of the sample. The result of the test was analysed using SPSS. Every item in the instrument was examined for consistency using Cronbach's alpha. Greater internal consistency among the scale's variables is indicated by values that are closer to 1.0. This indicates that scale dependability is higher for higher Cronbach's alpha values. A score of 1.0 means that there is no measurement error and that the genuine score differences account for all of the variation in test results. On the other hand, a value of 0.0 denotes that the items solely contain measurement error and no true. Put another way, a Cronbach's alpha of 1.0 denotes complete measurement consistency, while a value of 0.0 denotes no measurement consistency (Cho and Kim, 2015).

Conceptual Learning Test. A thirty-seven (37) item test was set to assess the conceptual learning of the students based on their Science major subject in Grade 11 which was General Chemistry 1. This test was a multiple choice type of test with 4 choices. The items were divided into four areas such as concrete (9 items), identity (10 items), classification (9 items), and formalization (9 items).

To describe the conceptual learning level of students, the scale below was used:

Scale	Description
29.61-37.00	Very High
22.21-29.60	High
14.81-22.20	Moderately High
07.41-14.80	Low
00.00-07.40	Very Low

A table of specifications for the Conceptual Learning Test was prepared before finalizing the test to make sure that each item was covered and properly presented in the test. It underwent face validation by the research adviser. All necessary adjustments and recommendations were integrated into the evaluation tool.

After the validation test, the 37- item multiple choice adopted test also underwent pilot testing to 30 STEM students of Estefania Montemayor National High School who were not part of the sample. The result of the test in item analysis was analysed using SPSS. Item analysis was the basis if the items will be retained, revised, or discarded. Navarro (2012) states that items with 0.26-0.75 difficulty index and 0.46-1.0 discrimination index should be retained.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed / Refereed journal ⋇ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Scientific Reasoning Test. A twenty-four (24) item test was set to evaluate the scientific reasoning of the students. This test, was based on the Lawson Classroom Test of Scientific Reasoning (LCTSR) instrument, had twelve multiple-choice, two-tier questions. There were multiple choices for responses to each question, as well as multiple rationales for the answers. Conservation (4 items), Proportional reasoning (4 items), Identification and control of variables (6 items), Probabilistic and combinatorial thinking (4 items), and Hypothetical-deductive reasoning (4 items) were the scientific reasoning markers on the scientific reasoning test instrument.

The following scale was used to describe the STEM students' level of scientific reasoning:

Scale	Description
19.21-24.00	Very High
14.41-19.20	High
09.61-14.40	Moderately High
04.81-09.60	Low
00.00-04.80	Very Low

The adopted test was subjected to face and content validation, with the approval of the research adviser. All necessary adjustments and recommendations were integrated into the evaluation tool. Following the validation test, the 24 items multiple choice adopted test also underwent pilot testing to 30 STEM students of Estefania Montemayor National High School who were not included in the sample. The result of the test in item analysis was analysed using SPSS. Item analysis was the basis if the item will be retained, revised, or discarded. Navarro (2012) states that items with 0.26-0.75 difficulty index and 0.46-1.0 discrimination index should be retained.

Focus Group Discussion (FGD) Guide. Focus group discussion was used to collect the study's qualitative data through discussions. There were 11 guide questions formulated to serve as discussion points during the focus group discussion. A focus group discussion is a structured, facilitated conversation among a small group of stakeholders intended to gather perceptions in a defined area of interest in a permissive, non-threatening setting, as referenced by Balatayo (2019).

This technique is one way to verify the result of the quantitative data. Verification entails assessing the veracity of the data acquired, and triangulation is a technique frequently employed to this end. Triangulation is the process of interpreting a single piece of data from several points of view.

Data- Gathering Procedures

The researcher obtained a letter from the superintendents of Roxas City Division and Capiz Division requesting permission to conduct the study in their respective areas of jurisdiction after deciding on the necessary number of participants for the study and finalizing the adopted questionnaire for metacognitive strategies, adopted test for conceptual learning, and adopted test for scientific reasoning that underwent item analysis, validation, and reliability. Following the approval, the researcher submitted a letter addressing the principals' concerns together with the Division Supervisor's authorized letter. In order to ensure a 100% return rate, the researcher personally gave the respondents the instruments. With this, the researcher has more time to check the tests, tally, and verify the respondents' answers. Using SPSS, the collected data were processed and the relevant statistical techniques were used to tabulate, analyze, and interpret the results.

The participants were informed prior to data collection that the research is ethical and that there will be benefits from the study's completion; that participation in the study is voluntary; and that confidentiality will be protected through the procedures employed.

A Focus Group Discussion (FGD) was held via Google meet where all the conversations were documented and recorded. There were 11 participants who attended the activity representing the students of STEM in different schools. Participants in the FGD were given the opportunity to answer the questions. The focus group discussion's responses were all recorded in order to extract information, meaning, and interpretation.

Statistical Data Analysis Procedures

The study used the following statistical instruments:

Frequency Count. This was utilized to ascertain both the students' questionnaire responses and test scores.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Mean. This statistical tool was utilized to assess the metacognitive strategies, conceptual learning level, and scientific reasoning of the STEM students.

Standard Deviation. The purpose of this test was to assess the homogeneity and heterogeneity of students' metacognitive strategies, conceptual learning, and scientific reasoning.

One-way Analysis of Variance (ANOVA). This test was used to determine the significance on the difference of students' conceptual learning and scientific reasoning among the metacognitive strategies and was set at 0.05 alpha level of significance.

Pearson r. This test was set at 0.05 alpha level of significance to determine the relationships among metacognitive strategies, conceptual learning, and scientific reasoning of the STEM students.

III. RESULTS AND DISCUSSION

Descriptive Data Analysis
Levels of Metacognitive Strategies
of the STEM students

Data in Table 2 showed that the overall metacognitive strategies of STEM students is "high" with a mean of 3.55 and a standard deviation of 0.29. As clear from the table, the highest mean of the knowledge of cognition subdomains is for procedural knowledge (M=4.00; SD=0.51, followed by declarative knowledge (M=3.64; SD=0.56); while the lowest is for conditional knowledge (M=3.54; SD=0.74). On the other hand, the highest mean of the regulation of cognition subdomains is for debugging (M=3.61; SD=0.54, followed by the Information Management Strategies (M=3.56; SD=0.42) and evaluation (M=3.55; SD=0.47) which are all "high"; however the lowest is for comprehension monitoring (M=3.18; SD=0.78) and Planning (M=3.34; SD=0.64) as "moderate" level.

Table 2

Mean and Standard Deviation of Metacognitive Strategies

Variable	Mean	Description	SD
Overall Metacognitive Strategies	3.55	High	0.29
Knowledge of Cognition			
Declarative Knowledge	3.64	High	0.56
Procedural Knowledge	4.00	High	0.51
Conditional Knowledge	3.54	High	0.74
Regulation of Cognition			
Planning	3.34	Moderate	0.64
Comprehension Monitoring	3.18	Moderate	0.78
Information Management Strategies	3.56	High	0.42
Debugging Strategies	3.61	High	0.54
Evaluation	3.55	High	0.47

Scale	Description
4.21-5.00	Very high
3.41-4.20	High
2.61-3.40	Moderate
1.81-2.60	Low
1.00-1.80	Very low

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁒ Peer-reviewed / Refereed journal ⁒ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

The overall metacognitive strategies level shows that STEM students exhibited a high level of these methods. This suggests that students are aware of what type of learner they are and since they have this awareness, they have a clear understanding of the strategies which was effective in a certain scenarios. Addition to this, students may also identify in what condition they can learn better. They may also have the ability to strategize on how to absorb information better. Furthermore, as students learn, they also knew what to do when they encounter difficulties in learning and be able correct the problem. Moreover, they are also capable of evaluating themselves if they really learn after their learning process.

All of these might be due to the fact that students tend to understand better their self, their learning capabilities, weaknesses and strengths, and the instances where they can learn better by reflecting on their previous experiences while learning. Also, as students become more exposed to the internet and social media, especially in Tiktok, Facebook, and Youtube, where people are giving tips regarding learning strategies, students might become more aware of other different learning strategies which they have not explored. This may also make them curious, trying to experiment these strategies, and evaluate among themselves on what might be effective to them. Moreover, through the guidance of their teachers and family and collaboration with classmates and friends on what to do in order to learn better, students' awareness and utilization of the different metacognitive strategies were applied.

However, since the metacognitive strategies do not reach the very high level, it also indicates that students may also face some challenges in materializing what they have planned to learn the lessons or achieving their strategies in planning. Also, they may encounter difficulties in monitoring their comprehension which may have an impact on their learning process.

The findings of the study were reinforced by the participants' thoughts and experiences regarding how they locate and utilize resources and materials to enhance their metacognitive abilities. By experimenting on the different learning styles such as using audio, visual, kinesthetics, and reading and writing techniques, students determine what type of learner they are. It is also with the use of different sources like online platforms, articles, books or asking their teachers help them recognize what strategies suited to them.

The following were the statements of the discussants during the Focus Group Discussion:

Discussant 10: *I recognize first my past learning techniques to which I can learn effectively and which makes easier for the lessons to sink in my mind and will not eventually drain it. I also assess my preferred learning styles which will suit to the methods where I can learn better and effectively.*

Discussant 3: *I can recognize learning style by experimenting different study methods such as visual, auditory, kinesthetics, and reading and writing techniques. Reflecting in these methods result in better comprehension and retention can help determine my learning style. For example, I am a STEM student, and I like interactive learning and I can find other domain to help me learn and develop my understanding subjects and improve fundamental skills.*

Discussant 2*: To improve my metacognitive abilities, I explore different sources like online platforms, articles, books to deepen my metacognitive ability.*

Discussant 1: *Metacognitive is thinking about thinking, and it is a factor on how we think from the given outputs from our teachers. It is on how students perceive each topic on their everyday lessons.*

The results of this investigation were corroborated by a prior study conducted in Turkey by Oguz and Ataseven (2016), who examined motivation and metacognitive abilities in university students and found that the participants in the study have a high degree of metacognitive abilities. This result, however, differs from that of a study conducted in 2015 by Aljaberi and Gheith, who discovered that most participants had a moderate level of metacognition.

Furthermore, it was discovered that over two thirds of nursing students exhibited a high degree of metacognitive thinking in the study conducted by Ata and Abdelwahid (2019). They concluded that the nursing faculty members face extreme stress and demands, necessitating the development of specific learning, clinical problem-solving, and critical thinking abilities in their students. As a result, nursing students who successfully apply their metacognitive abilities and who are more conscious of what, how, and when they can acquire knowledge may find it difficult to get beyond challenges that arise during the learning process.

In terms of the knowledge of cognition, the "high" level of procedural knowledge with the highest mean implies that students have the understanding of the different strategies which they can apply in their learning and in the activity they

DOI: 10.17148/IARJSET.2024.111204

intend to finish. This might be due to the fact that as students are exposed and have the freedom to explore the different learning strategies, they might have identified and understood what strategies are suitable to them as learners. Students have the ability to successfully accomplish a certain activity and able to learn a lesson because they know what and how to apply that certain strategy. Additionally, students may try to use strategies that they think have worked in the past to the present scenarios. They may also have an intended purpose for each strategy they use.

In addition, to support the data from the questionnaire, in the conduct of FGD, students also shared that they explore first the different strategies and assess themselves on what strategies they fit in. They further said that they commonly used strategies which they are comfortable with.

Discussant 9: *First, I assess my learning style so that when I study it will not be difficult. And for you to know the topics you need to know you're learning style and habits suitable to you. If you learn more in hearing then you listen, and if you learn more in writing then you write all the important concepts to understand it effectively. You need to have a step-by-step process to reach your goal.*

Discussant 10: *I recognize first my past learning techniques to which I can learn effectively and which makes easier for the lessons to sink in my mind and will not eventually drain it. I also assess my preferred learning styles which will suit to the methods where I can learn better and effectively.*

Discussant 11: *As a student, I really need a flexible learning method. I determine relative study materials, and then try different study methods, for example if it is better to use cellphone or hard copy. And find to which I am much comfortable in that situation that is what I use.*

Discussant 1: *The method I use is the method I am really comfortable with because I am the type of person who is not fond of changing my learning strategies. I always take down notes, even though we have hard copies, I still write it down, in that way I can remember it more.*

The "high" level of declarative knowledge implies that students understand their learning process. This means that students are aware of what they are thinking, what type of learner they are, and how they are learning. They know their strengths and weaknesses and what they are good about. As students know what kind of information is most important to learn, they have the control over how well they learn in a certain lesson thus, knows what is best for them.

