ISSN No:-2456-2165

Perceived Cognitive Skills in Chemistry through Case-Based Learning Approach

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Abstract:- This study investigated the effects of case-based learning approach to the perceived cognitive skills among Grade 9 students at two (2) selected schools in Region 10, Philippines. Specifically, it aimed to assess students' level of perceived cognitive skills in terms of: processing speed; working memory; logic and reasoning; long term memory; and comprehension; and ascertain significant difference on students perceived cognitive skills. The study utilized a quasi-experimental research design to assess the effectiveness of the case-based learning approach on students perceived cognitive skills in Chemistry. The Gibson Cognitive Skill test questionnaire with Cronbach alpha of 0.87 was used to measure the perceived level of cognitive skills. It was found that the students from school A under CBL had a high perceived cognitive skill while students exposed to non-CBL had moderate perceived skills. For School B, students had high perceived cognitive skills in science for both CBL and non-CBL group. However, there was no significant difference on students perceived cognitive skill from School A and B.

Keywords:- *Perceived Cognitive Skills And Case-Based Learning.*

I. INTRODUCTION

A. Background of the Study

Science education aims to develop students to have a good understanding of concepts and enhance their ability to apply this understanding to new concepts. Teachers are expected to equip students with the necessary knowledge and skills to think critically and solve complex problems. However, this aim is impeded due to lack of understanding and cognitive skills. To address this concern, there should be development and application of teaching approaches that are geared towards meaningful and retentive learning (Bondoc, 2016). In PISA 2022, the Philippines obtained an average Scientific Literacy score of 356 points, significantly lower when compared to the standard score of the Organization of Economic Cooperation and Development (OECD), 485 points. When compared to the national mean score, Region 10 obtained a significantly lower average scientific literacy score of 342 points (OECD, 2023). The scientific literacy of the Philippines falls behind the ASEAN countries that participated.

There is a limited amount of research on the cognitive skills in chemistry of students in the Philippines. Some studies have been conducted on specific aspects of cognitive skills in chemistry, such as problem-solving and critical thinking, but there is no comprehensive study that has examined the full range of cognitive skills in chemistry of Filipino students. One study that examined the cognitive skills in chemistry of Filipino students was conducted by De Leon and Delos Santos (2018). The study found that Filipino students have relatively low scores on cognitive skills assessments in chemistry, such as the Chemistry Concept Inventory and the Test of Chemistry Achievement. The concept of cognitive skills relates to how human brains recall, reason, pay attention, solve issues, think, and learn. It permits learners in the absorption of new knowledge by redistributing in the most efficient regions across the brain. By increasing one's cognitive skills, one may speed up the processing of new knowledge (MacKay, 2012). There are several components of cognitive skills, and these include processing speed, visual processing, working memory, logic and reasoning, auditory processing, long term memory, comprehension, and attention abilities (Finn et al., 2014). According to Shi and Qu (2021), if the overall level of cognitive ability is poor or a specific cognitive capacity is inadequate, part of the information will be lost in the process of information processing, lowering the output of effective information, and resulting in lower academic performance.

Case-based learning is a student approach whereby students apply their knowledge and skills in analyzing problems and real-life events related to the subject matter. The students are required to engage in situational problems in which their decisions are needed (Giacalone, 2016). This approach could give students an avenue to apply theoretical knowledge to real school contexts, reason out critically about complex situations, develop self-knowledge and recognize their own assumptions. Moreover, it compares and evaluates their own and other's perspectives which could help in honing critical thinking. The implementation of the K to 12 curriculum requires teachers to be more innovative in delivering quality classroom instruction. More importantly, students may be able to enhance their performance in science by developing their cognitive abilities combined with competence, it becomes a hallmark of self-efficacious learners. Thus, the implementation of the case-based learning approach will be examined to investigate its effects on perceived cognitive skills of students.

B. Statement of the Problem

The study examined the effects of case-based learning approach on perceived cognitive skills in Chemistry. Specifically, it sought to answer the following questions:

- What is the level of students' cognitive skills in science when exposed to case-based learning (CBL) and those in non-CBL approach in terms of:
  - Processing speed;
  - Working memory;
  - Logic and reasoning;
  - Lon-term memory; and
  - Comprehension?

- Is there a significant difference between the level of students' cognitive skills in science when exposed to CBL and those in non-CBL?

C. Objective of the Study

The study investigated the students' cognitive skills through case-based approach in Grade 9 Science. Specifically, this study aimed to:

- Ascertained the level of students' cognitive skills in science when exposed to case-based learning (CBL) and those in non-CBL approach in terms of:
  - Processing speed;
  - Working memory;
  - Logic and reasoning;
  - Long-term memory; and
  - Comprehension.

- Assessed the significant difference between the level of students' cognitive skills in science when exposed to CBL and those in non-CBL?

D. Definition of terms

- Cased-based Learning Approach refers to students being presented with a case, which is a description of a real-world situation or problem.
- Cognitive skills are perceived ability to receive, process and communicate information. These are strategies for learning wherein the underlying skills must function to successfully read, hear, think, prioritize, plan, understand, remember and solve problems to ensure academic success.
- Logic and reasoning refer to how students reason out, formulate concepts and solve problems using unfamiliar information or procedures.
- Long-Term memory is the ability of the learners to store information and use it later in processing information.
- Processing speed refers to the ability to perform cognitive tasks, particularly how the brain works in processing information or concepts.
- Working memory refers to how the learners learn best using his brain while performing a mental operation on a specific task or activity

II. REVIEW OF RELATED LITERATURE

A. Student' Perceived Cognitive Skill

One of the most important aims of education is to provide students with the knowledge and skills they need to think critically, solve tough issues, and thrive in the 21st-century society and economy, among other things. Examining and evaluating students' knowledge and skills is essential for tracking students' academic performance in school (Finn et al., 2014).

In teaching, one of the fundamental mental processes that allow basic knowledge and learning is referred to as cognitive capacity. A cognitive skill is defined as the acquisition of the capacity to solve issues in intellectual activities in which the subjects' knowledge has a greater influence on their performance than their physical capabilities (Liu & Fleisher, 2022). The learner's academic skills and cognitive abilities play critical role on the whole development of the individual. In order for a person to overcome difficulties in any intellectual pursuits, one must first demonstrate the growth of his or her cognitive abilities. To the best of contemporary cognitive theories, a cognitive skill is a complete ability that has a unique history of quantitative and qualitative growth change across time (Kuiper & Pesut, 2014). The concept of behavioral theories emphasizes that cognitive abilities as a set of skills required as a critical factor for people's general growth and development which include the brain to function such as thinking, reading and remembering, keeping information and paying attention (Fosnot & Perry, 1996; Logie, 2011). In relation to both modern cognitive theories and