Furthermore, students elaborated during the FGD that they can understand better the lesson based on their own way of learning through summarization, reading and writing, self-test, and self-explanation. They also acknowledge the area where they find difficult to learn. This simply signifies that students have the knowledge on what learning style works best for them.

The following statements were stated by the discussants:

Discussant 7: *The technique I find particularly successful in learning is I take down notes and summarize the context that I have to study. I can understand better in my own way the definition and I can memorize faster the words or lesson. I give time when to study, and I usually do it at night which is I find effective for me and depending on the level of difficulty and on how much should I study for my subjects.*

Discussant 5: *I am most comfortable in learning through auditory learning, and read and write. Since we are now learning through visual learning as we are now living in the 21st century wherein teachers use PowerPoint presentations which improves our visual. And for me, through learning when I listen or writes it down, I can memorize it more. However, sometimes, I cannot perform well especially those questions which needs to reason out. Maybe because I focus more in memorization.*

Discussant 6: *For me the successful technique is memorizing using keywords and listening while the teacher teaches. As well as practicing or self-test which had been effective for me since my elementary days. But then, I encounter difficulties sometimes especially those questions which needs a critical thinking because I am not comfortable with the teaching strategies of my teacher.*

Discussant 8: *Self-explanation is one my technique in explaining concepts to myself and deepens my understanding and retention. I use mnemonic devices such as acronym and rhymes which have been great for remembering list of sequences. Visualization techniques like creating mental images or diagrams which aids memorization and understanding. And also watching educational videos that suits to our topic.*

The “high” level of conditional indicates that students use different learning strategies depending on the situation and capable of motivating themselves in learning when they needed to. Additionally, students are well aware on what conditions suit them best in learning and what strategy should be used to have a better result. Students might have no difficulties in knowing when and why they can use particular learning strategies in their learning process. Students do not find it difficult to apply different learning strategies depending on the situation. In other words, students can choose appropriate strategies, using them as necessary, and monitor the construction of meaning and the task related work.

In the conduct of FGD, discussants further explained that they can determine which circumstance of their current cognitive activities are appropriate based on the availability of the materials and their current level of understanding in a certain lessons. They commonly assess first the situation and what might be the challenges they may encounter in learning then identify what strategies they will employ. Additionally, students are also aware of the situation in which they can learn better. This simply implicate that they have good knowledge about how to deal with their cognition in order to achieve the best performance in learning.

The following were the statements of the discussants:

Discussant 2: *I determine the appropriateness of my cognitive activities based on factors such as requirements, available resources and current level of my understanding. By evaluating the demands of the situation and potential challenges, I can adjust my performance and learning outcomes.*

Discussant 5*: I assess first my strength, if it is memory, attention, problem solving or critical thinking and which is more appropriate cognitive activities for me. And what works for me is when I study before I go to sleep. Then I visualize in my mind what I need to study because I love it better if it is arranged orderly and I tend not to forget it but rather remember the mental images I made.*

Discussant 3: *The best way is assessment like flashcard application wherein I can put the question and try to answer it. When it comes to tasking, I try to break down the topics and study which are easy first then the difficult ones. I also do not stick to one technique but I try things and determine which one is best for me.*

Discussant 4: *I actually don’t have a study habit. What I do is active recall and space repetition. The strategy I use is Domodoro, wherein I give time to study, rest and go back studying again because for me it is more effective in learning and absorbing lessons.*

Discussant 1: *I always have three things I do before I review. First, is I sleep, because you should not force yourself, if you are tired sleep first. Second, I find my interest. And last, is the review time. And through that, learning sinks in.*

The current study findings were supported by a previous study carried out by Ata, Elsayed-El, and Abdelwahid (2019), who investigated the nursing students' level of metacognitive thinking, in Egypt, and they found that the conditional knowledge had the lowest mean percent score in the knowledge of cognition and comprehension monitoring in regulation of cognition.

On the other hand, the highest mean of the regulation of cognition subdomains was for debugging which was “high”. This implies that students have ability to correct comprehension and performance errors as they ask others for help when they do not understand something. They mostly stop and reread when they get confused. They might also capable of changing their strategies when they fail to understand better the lessons. This may due to the fact that students are doing self-testing, seek clarifications, and practice trial and error, in order to correct the performance and comprehension errors in their process of learning.

Moreover, in the FGD, it was found out that students test themselves if they really understand the lessons with the use of their strategies. Additionally, when facing difficulties, they go back to the start and trying again to find the problem in their learning through the use of online resources. They also tend to ask the help of their peers and teachers in order to correct the problems they encountered.

The following were the statements of the discussants:

Discussant 10*: I do self-testing wherein I assess myself of what I have learned, what I have memorized and what topics do I need to improve and study more. Also revisiting relevant materials so that I can correct what I lack and reinforce my understanding regarding the topic.*

DOI: 10.17148/IARJSET.2024.111204

Discussant 11*: I seek clarifications after determining the misconceptions. I use my peers, teachers and internet for this, like if I have something I cannot understand I search from the internet, and if still not, then I ask my classmates or last resort is asking my teacher for clarification even through messenger.*

Discussant 1: *If I encounter errors, I go back to zero. Meaning I try and try again to find answer like asking my teacher again, revisit past learning materials available. And I take these errors as a symbol of my motivation to be curious.*

Discussant 2: *I do two things; one is I seek clarifications from my teachers or classmates or use online sources such as Youtube and other online platforms.*

Given the "high" Information Management Strategies, this implies that STEM students have the skills and strategies used in the process of understanding the information more efficiently. Some students might try to translate new information into their own words, try to break down the information, and take down notes in order to understand the information better. Additionally, students consciously focus their attention on important information they are learning about in order to understand it better. Most of them are asking clarifications to their teachers, peers or searching for videos in the internet in order to understand better the lessons. Moreover, they employ the mind mapping for them to easily retain the information.

Furthermore, students have stated during the focus group discussion that they use active learning in learning better. They tend to listen actively while taking down notes of the lessons. After this, they will summarize the lessons in their own words.

The following were the statements of the discussants:

Discussant 6: *It is by active listening and giving of full attention, note taking and asking questions for clarifications.*

Discussant 7: *I also apply active listening and I focus my attention. I also take down notes, and I write the summary of what my teacher tells. And I also ask my classmates so that I can understand more what is being discussed.*

Discussant 8: *I utilize techniques such as skimming, scanning and summarizing and then I also employ mind mapping so that it is easier to retain information.*

Discussant 9: *I also do active learning during the lecture and I use skimming and scanning techniques that can help me to identify important information efficiently. And also engaging in active reading is an essential technique to determine underlying key points, and also summarizing paragraphs in my own words. But then, due to many school works, teaching strategies of the teacher, and also the classroom environment (which now, we experienced extreme hot weather conditions), I find it sometimes hard to understand the lessons, especially those which needs deep critical thinking.*

Discussant 1: *I find resources through surfing the internet, or asking copy the topic from our teacher. And then I write it down myself as it sinks in more if I write it down because when you write it down you not only have it as reference but you are more likely to remember it. I highlight important details or underline it then research for unfamiliar words or ideas. And I also watch videos related to it as it is more entertaining and then do self-evaluation wherein, I also answer self-made test.*

Discussant 8: *I actively read and I take down notes what I read and then I organized it and summarize words, essential points and concepts that I encounter in a topic.*

On the other hand, in the study carried out by Irwan et al. in 2023, the information management strategies—a collection of skills and procedures used to handle information more efficiently and include organizing, elaborating, summarizing, and selective focusing—were the least used signal.

A "high" level of evaluation indicates that STEM students analyse their performance and strategy effectiveness once the learning process has completed. This implies that they know how well they do once they finish a test or when accomplish their goals. It is also important to note that students possibly ask themselves what they have learned. Students done it commonly by doing self-assessment in order to identify the level of what they have learned. Some of them also assess their learning through their performance in tests, recitations, and performances while others can able to summarize the lessons that they have learned in that day. With this, they could be able to identify the problems that they have experienced, the gaps or lapses in their learning, and could determine the possible solution so that in the next day, they can learn better.

Likewise, in the conduct of focus group discussion, discussants evaluated their performance and the efficacy of their strategy when the learning process was over by analyzing their performance during test, oral recitation, and the application of their learning strategies in the real life scenario. They tend to summarize of what they have learned at the end of the day and asking their self of their performance after the task was done.

Discussants stated the following statements:

Discussant 3: *I can say that it is effective because what I use is space repetition and active recall, so when have oral recitation, I can check that what I have learned was absorbed by my brain because I can recall the topics, the definitions and the concepts. With this, I could determine that I have learned many lessons.*

Discussant 4: *It is because we were exposed in many problems and topics that require evaluation skills. For example, when we solve in Math, we are forced to apply evaluation. And it is also effective based on my scores and grades in our performance and recitation.*

Discussant 5: *I can say that my strategy is effective when I can apply it already in the real world, like I am active in extra-curricular activities like journalism, so when I join those competitions, it is much easier for me to study and write, as I can apply my study habits. As there is an application or utilization of learning therefore, I can say my strategies are effective. Also, I really make it sure that, at the end of the say, I will take down notes and summarize all that I have learned in that day.*

Discussant 6: *It is by evaluating and determining the range of what I had learned by having self-assessments. Also, when our teachers give quiz and I got high scores then I can say that strategies used are effective.*

The result aligns with the conclusions of the study conducted by Irwan et al. (2023). The third most significant factor, according to their findings, is evaluation—the capacity to gauge performance and strategy effectiveness following learning. Aljaberi and Gheith (2015) discovered the opposite among Jordanian Petra University students, with evaluation ranking as the second-lowest indication. Students in the English Education Study Program at IKIP PGRI Pontianak exhibit yet another noteworthy trend.

The "moderate" level of planning indicates that STEM students have some difficulties in goal setting and allocating resources prior to learning. They see to it to organize their time to accomplish their goals, and have a guide on what to accomplish at the end of the day. However, some of them might failed to read the instruction carefully before doing any tasks. They may experience different challenges which lead them having difficulties in planning. This might be due to many tasks or activities given to them which they are bombarded with, the time management, and other school related and non-school related activities which causes them to fail planning out what they will do in order to learn better. Additionally, they are also being distracted by the technologies that make them unable to organize their time to accomplish better their goals. These were also agreed by the statements of the discussants during the Focus Group Discussion, discussants confirmed that they do have a guide on what to accomplish at the end of the day, organize their time to best accomplish their goals, and set specific goals to achieve. Also, organizing the subjects from very interesting to less interesting one helps in learning better. But, because of the bombarded activities and many tasks needed to accomplish, they cannot plan out what to do. Additionally, it was also confirmed that some students failed to read the instruction before doing a task.

The discussants stated that:

Discussant 7: *When I start reviewing or doing a task, I make sure that I set my own goal so that I have a guide on what to accomplish at the end of the day. This also helps be evaluate if my task is a job well done. However, sometimes, because I have a lot to do and we are bombarded with many tasks, I cannot really plan out what to do thoroughly.*

Discussant 9: *I rely on a variety of effective strategies and of this is outlining which helps me structure key points and details, next is mind mapping, summarizing contents in my own words which aids comprehension and retention. Learning requires planning, you need to plan how you make reviewers that summarizes things. With this, I somehow organize my time to best accomplish my goals. Somehow, because like what discussant 7 said, we are bombarded with activities and other factors.*

Discussant 10: *I give time to each subject on when I would study them so that my mind will not be drained mind in memorizing key points or ideas. When I makes reviewers, I break long definitions for easy understanding and so that my brain will not find it hard during exam. Also it is important to read the instruction first before starting since some of us failed to do this.*

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed / Refereed journal ⋇ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Discussant 1: *For me, I analyze the information I am interested with, then I study the subject I am most interested with to the less interesting one. I find it hard to balance my time management. If I have a lot of works to do including not school related activities, it could be a factor planning what to do before learning a lesson.*

Lastly, with lowest mean and has a "moderate" level was the comprehension monitoring. This means that STEM students have difficulties in determining whether they understand a lesson or of what they are reading. They somehow failed to realize that they cannot deeply understand the lessons which makes them unable to correct their comprehension. They may sometimes also failed to ask their self some questions about how well they are doing while they are learning something new. Also, although they are using different strategies in order to monitor if they really comprehend the lessons, they also fail because they are easily distracted by the technologies which make them unable focus in monitoring their comprehension. Moreover, qualitative data were gathered from focus group discussions presented that STEM students have different strategies used in monitoring their comprehension as well as the problem they encountered however, they easily got distracted by their cell phone, social media, and internet which make them cannot monitor well their comprehension.

Discussant 2 stated that: *I use Feyman strategy where I need to understand the underlying concept, like I need to explain it to someone and the moment I encounter a topic I forgot I try to take note of that. Then I go back to my notes and check where I am stuck and needs to be studied again.*

Discussant 3: *I use the same strategy wherein I talk to myself and explain what I have learned. Then, pausing to check my comprehension. But then, I get distracted because I tend to do surfing in the internet rather than studying.*

Discussant 4: *With my assessment, I am weak when it comes to comprehension and I need to improve further because it is a bit alarming for me that the level of our comprehension is only moderate. I cannot understand it, I ask help from my sibling. I list down the words I cannot understand, find the meaning and use it in sentences.*

Discussant 5: I improve my comprehension through summarization and paraphrasing, even though we have test booklets or reviewers, I paraphrase it on my own understanding because what comes out in the exam is application of what you have learned. But I sometimes find it hard to comprehend because I lost focus because of my cellphone, social media and internet. So sometimes I cannot follow the set time I have for my studies.

The results of this study are supported by a comparison of the eight indicators found in the study by Irwan et al. (2023), which shows that the most widely utilized indicator among students is Debugging Strategies, or the techniques that students employed to repair their comprehension and performance errors. This is completely at odds with the findings of a study conducted in 2021 by Taufiqurachman, who discovered that debugging techniques are the second-lowest indication of university students in their last semester. Furthermore, Conditional Knowledge—which discusses the efficacy of particular learning strategies—is the second most employed indicator.

Levels of conceptual learning Of STEM students

Data found in Table 3 depict the "moderate" level of conceptual learning of the STEM students in the public schools in the province of Capiz with a mean of 18.24 and a standard deviation of 5.22. Specifically, the highest among the categories is the concrete (M=6.22; SD=1.65) as "high", followed by identity (M=5.13; SD=1.73) and classification (M=4.31; SD=1.74) which are "moderate"; while the formalization is "low" (M=2.61; SD=1.60).

Table 3

Mean and Standard Deviation of Conceptual Learning

Variable	Mean	Description	SD
Conceptual Learning	18.24	Moderate	5.99
Concrete	6.22	High	1.65
Identity	5.13	Moderate	1.73
Classification	4.31	Moderate	1.74
Formalization	2.61	Low	1.60

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed / Refereed journal ⋇ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Scale	Description	Scale	Description	Scale	Description
29.61-37.00	Very high	7.21-9.00	Very high	8.01-10.00	Very high
22.21-29.60	High	5.41-7.20	High	6.01- 8.00	High
14.81-22.20	Moderate	3.61-5.40	Moderate	4.01- 6.00	Moderate
07.41-14.80	Low	1.81-3.60	Low	2.01- 4.00	Low
0.00-07.40	Very low	0.00-1.80	Very low	0.00- 2.00	Very low

A moderate conceptual learning of the STEM students simply implies that students may have some difficulties in learning the concepts of their lessons specifically in General Chemistry 1 as students merely retain the knowledge that was taught to them. They might be able to recall characteristics or attributes of the lessons. Also, they can understand the perceptible features of an object, differentiating each from one another, and remembering those discriminated one since they mostly used internet to watch videos regarding those concepts aided with images and animation.

However, they might moderately use those attributes that they have in recalling or identifying an example in their memory. They might sometimes cannot be able to distinguish the characteristics of the concept which differ from others and might have difficulties in identifying this concept among different examples. With that, they cannot generalize that two or more examples belong to a certain group.

This might lead them also to have difficulties in organizing the concepts based on their similarities and differences into categories or classifying new examples or situations based on the attributes and different examples in their memory. With this, students could not be able to articulate of what they understand regarding the concept using symbols, abstract language, or a formal definitions. They may be experienced difficulties understanding deeply the concept or information to produce new knowledge or idea or applying it into different context.

This might be because of the weak deep knowledge foundation of the students or the initial skills they needed. Without a strong or solid understanding on the basic concepts, it is difficult for the students to progress their learning.

Additionally, the lapses in the time the lessons are taught, evaluation, and feedbacks contributed a lot since other students may have forgotten the lessons being taught to them before the evaluation and teachers sometimes failed to give feedback to the students. As feedback helps in guiding students learning and correcting their misconceptions. Students do not receive timely, specific, and constructive feedback on their understanding of the concept, they struggle to identify and correct their misunderstandings, limiting their progress in other stages. Also, motivation plays an important role where students may not also interested in some lessons in General Chemistry 1 which makes it difficult for them to learn the concepts.

Also, the physical environment of the classroom also affects the conceptual learning level of the students since students cannot concentrate more on learning the conceptual information if they were distracted by the environment they have. Teaching materials and teaching strategies used by the teachers may sometimes affect the level of conceptual learning of the students. Additionally, students need to have interactive learning where they could interact with each other in order to share knowledge.

Also, students might have less exposure in the hands-on activities like experimentation and which makes them unable to grasp fully the concepts in concrete level that could affect the latter stages. The STEMS students may have less ability to write logical relationships and representations of concepts, explain, interpret and apply the concept in real life situations. Moreover, the two years on modular mode of teaching could greatly impact the result as students might have been struggling to adjust in the face-to-face class during the teaching of the lessons in General Chemistry 1.

The qualitative data present that teaching strategies play the important role as the factor in the moderate level of conceptual learning. Furthermore, the physical environment of the classroom also adds up to the reason why the conceptual learning got the moderate level.

Discussants narrated the following:

Discussant 7: *Personally, I find other subjects like General Chemistry very hard because I think I am not that comfortable on how our teacher teaches us that is why I cannot understand what is being discussed so what I do is I study it again at home or the next day. But because my way of learning is through listening, I have determined during our examination that I find it hard understanding the questions.*

DOI: 10.17148/IARJSET.2024.111204

Discussant 10: *I think it is more in the learning approach, so in a classroom every student has a different learning technique and how and how to digest the topics.*

Discussant 2: *The facilities and classroom environment also affects the outcome of the conceptual learning. Since we cannot focus on the lessons being discussed when the classroom is not well ventilated and well lighted. It is also important that our teacher* consider our different learning styles.

This finding is consistent with a study Van der Graaf, Segers, and Verhoeven (2018) where they states that another drawback is that neither the teachers' roles nor the caliber of the questions during the course series were officially evaluated. Lesson videos on videotapes would offer rich information that would improve comprehension of the underlying mechanisms. It would be intriguing to investigate whether domain-specific knowledge is predicted by the caliber of the conclusions.

Additionally, Rillero (2016) states that it is necessary to provide professional development programs to assist educators and administrators in identifying useful resources and techniques for DCL. These will make it feasible to transform indifferent surface students into learners who want to make connections between ideas and apply what they have learned to their daily lives.

The subcomponent concrete has a “high” level indicates that some of the students have the ability to recall those critical attributes or lessons related to General Chemistry 1. They are capable of understanding the perceptible features of an object, discriminating each from one another, and remembering those discriminated one. Students may find it easier recognize the unique characteristics of a concept in a tangible, hands-on manner which they can see, touch or experience. They can able to make use of logical principles in solving problems involving the physical world.

This might be because since students are Grade 12 students, they are already exposed on the tangible objects which were used in teaching Chemistry in their elementary and junior high school years. Additionally, they may have recalled those attributes or characteristics of those concepts which they might have experienced, feel, or see during their class in General Chemistry 1. Also, since they are using and exposed in the technological advancement, it is easier for them to search and explore the lessons that help them understand the aspects or characteristics of the concept. As other teachers might also use images, models, and videos in explaining a concepts to the students which can make the concept of intangible becomes tangible. This makes students understand better the attributes or characteristics of the concepts.

However, since the concrete does not reach the very high level, it implies that other teachers might not give much attention in exploring the students, especially in experiments and activities where they can have real life experience with those concepts. Moreover, students may tend to memorize only those concepts and not have a deeper understanding about those concepts.

Furthermore, the qualitative data showed that students used the technologies in order to understand the concepts and usually memorize this in order simply recall the lessons. Addition to this, they tend to remember also those activities they have in their lower years related to Chemistry which help them able to understand and recall those concepts.

Discussant 4 stated that: *Personally, I cannot really understand sometimes the lessons especially at that time, we are still adjusting in the new normal. So, what I am doing is that I search the lessons in the Google and Youtube. Also, by recalling those activities that we did in our elementary and junior years related to chemistry helps me a lot. I guess, it is important to let us explore more on the experiments to have experience.*

Discussant 1: *As a student, we struggle really in understanding the concepts especially if teachers have a different strategies employed which are not suited to some of us. So, what I did is that, I also look for alternative ways to learn. I am also searching on the Youtube the lessons since it has some examples which you can see virtually and not just imagining in your head what it is.*

In the same way, Carstens et al. (2021), cited how technology has "helped them understand what they were talking about in class" by making it simple for students to search for and obtain information. This reinforces what is being learned in the classroom. They take pride in sharing their technologically mastered work and knowledge. Additionally, students are at ease utilizing technology and doing assignments. Their self-assurance enables them to develop learning motivation.

The students "moderate" degree of identity suggests that the STEM students may have difficulties in recognizing the define characteristics of a certain concepts. They might not be able to comprehend and gives distinction of the concept

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed / Refereed journal ⋇ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

among others and identify some pertinent instances that illustrate this concept. Students in this stage might not fully develop a clearer mental representation of the concepts which later impact in identifying examples under these concepts. This be because the new lessons being taught to them are so complex or difficult to understand, some of them find it difficult to identify the characteristics of the concepts and relate these new concepts to what they already know or retrieve or find examples under this concept.

This might be in this case because students may have difficulties in generalizing the lessons since it is more complicated than what students learned in junior high school because General Chemistry 1 is a difficult subject. As science classes learned through modules and other modalities, where knowledge is retained mostly in short-term memory and inadequate exposure to diverse examples or instances of the concept, without sufficient exposure to real-world examples, demonstrations, or experimentation, students may struggle to develop a clear understanding of what constitutes the concept. Because of this, students find it difficult to identify the distinct characteristics of the concepts from each other nor able to retrieve examples from their prior knowledge which is under these concepts.

The qualitative data gathered in the focus group discussion showed that the teaching method and instructional approach play a significant role in understanding the distinct characteristics of the concept and identify these concepts from the given examples nor recalling an example under the concept. Also, a weak foundation in the concrete stage and the lack of engagement and only giving few examples during the discussions took a great toll in the enhancement of the identity stage of the STEM students' conceptual learning.

Discussants iterated that:

Discussant 9: *I think the effectiveness of teaching method and instructional approach play a significant role in our conceptual learning. If teaching is focused in rote conversation or lack engagement, and there are only few examples given to us, we struggle to develop good conceptual understanding.*

Discussant 3: *One of the reason is the pandemic. Actually, it is really hard to study in a modular approach. There are things that I want to clarify but since it is not a face-to-face and I have no one to ask in our home, I just rely on the internet and sometimes just search for the correct answer without studying. So, when we have the face-to-face class, I find it difficult to understand the topic. Especially that it is more complicated or complex.*

This finding is supported by Piaget (1974), who claimed that children's abstraction from the concrete properties of objects and ideas is actually a transformational process that necessitates rearranging knowledge in their minds. Children therefore do not comprehend the abstract presentation of new knowledge until they internalize it, during the stage of transferring from concrete to abstract features.

A "moderate" level of classify suggests that there may be some challenges for students when it comes to generalizing of the concept into categories or groups. The fact that the classification did not reach the high level suggests that some of them may have difficulties in identifying the similarities and differences between various instances of the concept and could have some problems in developing mental frameworks for organizing their knowledge.

This could be as a result of teachers being unable to classify new information using the idea representation. Students struggle to gain the ability to generalize from specific cases to develop wider concepts that may be applied in new situations on their own when teachers fail to provide clear instructions or examples for classifications.

Applications also in real life scenario were taking for granted in which students could not be able generate an idea based on the given scenario. Furthermore, STEM students might not receive feedback on their performance and may only have limited opportunities to practice classifying the new information. Additionally, when students have a limited prior knowledge regarding a concepts, they will have a hard time to classify new information especially, if this information is very complex.

Additionally, the data gathered in the focus group discussion showed that students find it difficult to classify concepts during the class since they are confused because of the complexity of the lessons and cannot be understood sometimes how the examples are classified. Their teachers only give them few examples which are not enough for them to understand on what ground those examples become part of that certain group or how that example being considered as like that.

The following were the statements given by the discussants:

Discussant 7: *Personally, I find other subjects like General Chemistry very hard because I think I am not that comfortable on how our teacher teaches us that is why I cannot understand what is being discussed so what I do is I study it again at home or the next day. But because my way of learning is through listening, I have determined during our examination that I find it hard understanding the questions.*

Discussant 8: *I think the teaching technique of a teacher is a factor why the conceptual learning of the students is just moderate. Even though you listen to them, you cannot understand how they explain.*

Discussant 6: *Chemistry is a hard subject. But teachers sometimes makes it harder. I think, they need also to consider giving more examples where the lessons can be applied in real life. Activities also should be in hands-on application. This way, we can really observe and analyze the scenario.*

Beydoğan and Hayran (2015) also stated sensations perceived by multiple sensory organs add depth to perception and interpretation in cognition. While some individuals can internalize abstract and symbolic concepts thanks to concrete experiences, other who fail to do so regard abstract concepts to be only superficial words and phrases to be memorized instead of evaluating them as part of the perception process. When students are asked to explain a concept within a conceptual category, they demonstrate their understandings based on their personal perceptions and in their own words. However, when students are asked to remember only the process without explaining any conceptual categorization, they confuse concepts and generally forget them.

A “low” level of formalization implies that students are having hard time to express what they have understood regarding the concepts in a formal definitions, abstract language, or even using symbols. They somehow cannot accurately and systematically develop important background knowledge and apply it to building new knowledge and knowledge frameworks. Additionally, they may fail to discriminate new instances which involve analyzing specific characteristics or features to differentiate between different examples or categories. Lastly, they might not be able to grasp the idea thoroughly and adaptably which they can use in problem solving, deductive and inductive reasoning, hypothesis testing, cognizing cause and effect, and among others.

This is because they may not fully understand the characteristics they need to use in order to identify and classify the differences and similarities of a given example. Additionally, as students cannot fully adjust on the face-to-face in their Grade 11 and given the fact that they were bombarded with many activities, requirements, and subjects are very hard compared to others, they might be overwhelmed which leads to having difficulties in discerning the relevant information. Furthermore, students may have given a limited examples that lack of real life application and make them difficult to generalize their understanding to the new situation. Lack of guidance also in achieving the concrete, identity, and classification lead to a poor level of formalization stage.

In line with this, the qualitative data also revealed that students are having a hard time learning the lessons because of the modular approach during pandemic. The lack of guidance during this time have greatly impacted the foundation of knowledge of the students which leads them in having problems in successfully attaining the formative stage. Moreover, bombarded activities, less examples, and minimal application in real life in the conduct of activities were elaborated by the students.

Discussants statements during the FGD were as follows:

Discussant 1: *I also wanted to add up that since I, personally, is a student leader and also member of different clubs, I am bombarded with many deadlines and activities. Some of my classmates or other STEM students were the same in my case. So, we are trying our best to manage everything yet, we cannot deny that somehow, we really need to take some time to study especially in our major subjects.*

Discussant 6: *Chemistry is a hard subject. But teachers sometimes makes it harder. I think, they need also to consider giving more examples where the lessons can be applied in real life. Activities also should be in hands-on application. This way, we can really observe and analyze the scenario.*

Discussant 3: *One of the reason is the pandemic. Actually, it is really hard to study in a modular approach. There are things that I want to clarify but since it is not a face-to-face and I have no one to ask in our home, I just rely on the internet and sometimes just search for the correct answer without studying. So, when we have the face-to-face class, I find it difficult to understand the topic. Especially that it is more complicated or complex.*

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Beydoğan and Hayran (2015) cited that some people absorb new information quickly during interactions, whereas others take longer to digest, incorporate, and organize new information in their brains. Concrete conceptual knowledge is given differently and with less qualification than conceptual knowledge based on abstractions, which is why there is a difference.

Level of scientific reasoning of STEM students

The data in Table 4 show the “low” level of scientific reasoning of the STEM students of public schools in the province of Capiz a mean of 8.73 and standard deviation of 4.71. To be more specific, the hypothetical-deductive reasoning (M=2.48; SD=1.21) is “high” while the identification and control of variables (M=2.16; SD=1.22), probabilistic and combinatorial reasoning (M=1.46; SD=1.00), proportional reasoning (M=1.37; SD=0.98), and conservation (M=1.27; SD=0.95) are all “low”.

Table 4

Mean and Standard Deviation of Scientific Reasoning

Variable	Mean	Description	SD
Scientific Reasoning	8.73	Low	4.71
Conservation	1.27	Low	0.95
Proportional Reasoning	1.37	Low	0.98
Identification and Control of Variables	2.16	Low	1.22
Probabilistic and Combinatorial Reasoning	1.46	Low	1.00
Hypothetical-Deductive Reasoning	2.48	High	1.21

Scale	Description	Scale	Description	Scale	Description
19.21-24.00	Very high	3.21-4.00	Very high	4.81-6.00	Very high
14.41-19.20	High	2.41-3.20	High	3.61-4.80	High
9.61-14.40	Moderate	1.61-2.40	Moderate	2.41-3.60	Moderate
4.81-9.60	Low	0.81-1.60	Low	1.21-2.40	Low
0.00-4.80	Very low	0.00-0.80	Very low	0.00-1.20	Very low

The findings indicate that STEM students have poor scientific reasoning abilities, which suggests that they struggle to make connections between scientific theory and observed occurrences in order to forecast potential consequences. Students are having a hard time using logical operations associated with concrete reasoning from their experiences especially in the principles of conservation of mass and volume. Additionally, they also have difficulties in the area of proportional relationships which involve mathematical concepts. Students also have problem in recognizing, manipulating, and controlling variables and understanding as well as applying the concepts to determine the relationships of the variables in a certain problem.

It can be the case that, STEM students received very little guidance on how to build critical thinking abilities and are occasionally not given enough chances to investigate and produce scientific reasoning. Furthermore, it is possible that students will not receive as many opportunities to practice Higher Order Thinking Skills (HOTS). The STEM students' ability to reason and the conclusions drawn from their reasoning were further restricted by the fact that some of the teachers continued to emphasize memorizing of facts, processes, and rote learning.

The development of scientific reasoning is greatly aided by the use of instructional strategies, approaches, models, and methods because these activities entail the generation, testing, and revision of hypotheses as well as decision-making in problem-solving. Students' exercises and practice were inadequate, and in certain instances, the use of scientific reasoning was taken for granted. Since it is a fact that some teachers hardly ever provide real-life scenarios in which students are unable to apply scientific reasoning, the way the teacher evaluates the scientific reasoning may have an impact on the outcome. Additionally, there is a dearth of experience in drills and activities that could improve students' scientific reasoning.

DOI: 10.17148/IARJSET.2024.111204

It is also observed that students are becoming so reliant on technology that they take the assignments and performances their teachers assign to them not seriously. Additionally, a crowded setting hinders STEM students' ability to develop their scientific reasoning. Education system also affects students' ability to reason scientifically and prolonged exposure to memorization of facts would cause the students to develop weak cognitive thinking skills and poor scientific reasoning abilities. Lastly, it cannot deny the fact that pandemic is one of the reason of this low level since students cannot explore and are not exposed to the problems and practices which use scientific reasoning or applying this skill.

However, STEM students have the high capability to formulate hypotheses which was enhanced through interaction, sharing of scientific idea, and findings since the capacity to formulate and test hypotheses is essential for knowledge advancement and the comprehension of natural occurrences in many scientific fields. This is because students tend to be involved in group activities where they share some scientific information that lead them clearer understanding and since the K–12 grading system assigns a higher percentage of performance marks and most performances are completed in groups. This outcome could also be attributed to the students’ desire in studying.

The qualitative data gathered during the FGD showed that commonly, students memorized only the lessons without thinking it critically which makes them hard to establish skills in scientific reasoning. Additionally, teaching strategies as well as facilities to be used play an important role in developing this skill. Since some of them are having a hard time understanding what their teacher is discussing. Also, the lack of interest of the student makes the situation not even better. It was also found out that students tend to share their own understanding of a lessons which leads them to improve their hypothetical-deductive reasoning when teachers provide activities which are applicable in real life scenario.

During FGD, discussants stated that:

Discussant 2: *The challenge is that students nowadays are focused in memorization and it can hinder their scientific reasoning. It limits students’ capability for critical thinking and application of the knowledge. It is a disadvantage for students to rely on memorization.*

Discussant 3: *For me, the subject is already difficult but it becomes more difficult depending on how the teacher facilitates learning. Also, the lacking facilities in our school which hinders us in the application of what we have learned.*

Discussant 5: *Teaching strategies really plays an important role in developing our scientific reasoning. When they give us activities which are applicable and we can relate, I think, it would really improve our scientific reasoning. Because as what I have observe, when we can relate on the topics, each one of us can share our own thoughts which is very good as we understand the lessons better.*

This is in line with the results in the study by Daryanti, Rinanto, and Dwiastuti (2015) as they assessed students' scientific thinking abilities and found that they were still lacking. The research conducted by Rimadani, Parno, and Diantoro (2017) indicates that students' scientific reasoning abilities are still lacking. Teachers should be able to improve the quality of instruction in schools to satisfy the requirements of this scientific reasoning profile by putting the right learning models and techniques into place.

Mariana, Siahaan, and Utari (2023) cited that it is essential to design courses that help students advance their capacity for reasoning, thinking, and problem-solving. By doing this, students can better prepare to design experiments and communicate science to others.

In terms of conservation (mass and volume) the level was “low” which indicates that STEM students struggle to understand and apply the principle of conservation of mass and volume. In specific manner, STEM students may have difficulties on realising that when a solid body is transformed, its quantity of matter and its weight and volume remain unaffected. They also having a hard time using logical operations associated with concrete reasoning from their experiences. This is maybe because they do not fully understand the concept and implication of conservation of mass and volume. They may not also interested learning deeply the conservation of mass and volume. Additionally, even they know the concept, they might have a hard time how the conservation of mass and volumes apply in the real world context. Furthermore, the lack of practice or activities given by the teacher with regard to conservation of mass and volumes play also a significant role in the low level.

It was elaborated in the data gathered during FGD that the limited activities, disinterested in the topic, and the teaching techniques of the teachers lead them to have a low scientific reasoning.

DOI: 10.17148/IARJSET.2024.111204

The following discussants iterate that:
Discussant 4: *I think it is because we are not also given lots of activities that could enhance our scientific reasoning.*

Discussant 1: *First is the lack of interest. Honestly, I find it boring and hard. Next is teaching technique, especially when you have traditional teachers, so you will find it new compared to your teachers who uses modern technologies when teaching. Another is when what comes out from the tests are lessons that were not taught.*

The "low" proportional reasoning of the STEM students indicates that they struggle in understanding, applying, and reasoning about the proportional relationships. They might not understand deeply the relationships between quantities where one quantity changes, the other changes in a predictable and consistent ratio. This might be because students might have a weak foundation in mathematical concepts. Since proportional reasoning involves with ratios, fractions, and percentages, they might struggle with these concepts which make them difficult to reason about proportional relationships. Additionally, students also have a limited problem solving skills. They tend to answer only the questions without identifying and applying the appropriate strategies to solve problems. Also, limited examples and practice regarding the proportional reasoning may impact their performance. Furthermore, with limited knowledge that they have in their junior high school, it might really understandable that they will have a low level of proportional reasoning.

Moreover, it was showed in the quantitative data that students have a weak knowledge foundation which makes them foresee the test as really hard which leads them unable to analyze the questions.

Discussants explained that:
Discussant 6: *Actually, the test in scientific reasoning is really hard. Honestly, I just answered it without really analyzing the questions.*

Discussant 7: *I am also guilty about just answering it without analyzing the questions. The questions are hard actually. I think, it has something to do also of what foundation we have in our junior high school. I am trying to be competent student since subjects in our strand are very hard but, I find it difficult when there are concepts which needs to have a prior knowledge.*

The study of Bhaw, Kriek, and Lemmer (2022) finds that the lowest performance occurred in the proportional reasoning dimension while findings of lowest performance in the proportional reasoning dimension is in agreement with Hrouzkova and Richterek (2021). Student responses indicate a need for more understanding of the multiplicative nature of proportionality. Even though students may report that one variable is directly proportional to another, they need to comprehend what it means. They also do not realise that proportionality exists only on the condition that all other possible variables are constant.

The "low" level of identification and control of variables implies that STEM students cannot recognize, manipulate, and account variables which can affect the result of an experiment of observation. This might be because STEM students cannot determine the independent, dependent, and extraneous variables in the problem. They may also have limited experimental experience which leads them to struggle in careful planning and consideration of the potential causes of error or biases. They might also have difficulties in controlling the variables involve.

These can be also connected to the teaching strategies, exposure of students in the tangible and non-tangible materials related to experiments and also the unavailability to explore experimentation in their lower years due to pandemic.

The data gathered during the focus group discussions showed that pandemic greatly affected in their level of scientific reasoning. With a weak foundation of knowledge, students are having a hard time in learning specially that, science is not only about theories but also in the application in real life scenarios. The lack of materials, activities, and practice especially in the experimentation also impacted their low scientific reasoning.

Discussants shared during FGD that:
Discussant 8: *For me, it was because of the pandemic. I know it sounds cliché but it really impacted how well we are performing during face-to-face classes. It is not really easy to just have a high level of scientific reasoning when we are still taking baby steps towards progress after the pandemic. It takes a lot of time to progress well.*

Discussant 11: *One of the challenges is that Science is not only in theoretical learning but also to application, which makes it hard for us to study subjects related to science. And also, the access to materials for activities so we cannot really practice the application of the subject. Especially during experimentation.*

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⅙ Peer-reviewed / Refereed journal ⅙ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

The study of Bhaw, Kriek, and Lemmer (2022) states that across all reasoning dimensions, the student's responses indicate an inadequate scientific reasoning ability, particularly in the control of variables dimension. Only a third of students knew how to control variables scientifically in the formal physics context of the single pendulum. Most students did not keep the weight constant in determining the relation between the length and period of a pendulum. This lack of understanding of constant variables is also evident in the poor performance of questions related to the volume of a marble. Additionally, the quantity of water remains the same before and after submerging the marble into the water. Only the question related to the shape change indicated any positive measure of scientific reasoning ability.

A "low" level of probabilistic and combinatorial reasoning indicates that students may have hard time in understanding and applying the concepts to determine the relationships of the variables in the problem. They may have limited exposure to the real-life world scenarios or applications concerning to probabilistic and combinatorial reasoning. Additionally, with limited opportunities to practice the application of probability concepts in a different contexts, they may struggle to apply their understanding in a new situation.

Additionally, since the probabilistic and combinatorial reasoning requires analytical reasoning, critical thinking, and problem solving skills, students may also have a weak foundation of these skills. Furthermore, teachers might gave little attention to activities and performances which could enhance their probabilistic and combinatorial reasoning.

The data revealed in the qualitative that students tend to focus on memorization which limits their critical thinking ability and application of this knowledge. Additionally, with a limited amount of activities which were given to the students makes them having difficulties in developing scientific reasoning.

As discussants stated that:
Discussant 2: *The challenge is that students nowadays are focused in memorization and it can hinder their scientific reasoning. It limits students' capability for critical thinking and application of the knowledge. It is a disadvantage for students to rely on memorization.*

Discussant 4: *I think it is because we are not also given lots of activities that could enhance our scientific reasoning.*

Zulkipli et al. (2019) concluded that the mastery of scientific information processing skills is crucial in carrying out scientific investigation such as in carrying out experiments and projects. Education system also affects students' ability to reason scientifically and prolonged exposure to memorization of facts and procedural knowledge in teaching would cause the students to develop weak cognitive thinking skills and poor scientific reasoning abilities.

The "high" level of hypothetical-deductive scientific reasoning indicates that STEM students have the ability to formulate hypotheses. This might be because they tend to interact with others and shares scientific idea, hypothesis, and findings. They may also able to articulate their ideas and collaborate these to others to have a clearer explanation. Additionally, being inquisitive and have the intrinsic motivation to understand concepts in science may lead them to engage in scientific inquiry and hypothesis testing. They may commonly ask questions, seek new ideas and answers. Additionally, with the aid of technology, they may explore on different videos which lead them to develop ability in hypothesis testing and scientific inquiry.

Qualitative data also revealed that when activities given to them are relatable, they can share what they think to each other make their learning better. Additionally, during group activities, they collaborate their ideas with each other which enhance their capability to formulate hypothesis.

The following were the statements stated by the discussants:
Discussant 5: *Teaching strategies really plays an important role in developing our scientific reasoning. When they give us activities which are applicable and we can relate, I think, it would really improve our scientific reasoning. Because as what I have observe, when we can relate on the topics, each one of us can share our own thoughts which is very good as we understand the lessons better.*

Discussant 10: *I think it is because we are not that given lots of activities which we can explore on our own. Sometimes, teachers are just focus on finishing the topics by just purely discussions. For me, as what I have experienced, it is better to have a more group activities where we can collaborate with each other and that we can learn better.*

The result also inclined to the study of Pratama and Supriyatman (2021) where they said that the factors which affect students' hypothetical-deductive reasoning abilities include the learning process carried out during the implementation of

DOI: 10.17148/IARJSET.2024.111204

the particle dynamics learning and teaching. The classroom activities are always conducted in groups. In this case, the teacher elaborates a problem and students are expected to discuss to solve the problem in groups. After that, the representatives from each group explain the result of their discussion in front of the class. This can lead to promoting hypothesis deductive reasoning abilities.

Inferential Data Analysis
Difference in Scientific
Reasoning Among the Levels
of Metacognitive Strategies

The data found in Table 5 shows the result of Analysis of Variance on the difference of scientific reasoning among the levels of metacognitive strategies of the STEM students.

The result shows that there is no significant difference in scientific reasoning among the levels of metacognitive strategies of the STEM students in the public schools in the province of Capiz with F (2)= 0.094^{ns} p > 0.05 in 0.91 significant difference value.

Table 5
Analysis of Variance of Scientific Reasoning Among the Levels of Metacognitive Strategies

Source of Variation	SS	Df	MS	F	Sig.
Between Groups	4.18	2.00	2.09	0.094^{ns}	0.91
Within Groups	6903.20	309.00	22.34		
Total	6907.39	311.00			

* p<0.05 significant @ 5% alpha level

ns p>0.05 not significant @ 5% alpha level

The fact that there is no discernible difference in the scientific reasoning of STEM students with varying levels of metacognitive strategies suggests that there is no variation in the students' scientific reasoning ability regardless of their metacognitive strategy level.

In other words, it is hard to dispute that STEM students do poorly on an equal basis, even when various metacognitive methods are applied to variable degrees. This is true even if they may find it easy to get over challenges they encounter during learning, even though they are more aware of what, how, and when they can acquire knowledge.

Furthermore, the outcome offers compelling evidence that a high degree of scientific reasoning cannot be guaranteed by possessing a high level of metacognitive strategies. The findings ensure that STEM students with high metacognitive skills still struggle with critical thinking when solving problems involving conservation, proportional reasoning, variable identification and control, probabilistic and combinatorial reasoning, and hypothetical-deductive reasoning.

Discussant 5 stated that*: I am most comfortable in learning through auditory learning, and read and write. Since we are now learning through visual learning as we are now living in the 21st century wherein teachers use PowerPoint presentations which improves our visual. And for me, through learning when I listen or writes it down, I can memorize it more. However, sometimes, I cannot perform well especially those questions which needs to reason out. Maybe because I focus more in memorization.*

Discussant 6: *For me the successful technique is memorizing using keywords and listening while the teacher teaches. As well as practicing or self-test which had been effective for me since my elementary days. But then, I encounter difficulties sometimes especially those questions which needs a critical thinking because I am not comfortable with the teaching strategies of my teacher.*

Discussant 8: *Self-explanation is one my technique in explaining concepts to myself and deepens my understanding and retention. I use mnemonic devices such as acronym and rhymes which have been great for remembering list of sequences. Visualization techniques like creating mental images or diagrams which aids memorization and understanding. And also watching educational videos that suits to our topic.*

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⪤ Peer-reviewed / Refereed journal ⪤ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

This study's findings were consistent with those of Limueco and Prudente's (2018) investigation, which found that students' metacognitive awareness levels are evenly distributed across the six grade levels and that those with high awareness typically had relatively strong scientific reasoning abilities.

Aljaberi and Gheith (2015) noted that learners are able to define the problem, choose appropriate solution strategies, monitor how effective this strategy solution is, and both recognize and act on constraints while solving the problem, all with the aid of metacognitive skills. Regardless of whether the problem is mathematical or scientific, it still requires a person to decide which strategy is needed and come up with a solution, and metacognition is thought to be a crucial component of problem solving success.

Hence, the hypothesis stated that there is no significant difference in scientific reasoning among the levels of metacognitive strategies of STEM students is accepted.

Difference of Scientific Reasoning Among the Levels of Conceptual Learning

Table 6 shows the analysis of variance in the scientific reasoning among the levels of conceptual learning. Statistical analysis showed that there is a significant difference the scientific reasoning among the levels of conceptual learning with F (2)= 13.685* p < 0.05 in 0.000 significant difference value.

Table 6

Analysis of Variance of Scientific Reasoning Among the Levels of Conceptual Learning

Source of Variation	SS	Df	MS	F	Sig.
Between Groups	1045.25	4.00	261.31	13.685*	0.000
Within Groups	5862.13	307.00	19.10		
Total	6907.39	311.00			

* p<0.05 significant @ 5% alpha level

ns p>0.05 not significant @ 5% alpha level

The findings indicate that there are notable variations in scientific reasoning across conceptual learning levels. This suggests that there are differences in the scientific reasoning level of STEM students with respect to conceptual learning. This indicates that, in comparison to other students, those with a high conceptual learning likely to have a high scientific reasoning. As STEM students gain a thorough understanding of concepts in science, they often hone and refine their scientific reasoning skills as well. Additionally, the result indicates that some students who are not excelling in understanding the concepts and theories may have difficulties with the application of the critical and logical thinking as well as ability in problem solving in science while those who have the deep understanding of concepts may have a higher level of scientific reasoning.

It is noteworthy that in addition to learning various science concepts, students are exposed to a variety of exercises and activities that could improve their capacity for scientific reasoning.

Discussant 11 stated that: *I think there is a lack on the basic foundation of learning, like understanding of prerequisite topics. Because there are students who tend to lose certain concepts that they cannot understand.*

Discussant 4: *With my assessment, I am weak when it comes to comprehension and I need to improve further because it is a bit alarming for me that the level of our comprehension is only moderate. If I cannot understand it, I ask help from my sibling. Then, I list down the words I cannot understand, find the meaning and use it in sentences.*

Discussant 7: *I find particularly successful in learning when I take down notes and summarize the context that I have to study. I can understand better in my own way the definition and I can memorize faster the words or lesson. I give time when to study, and I usually do it at night which is I find effective for me and depending on the level of difficulty and on how much should I study for my subjects.*

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⪤ Peer-reviewed / Refereed journal ⪤ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Taduran and Monterola's (2017) study's findings, which showed that pupils with strong reasoning skills had greater conceptual knowledge, provide credence to the arguments made. In addition, students with average reasoning skills outperformed pupils with low reasoning skills in their conceptual comprehension exam.

Furthermore, Zulkipli et al. (2019) cited that students will be influenced differently by the various science disciplines, especially with regard to how they gather and arrange data. This would have an impact on how pupils interpret data while using scientific reasoning.

Hence, the hypothesis stating there is no significant difference in scientific reasoning among the levels of conceptual learning of STEM students is rejected.

Relationships among metacognitive strategies, conceptual learning, and scientific reasoning

Table 7 shows the result of Pearson r on the relationships among metacognitive strategies, conceptual learning and, scientific reasoning of the STEM students of the public schools in the province of Capiz. Result shows that there is no significant relationship between metacognitive strategies and conceptual learning r= 0.013^{ns} p > 0.821 and metacognitive strategies and scientific reasoning r= 0.008^{ns} p > 0.888 while there is a significant relationship between conceptual learning and scientific reasoning r= 0.352* p < 0.000.

Table 9

Pearson r Among Metacognitive Strategies, Conceptual Learning and, Scientific Reasoning

Variables	r	Sig
Metacognitive Strategies and Conceptual Learning	0.013^{ns}	0.821
Metacognitive Strategies and Scientific Reasoning	0.008^{ns}	0.888
Conceptual Learning and Scientific Reasoning	0.352*	0.000

* p<0.05 significant @ 5% alpha level

ns p>0.05 not significant @ 5% alpha level

There is no discernible connection between STEM students' conceptual learning and metacognitive techniques. This essentially indicates that students' conceptual learning is unaffected by the metacognitive techniques they use. Although they have a high metacognitive strategies, students may still have a moderate level of conceptual learning since there are several factors to be considered. Students' conceptual learning can be affected by their prior knowledge, the teaching strategies, experiences, and also the modular approach during the pandemic. Moreover, the learning environment, availability of learning materials, and school activities may have an impact also and not the metacognitive strategies on the conceptual learning of the students.

Additionally, students' interests may also have a role in their moderate level of conceptual learning. This is because students who are highly engaged in a lesson are more likely to be motivated to learn more about science. In other words, a high level of metacognitive strategies does not necessarily indicate that the students' conceptual learning will be impacted.

Discussant 2 stated that*: The facilities and classroom environment also affects the outcome of the conceptual learning. Since we cannot focus on the lessons being discussed when the classroom is not well ventilated and well lighted. It is also important that our teacher consider our different learning styles.*

Discussant 1: *For me, I analyze the information I am interested with, then I study the subject I am most interested with to the less interesting one. I find it hard to balance my time management. If I have a lot of works to do including not school related activities, it could be a factor in applying my strategies for planning.*

Discussant 5*: I assess first my strength, if it is memory, attention, problem solving or critical thinking and which is more appropriate cognitive activities for me. And what works for me is when I study before I go to sleep. Then I visualize in*

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁒ Peer-reviewed / Refereed journal ⁒ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

my mind what I need to study because I love it better if it is arranged orderly and I tend not to forget it but rather remember the mental images I made.

Discussant 4: *With my assessment, I am weak when it comes to comprehension and I need to improve further because it is a bit alarming for me that the level of our comprehension is only moderate. If I cannot understand it, I ask help from my sibling. Then I list down the words I cannot understand, find the meaning and use it in sentences.*

This is also true, as stated by Rillero (2016), who noted that although individuals may have a preference for deep or superficial learning, the learning environment can influence the method of learning. Surface learning results from evaluations that concentrate exclusively on minute details, time constraints, and cramming information in order to perform well on exams. Curiosity about a subject can lead to DCL in learning contexts with abundant resources, welcoming classroom cultures, suitable workloads, and well-organized curricula. According to Goldspink and Foster (2013), curriculum and instructor influence on student engagement levels may play a significant role in fostering DCL. Additionally, the study of Zulkipli et al., (2019) states that pupils have shown a greater degree of memory as opposed to making understanding-based content judgments. It goes without saying that prolonged exposure to these thought processes will lead to the low development of conceptual comprehension, cognitive thinking abilities, and effective reasoning.

The lack of a significant correlation between students' scientific reasoning and metacognitive strategies indicates that even if a student's level of metacognitive strategies may be high, it does not necessarily translate into a low level of scientific reasoning. This could be because even though students used their metacognitive strategies in learning, there are underlying factors to be considered. One of these is the lack of practice of the students in critical thinking which involves conservation, proportional reasoning, identification and control of variables, and probabilistic and combinatorial reasoning.

Additionally, the weak foundation of knowledge with these different types of reasoning can also be considered. Additionally, the instructional methodologies used, the failure of real-world application, reliance on technology, and motivation may also have an impact on the scientific reasoning of STEM students.

Discussant 9 stated that: *I also do active learning during the lecture and I use skimming and scanning techniques that can help me to identify important information efficiently. And also engaging in active reading is an essential technique to determine underlying key points, and also summarizing paragraphs in my own words. But then, due to many school works, teaching strategies of the teacher, and also the classroom environment (which now, we experienced extreme hot weather condition), I find it sometimes hard to understand the lessons, especially those which needs deep critical thinking.*

Discussant 2: *I determine the appropriateness of my cognitive activities based on factors such as requirements, available resources and current level of my understanding. By evaluating the demands of the situation and potential challenges, I can adjust my performance and learning outcomes.*

The outcome was in contrast to that of a study by Limueco (2018), which found a strong positive correlation between scientific reasoning and metacognitive awareness and suggested that the Philippine K–12 science curriculum may have contributed to this. The concepts in the various levels are quite similar to one another and only differ in terms of difficulty and complexity, following a spiral trend. It is claimed that content learning and scientific reasoning are related. Students' scientific thinking gets better as they gain knowledge (Ding, 2013).

The significant relationship between conceptual learning and scientific reasoning indicates that the conceptual learning positively influence the scientific reasoning and vice versa. This implies that the learned concepts of the students are being used in the scientific reasoning of the students. This is may be because STEM students need to learn first the concepts in science before having the ability to reason out scientifically. As learning the concepts will give an idea to the students on what is the correct way of analysing the situation given in the scientific reasoning. Furthermore, it is important to note that concepts being tackled in the lesson were all about science, it cannot be deny the fact that concepts learned by the students will greatly impact their scientific reasoning.

During the conduct of the FGD, discussants stated the following:

Discussant 1: I really try to learn what I find difficult. I try to find the beauty of the subject but I think it is really not my forte. But as a student we really need to comply. Maybe the subject is not given enough importance without knowing that it is an essential subject for STEM students. I can suggest that it should be given equal importance just like with other applied subjects.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Discussant 11: One of the challenges is that Science is not only in theoretical learning but also to application, which makes it hard for us to study subjects related to science. And also, the access to materials for activities so we cannot really practice the application of the subject.

The finding corroborated what Richterek (2021) cited which states that for science, technology, engineering, and math (STEM) students to be able to successfully complete open-ended real-world activities in their future jobs, they must possess general scientific abilities. Developing broad scientific skills and strengthening content knowledge are two of the teaching objectives in STEM education. Scientific reasoning is one such skill that is connected to cognitive skills like reasoning and critical thinking. Skills in scientific reasoning can be conveyed and enhanced through training. Long-term student academic progress may also benefit from training in scientific thinking.

Furthermore, Taduran and Monterola's (2017) study's findings demonstrated a positive correlation between scientific reasoning and conceptual knowledge in physics. The average scientific mastery of Filipino pupils was demonstrated by their 2009 National Achievement Test results. The incapacity of certain students to understand the ideas taught in high school may stem from their deficiency in scientific reasoning skills.

Hence, the hypothesis stated that there is no significant relationships between metacognitive strategies and conceptual learning and metacognitive strategies and scientific reasoning is hereby accepted. On the other hand, in terms of conceptual learning and scientific reasoning of the STEM students, the null hypothesis is hereby rejected.

IV. CONCLUSION

1. Most of the STEM students have a high metacognitive strategies which would help them learn their lesson quickly. This could be able to understand better the lessons they take in their classes which they could apply in the real life scenario. STEM students are aware of how to use metacognitive thinking strategies, as well as how to evaluate these strategies and their own personal education process, in addition to the ability to use the necessary strategies to fix mistakes during problem solving. Students also understand what is the most fitting method or strategies they will utilize or appropriate in a certain situation. And so, they are continually developing and monitoring their learning strategies based on their evolving self-knowledge. This could lead them to have a better adaptation on a certain scenario where they need to adjust. Thus, making them versatile not only in learning the lessons but also in the problems and challenges that they may encounter in life. Additionally, as students know how to correct the performance and comprehension errors in the process of learning, it only means that they have a self- awareness and open –mindedness to spot on the problem and solve it on their own. Hence, making them not only academically good but also competent in life.

On the other hand, since the planning and comprehension monitoring got the moderate level, they have difficulty in deciding when and why to use a certain strategy, and a lack in the ability of organizing information. Students may encounter difficulties in goal setting and allocating resources prior to learning as well as their learning process or strategy used which lead them to have problems in comprehending the lessons as well as identifying the steps to take before studying or learning to have a better learning. When the level cannot be improve, there is a possibility that they will encounter challenges in perform well in class.

2. As students have a moderate conceptual learning, this may signifies that they have difficulties in learning the concepts in science. When students faced difficulties while learning, this could greatly affect not only the absorption of knowledge and their academic performance but also the skills they needed in the higher level of academe. Additionally, they cannot excel well in classes which greatly affects the higher level of their thinking skills. Thus, having a hard time solving problems related to science and science related topics and eventually, in real life challenges. Furthermore, they may be struggling to have the competency required in scientific fields.

3. The STEM students have a low scientific reasoning which may implies that they have difficulties in reasoning scientifically. Students may find it hard to solve problems that calls for critical analysis of procedural, content, and epistemic knowledge. This problem unable them to perform well in science related problems which will greatly impact their performance specifically in their specialized subjects since the mastery of scientific information processing skills is crucial in carrying out scientific investigation such as in carrying out experiments and projects. When this level cannot be improve, there is a possibility that STEM students will have a lower performance in science as they will encounter difficulties in processing different problems and mathematical solutions. Additionally, as scientific reasoning is very crucial in performing experiments, analyzing data, and formulating conclusions, STEM students cannot perform well in their chosen career which is related in their strand.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

Teachers will exert more effort to discuss, introduce, and scientific reasoning to the students. Furthermore, it is hard for the students to adjust to the lessons due to the fact that he or she lack skills expected of them to possess. Additionally, this will also lead them to become demotivated and possibly shift into courses not aligned in their strand.

4. The different metacognitive strategies that the STEM students have, is not integrated and applied in their scientific reasoning. This can be concluded that students are still poor in scientific reasoning regardless of being highly aware of their metacognitive strategies. With regard to this situation, this can lead in exploring the factors that exists, the strategies employed by the teachers, and individualize learning methods of the students in order to give solution and avenue for the improvement of the scientific reasoning.

5. The significant difference in scientific reasoning among the levels of conceptual learning of STEM students shows that with the conceptual learning that the students have, they will be able to have a better scientific reasoning. This can be concluded that when students learned deeply the concepts, they can have a deeper critical thinking, problem solving, and hypothetical judgement. With this, students could be able to excel in the future. However, since the conceptual learning of the students was moderate and the scientific reasoning was low, some students may have some difficulties in their performances especially in Science related subjects. Hence, making it hard for them to compete in others in their higher degree.

6. The high metacognitive strategies do not necessarily affect the conceptual learning of the students. Being aware of the most appropriate method to be used, able to assess the process of learning or strategy, and able to correct comprehension and performance errors do not fully influence the students learning of the concepts in science. This can be concluded that it is still on the interest of the students, learning environment, teaching strategies, and hands-on activities make the learning of the students in the concepts of science better. Hence, considering these factors and not solely in the metacognitive strategies could help students learned better about concepts in science.

The metacognitive strategies do not influence the scientific reasoning of the students. The no correlation between the two means that it is not necessarily to be dependent on the metacognitive strategies to have a high scientific reasoning. Students who highly utilized different metacognitive strategies cannot guarantee that they are capable of having a logical and critical thinking abilities. It is also noteworthy that the practice the scientific reasoning ability of the students regularly, teaching strategy of the teachers, and motivation of the students will help improve the scientific reasoning of STEM students.

The positive correlation between conceptual leaning and scientific reasoning means that the higher the conceptual learning, the higher the scientific reasoning of the students. In dealing with science, students must utilize the concepts that they have acquired to have a better scientific reasoning. It is hard for the students to have a logical and critical thinking abilities without the science concepts that were introduced and taught to them. If students have a higher conceptual learning, there is a big chance for them to reach higher and more complicated scientific problems.

REFERENCES

[1]. Abdul Wahab, N., Othman, J., & Warris, S. N. (2016). Blended learning in higher education: An overview. e-Academia Journal UiTMT, 5(2), 115–122. Retrieved from https://journale-academiauitmt. uitm.edu.my/v2/images/vol5issue2/CRPID49-BLENDEDLEARNING.pdf. Accessed March 2020.
[2]. Aljaberi, N.M. and Gheith, E. (2015). University students' level of metacognitive thinking and their ability to solve problems. American International Journal of Contemporary Research; 5 (3): 121-134
[3]. Anthonysamy, L., Koo, A-C., Hew, S.-H. (2020). Self-regulated learning strategies and non-academic outcomes in higher education blended learning environments: A one-decade review. Education and Information Technologies, 1–28. https://doi.org/10.1007/s10639-020-10134-2.
[4]. Ata, A.A.,Elsayed-El, A., and Abdelwahid, A. (2019). "Nursing Students Metacognitive Thinking and Goal Orientation as Predictors of Academic Motivation," American Journal of Nursing Research, vol. 7, no. 5, pp. 793–801, Jul. 2019, doi: https://doi.org/10.12691/AJNR-7-5-12.
[5]. Aurah, C., Cassady, J. and McConnell, T. (2014). Predictingproblem solving ability from metacognition and self-efficacy beliefs on a cross validated sample. British Journal of Education; (2)1: 49-72.
[6]. Baird, B., Smallwood, J., Gorgolewski, K. J., & Margulies, D. S. (2013). Medial and lateral networks in anterior prefrontal cortex support metacognitive ability for memory and perception. Journal of Neuroscience, 33(42), 16657 -16665.
[7]. Beydogan, H. Ö. & Hayran, Z. (2015). The effect of multimedia-based learning on the concept learning levels and attitudes of students. Eurasian Journal of Educational Research, 60, 261-280 Doi: 10.14689/ejer.2015.60.14

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⪤ Peer-reviewed / Refereed journal ⪤ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111204

[8]. Bezci, F., and Sungur, S. (n.d.) How is Middle School stud-ents' Scientific Reasoning Ability Associated with Gender and Learning Environment?. Science Education International 32(2), 96-106 https://doi.org/10.33828/sei.v32.i2.2

[9]. Boser, U. (2018). Learning Is a Learned Behavior. Here's How to Get Better at It. Retrieved December 04, 2020, from https://hbr.org/2018/05/learning-is-a-learned-behavior-heres-how-to-get-better-at-it? utm_medium=social.

[10]. Broadbent, J., and Poon, W. L. L. (2015). Self-regulated le-arning strategies & academic achievement in online higher education learning environments: A systematic review. Internet and Higher Education, 27, 1–13. https://doi.org/10.1016/j.iheduc.2015.04.007.

[11]. Bursalı, N. and Öz, H. (2018). "The role of goal setting in metacognitive awareness as a self-regulatory behavior in foreign language learning," International Online Journal of Education and Teaching (IOJET), vol. 5, no. 3, pp. 662–671, Accessed: April 1, 2024 [Online]. Available: http://iojet.org/index.php/IOJET/article/view/455/260

[12]. Cahyaningrum, R. (2019). Lawson Instrument: Analyzing Studen-t's Scientific Reasoning Skill in Junior High School. Advances in Social Science, Education and Humanities Research, volume 349.

[13]. Cai, Y., King, R. B., Law, W., & McInerney, D. M. (2019). Which comes first? Modeling the relationships among future goals, metacognitive strategies and academic achievement using multilevel cross-lagged SEM. Learning and Individual Differences, 74(June). https://doi.org/10.1016/j.lindif.2019.06.004

[14]. Carstens, K., Mallon, J., Bataineh, M., and Al-Bataineh, A. (2021). Effects of Technology on Student Learning. https://files.eric.ed.gov/fulltext/EJ1290791.pdf

[15]. Center for Teaching Innovation. (2023). https://teaching.cornell.edu/teaching-resources/teaching-cornell-guide/teachig-strategies/metacognitive-strategies-how-people

[16]. Cera, R., Mancini, M. and Antonieti, A. (2013). Relationship

[17]. between metacognition, self-efficacy and self–regulation in learning. Journal of Educational, Cultural and Psychological Studies; 7: 115-141

[18]. Chen, M.-H. (2015). Fostering L2 speaking and thinking through a HOT approach. Curriculum & Instruction Quarterly, 18(4), 193-225.

[19]. Cho, M. H., and Heron, M. L. (2015). Self-regulated learning: The role of motivation, emotion, and use of learning strategies in students' learning experiences in a self-paced online mathematics course. Distance Education, 36(1), 80–99. https://doi.org/10.1080/01587919.2015.1019963.

[20]. Daryanti, E. P., Rinanto, Y., and Dwiastuti, S. (2015). Penin-gkatan Kemampuan Penalaran Ilmiah Melalui Model Pembelajaran Inkuiri Terbimbing pada Materi Sistem Pernapasan Manusia. Jurnal Pendidikan Matematika dan Sains 3 2 163-168

[21]. De Luna, S. (2014). Learning and transfer in hierarchically structured concept attainment tasks.

[22]. Deschacht, N., & Goeman, K. (2015). The efect of blended lea-rning on course persistence and performance of adult learners: A diference-in-diferences analysis. Computers and Education, 87, 83–89. https://doi.org/10.1016/j.compedu.2015.03.020.

[23]. Ding, L. (2013). Detecting progression of scientific reasoni-ng among university science and engineering students. 2013 PERC Proceedings. doi:10.1119/perc.2013.pr.019

[24]. Ding, L. (2014). Verification of Causal Influences of Reason-ing Skills and Epistemology on Physics Conceptual Learning. American Physical Society. 10 (2), 1554-9178.

[25]. Ding, L., Wei, X., & Liu, X. (2016). Variations in university students' scientific reasoning skills across majors, years, and types of institutions. Research in Science Education, 46(5), 613-632.

[26]. Dowd, J. E., Thompson Jr, R. J., Schiff, L. A., and Reynolds, J. A. (2018). Understanding the complex relationship between critical thinking and science reasoning among undergraduate thesis writers. CBE—Life Sciences Education, 17(1), ar4, 1-10. https://doi.org/10.1187/cbe.17- 03-0052

[27]. Dumford, A. D., & Miller, A. L. (2018). Online learning in higher education: Exploring advantages and disadvantages for engagement. Journal of Computing in Higher Education, 30(3), 452–465. https:// doi.org/10.1007/s12528-018-9179-z

[28]. Ellis, A. K., Denton, D. W., & Bond, J. B. (2013). An analysis of research on metacognitive teaching strategies. Procedia - Social and Behavioral Sciences, 116, 4015–4024. https://doi.org/10.1016/j. sbspro.2014.01.883

[29]. Erdoğan, F., and Şengül, S. (2017). The effect of cooperative learning method enhanced with metacognitive strategies on students' metacognitive skills in math course. Egitim ve Bilim, 42(192), 263–301. https://doi.org/10.15390/EB.2017.6492

[30]. Farillon, L. M. (2022). Scientific Reasoning, Critical Think-ing, and Academic Performance in Science of Selected Filipino Senior High School Students. https://doi.org/10.31849/utamax.v4i1.8284

[31]. Farris, P. J. (2015). Elementary and middle school social studies: An interdisciplinary, multicultural approach. Waveland.

DOI: 10.17148/IARJSET.2024.111204

[32]. Flavell, J. (1979). Metacognition and cognitive monitoring. A new area of cognitive development inquiry. American Psychologist, 34(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906.

[33]. Göhner, M. and Krell, M. (2020). Preservice science teachers' strategies in scientific reasoning: The case of modeling. Research in Science Education. https://doi.org/10.1007/s11165-020-09945-7

[34]. Goldspink, C., & Foster, M. (2013). A conceptual model andset of instruments for measuring student engagement in learning. Cambridge Journal of Education, 43(3), 291-311. doi:10.1080/0305764X.2013.776513

[35]. Goradia, T., and Bugarcic, A. (2017). A social cognitive view of self-regulated learning within online environment. Advances in Integrative Medicine., 4(1), 5–6. https://doi.org/10.1016/j.aimed.2017.05.001

[36]. Hacıömeroğlu, G., and Hacıömeroğlu, E.S. (2017). Examining the relationship between gender, spatial ability, logical reasoning ability, and preferred mode of processing. Adıyaman University Journal of Educational Sciences, 7(1), 116-131.

[37]. Harlen, W. (2013). Inquiry-based learning in science and mat-hematics. Rev. Sci. Math. ICT Educ., 7, 9–33.

[38]. Hartmann, S.; Upmeier zu Belzen, A.; Krüger, D.; Pant, H.A. (2015). Scientific reasoning in higher education. Z. Psychol., 223, 47–53.

[39]. Hashemyolia, S., Asmuni, A., Ayub, A. F. M., Daud, S. M., and Shah, J. A. (2015). Motivation to use selfregulated learning strategies in learning management system amongst science and social science undergraduates. Asian Social Science, 11(3), 49. https://doi.org/10.5539/ass.v11n3p49.

[40]. Hickendorff, M., Edelsbrunner, P.A., McMullen, J., Schneider, M., Trezise, K. (2018). Informative tools for characterizing individual differences in learning: Latent class, latent profile, and latent transition analysis. Learn. Individ. Differ., 66, 4–15.

[41]. Higgins, B., and Reid, H. (2017). Enhancing "conceptual teach-ing/learning" in a concept based curriculum. Teaching and Learning in Nursing, 12(2), 95-102.

[42]. Hu, M., and Li, H. (2017). Student engagement in online lea-rning: A review. 2017 International Symposium on Educational Technology (ISET), 39–43. https://doi.org/10.1109/ISET.2017.17.

[43]. Irwan, I., Haque, R., Rahman, A., and Osman,Z. (2023). A stru-ctural Equation Modelling Approach on Determinants of Working Adults' Choice to Further Study in Malaysian Online Distance Learning Higher Education Institutions

[44]. Kallio, H., Virta, K., and Kallio, M. (2018). "Modelling the Components of Metacognitive Awareness," International Journal of Educational Psychology, vol. 7, no. 2, pp. 94–122, doi: https://doi.org/10.17583/IJEP.2018.2789.

[45]. Kelly, S., Rice, C., Wyatt, B., Ducking, J., and Denton, Z. (2015). Teacher immediacy and decreased student quantitative reasoning anxiety: The mediating effect of perception. Communication Education, 64(2), 171-186. https://doi.org/10.1080/03634523.2015.1014383

[46]. Khan, S. and Krell, M. (2019). Scientific reasoning compete-ncies: A case of preservice teacher education. Canadian Journal of Science, Mathematics and Technology Education, 19, 446–464.

[47]. Khashab, A. S., Dortaj, F., Sadipour, E., Delavar, A., and Cheliche, K.S. (2021). Comparing The Effectiveness of Instructional Package of Cognitive - Metacognitive Strategies and Cognitive Intervention in Solving the Mathematical Verbal Problem and Cognitive Functions in Students with Special Learning Disabilities

[48]. Klausmeier, H. J. (1992). Concept learning and concept teac- hing. Educational Psychologist, 27(3), 267-286.

[49]. KMK [Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der BRD] (Eds.). (2020). Bildungsstandards im Fach Biologie für die Allgemeine Hochschulreife. https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2020/2020_06_18-BildungsstandardsAHR_Biologie.pdf

[50]. Koerber, S. & Osterhaus, C. (2019). Individual differences in early scientific thinking: Assessment, cognitive influences, and their relevance for science learning. Journal of Cognition and Development, 20(4), 510–533.

[51]. Krell, M., and Krüger, D. (2016). Testing models: A key aspect to promote teaching activities related to models and modelling in biology lessons? Journal of Biological Education, 50, 160–173.

[52]. Lawson, A.E. (2004). The nature and development of scientific reasoning: a synthetic view, Int. J. Sci. Math. 2 (3) 307–338.

[53]. Lazonder, A. W., and Harmsen, R. (2016). Meta-analysis of in-quiry- based learning: Effects of guidance. Review of Educational Research, 86(3),681–718. doi: 10.3102/0034654315627366

[54]. Lazonder, A.W.; Janssen, N. (2021). Development and initial validation of a performance-based scientific reasoning test for children. Stud. Educ. Eval., 68, 100951.

[55]. Lazonder, A. W. and Kamp, E. (2012). Bit by bit or all at on-ce? Splitting up the inquiry task to promote children's scientific reasoning. Learning and Instruction, 22(6),458–464. doi: 10.1016/j.learninstruc.2012.05.005

[56]. Lei, P. L., Sun, C. T., Lin, S. S. J., & Huang, T. K. (2015). Effect of metacognitive strategies and verbal-imagery cognitive style on biology-based video search and learning performance. Computers and Education, 87, 326–339. https://doi.org/10.1016/j.compedu.2015.07.004

DOI: 10.17148/IARJSET.2024.111204

[57]. Legazpi, G. (2023). What Is Conceptual Learning?. https://-www.practicaladultinsights.com/what-is-conceptual-learning.htm
[58]. Limueco, J. (2018). Predicting Progression Trends of Scientific Reasoning Skills and Metacognitive Awareness among Secondary Level Students. https://www.researchgate.net/publication/327818460
[59]. Li, J., Ye, H., Tang, Y., Zhou, Z., & Hu, X. (2018). What are the efects of self-regulation phases and strategies for Chinese students? A meta-analysis of two decades research of the association between self-regulation and academic performance. Frontiers in Psychology, 9(Dec.), 1–13. https://doi.org/ 10.3389/fpsyg.2018.02434.
[60]. Makela, M. L., Pei, J. R., Kerns, K. A., MacSween, J. V., Kapasi, A., & Rasmussen, C. (2019). Teaching Children with Fetal Alcohol Spectrum Disorder to Use Metacognitive Strategies. Journal of Special Education, 53(2), 119–128. https://doi.org/10.1177/0022466919832371
[61]. Mathesius, S.; Hartmann, S.; Upmeier zu Belzen, A.; Krüger, D. (2016). Scientific reasoning as an aspect of pre-service biology teacher education. In The Future of Biology Education Research. Proceedings of the 10th conference of European Researchers in Didactics of Biology (ERIDOB); Tal, T., Yarden, A., Eds.; Technion: Haifa, Israel, pp. 93–110
[62]. Metacognitive Strategies. (2015). https://inclusiveschools.org/metacognitive-strategies/
[63]. Moreno-Marcos, P. M., Muñoz-Merino, P. J., Maldonado-Mahauad, J., Pérez-Sanagustín, M., AlarioHoyos, C., & Delgado Kloos, C. (2019). Temporal analysis for dropout prediction using self-regulated learning strategies in self-paced MOOCs. Computers & Education, 145, 103728. https://doi. org/10.1016/j.compedu.2019.103728
[64]. Mozafari, M., Safari, Y., Abasifard, Z., Safari, M., and Sha-rafi, K. (2016). Assessing dimensions of metacognitive skills and its relationship with academic achievement in high school students. Journal of Acta Medica Mediterranea; 32:899-903.
[65]. Mulyono, & Hadiyanti, R. (2018). Analysis of mathematical problem-solving ability based on metacognition on problem-based learning. Journal of Physics: Conference Series, 983(1). https://doi.org/10.1088/1742-6596/983/1/012157
[66]. Muñoz-Muñoz, Á. E., & Ocaña de Castro, M. (2017). Uso de est- rategias metacognitivas para la comprensión textual. Cuadernos de Lingüística Hispánica, (29), 223.
[67]. National Research Council (2012). A framework for K-12 scie-nce education: Practices, crosscutting concepts, and core ideas. Washington, DC: National Academies Press
[68]. Nelson, G., Hunt, J.H., Martin, K., Patterson, B., and Khou-nmeuang, A. (2022). Current knowledge and future directions: proportional reasoning interventions for students with learning disabilities and mathematics difficulties, Learn. Disabil. Q. 45.159–171.
[69]. OECD (2019). Conceptual learning framework: Learning Compass 2030. https://www.oecd.org/education/2030-project/teaching-and-learning/learning/learning-compass-2030/OECD_Learning_Compass_2030_concept_note.pdf
[70]. Ogbonnaya, U.I. and Awuah, F.K. (2019). Quintile ranking of schools in South Africa and learners' achievement in probability, Stat. Educ. Res. J. 18 (1). 106–119.
[71]. Oguz, A. & Ataseven, N. (2016). The relationship between meta-cognitive skills and motivation of university students. Educational Process: International Journal; 5 (1): 54-64.
[72]. Osborne J. (2013). Journal Thinking Skills and Creativity 265-279.
[73]. Oz, H. (2016). Metacognitive awareness and academic motivati-on: A cross-sectional study in teacher education context of Turkey. Procedia - Social and Behavioral Sciences Journal; 232:109-121.
[74]. Özden, Y. (2021). Öğrenme ve öğretme (14nd ed.). Pegem Akademi
[75]. Özyürek, M. (2019). Kavram Öğrenme ve Öğretme. Ankara Unive-rsity Journal of Faculty of Educational Sciences (JFES), 16(2), 347-366. https://doi.org/10.1501/Egifak_0000000971.
[76]. Pedaste, M.; Mäeots, M.; Siiman, L.A.; de Jong, T.; van Rie-sen, S.A.N.; Kamp, E.T.; Manoli, C.C.; Zacharia, Z.C.; Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. Educ. Res. Rev. 2015, 14, 47–61.
[77]. Piekny, J.; Maehler, C. (2013). Scientific reasoning in early and middle childhood: The development of domain-general evidence evaluation, experimentation, and hypothesis generation skills. Br. J. Dev. Psychol., 31, 153–179.
[78]. Piraksa, C., Srisawasdi, N., and Koul, R. B., (2014). Effect of Gender on Students' Scientific Reasoning Ability: A Case Study in Thailand
[79]. Pratama, W.P. and Supriyatman. (2021). The analysis of hypo-thesis-deductive reasoning ability in learning particle dynamics. J. Phys.: Conf. Ser. 1760 012005
[80]. Preus, B. (2012). Authentic instruction for 21st century lea-rning: Higher order thinking in an inclusive school. American Secondary Education, 40(3), 59-80
[81]. Puška, A., Puška, E., Dragić, L., & Maksimović, A. (2020). Students ' satisfaction with E-learning platforms in Bosnia and Herzegovina. Technology, Knowledge, and Learning. https://doi.org/10.1007/ s10758-020-09446-6.

[82]. Ragma, F., and Valdez, R.J. (2017). Scientific reasoning abi-lity of students in the science curriculum. https://www.researchgate.net/publication/32413 689.

[83]. Reith, M., & Nehring, A. (2020). Scientific reasoning and vi-ews on the nature of scientific inquiry: testing a new framework to understand and model epistemic cognition in science. International Journal of Science Education. doi:10.1080/09500693.2020.1834168

[84]. Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. Psychological Bulletin, 138(2), 353– 387. https://doi.org/10.1037/a0026838.

[85]. Rillero, P. (2016). Deep Conceptual Learning in Science and Mathematics: Perspectives of Teachers and Administrators.

[86]. Rimadani, E., Parno, and Diantoro, M. (2017). IdentifikasiKemampuan Penalaran Ilmiah Siswa SMA Pada Materi Suhu dan Kalor Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan 2 6

[87]. Roth, A., Ogrin, S., & Schmitz, B. (2016). Assessing self-regulated learning in higher education: A systematic literature review of self-report instruments. Educational Assessment, Evaluation, and Accountability, 28, 225–250. https://doi.org/10.1007/s11092-015-9229-2.

[88]. Schiefer, J.; Golle, J.; Tibus, M.; Oschatz, K. (2019). Scien-tific reasoning in elementary school children: Assessment of the inquiry cycle. J. Adv. Acad. 30, 144–177.

[89]. Schlatter, E. and Lazonder, A. (2021). Individual Differences in Children's Scientific Reasoning. https://doi.org/10.3390/ educsci11090471.

[90]. Senemoğlu, N. (2020). Gelişim, öğrenme ve öğretim: Kuramdan uygulamaya (27nd ed.). Anı.

[91]. Spanjers, I., Könings, K. D., Leppink, J., Verstegen, D., Jong, N., Czabanowska, K., & Merriënboer, J. (2015). The promised land of blended learning: Quizzes as a moderator. Educational Research Review, 15, 59–74. https://doi.org/10.1016/j.edurev.2015.05.001

[92]. Suryadi, A., Yuliati, L., Wisodo, H. (2021). The effect of STEM-based phenomenon learning on improving students' correlational reasoning, in: AIP Conf. Proc. Proceedings, pp. 1–8.

[93]. Svirko, E.; Gabbott, E.; Badger, J.; Mellanby, J. (2019). Do-es acquisition of hypothetical conditional sentences contribute to understanding the principles of scientific enquiry? Cogn. Dev., 51, 46–57.

[94]. Sweller, J. (2016). Story of a research program. In J. D. F. S. Tobias, and D. C. Berliner (Ed.), Education Review (Vol. 23): Acquired wisdom series

[95]. Taduran, R.C. and Monterola, S.L. (2017). Student- Designed Inquiry: Effects on Scientific Reasoning and Conceptual Understanding in Physics.

[96]. Tajalli, P., and Satari, S. (2013). Effectiveness of Metacog-nitive Strategies on Reading Skills of Students with Hearing Disorders. Procedia - Social and Behavioral Sciences, 84, 139–143. https://doi.org/10.1016/j.sbspro.2013.06.524

[97]. Talib, C. A., Rajan, S. T., Hakim, N. W. A., Maimun, A., Kang, H. S., and Ali, M. (2018). Gender Differences as a Factor in Fostering Scientific Reasoning Skills Among Students

[98]. Taufiqurachman, B. (2021). "Metacognitive awareness of unive-rsity student: a survey study," Universitas Islam Indonesia, 2021. Accessed: March 24, 2024 [Online]. Available: https://dspace.uii. ac.id/handle/123456789/30590

[99]. Terras, M. M., and Ramsay, J. (2015). Massive open online courses (MOOCs): Insights and challenges from a psychological perspective. British Journal of Educational Technology, 46(3), 472–487. https://doi.org/10.1111/bjet.12274

[100]. Tormey, R. (2014). The centre cannot hold: untangling two di-fferent trajectories of the 'approaches to learning' framework. Teaching In Higher Education, 19(1), 1-12. doi:10.1080/13562517.2013.827648

[101]. Trzebinski, W. and Marciniak, B. (2022). There is no smoke without fire: how frequency information and the experience attribution make negative online restaurant reviews more harmful, PLoS One 17 (7) 1–25.

[102]. Van de Sande, E., Kleemans, M., Verhoeven, L., and Segers, E.(2019). The linguistic nature of children's scientific reasoning. Learn. Instr., 62, 20–26.

[103]. Van der Graaf, J., Segers, E., & Verhoeven, L. (2018). Indi-vidual differences in the development of scientific thinking in kindergarten. *Learning and Instruction*, *56*, 1–9. doi: 10.1016/j.learninstruc.2018.03.005

[104]. Vorholzer, A., von Aufschnaiter, C. & Boone, W. (2020). Fost-ering upper secondary students' ability to engage in practices of scientific investigation: A comparative analysis of an explicit and an implicit instructional approach. Research in Science Education, 50, 333–359.

[105]. Vorholzer, A., von Aufschnaiter, C., & Kirschner, S. (2016). Entwicklung und Erprobung eines Tests zur Erfassung des Verständnisses experimenteller Denk- und Arbeitsweisen. Zeitschrift für Didaktik der Naturwissenschaften, 22(1), 25–41.

[106]. Wagaba, F., Treagust, D. F., Chandrasegaran, A. L., & Won, M. (2016). Using metacognitive strategies in teaching to facilitate understanding of light concepts among year 9 students. Research in Science and Technological Education, 34(3), 253–272. https://doi.org/10.1080/02635143.2016.1144051

DOI: 10.17148/IARJSET.2024.111204

[107]. Widodo, SA., Pangesti, A.D., Istiqomah, I., Kuncoro, KS., andArigiyati, T.A. (2020). Thinking process of concrete student in solving two-dimensional problems.

[108]. Wieselmann, J.R., Dare, E.A., Ring-Whalen, E.A., and Roehrig, G.H. (2020). “I just do what the boys tell me”: Exploring small group student interactions in an integrated STEM unit. Journal of Research in Science Teaching, 57(1), 112-144.

[109]. Williams, M., Mercer, S., and Ryan, S. (2016). Exploring psy-chology in language learning and teaching. Oxford: Oxford University Press. Accessed: April 1, 2024 [Online]. Available: https://books.google.com/books/about/Exploring_Psychology_in_Language_Learnin. html?id=fcSNDAAAQBAJ

[110]. Yerdelen, S. (2013). Measuring teacher engagement: Developme-nt of the engaged teachers scale (ETS).

[111]. Yüzüak, A.V. (2012). Adaptation and Application of Lawson’s Classroom Test of Science Reasoning. Master’s thesis, Gazi University, Ankara, Turkey.

[112]. Zulkipli1, Z.A., Yusof, M.M.M., Ibrahim, N., and Dalim, S.F.(2019). Identifying Scientific Reasoning Skills of Science Education Students. http://doi.org/10.24191/ajue.v16i3.10311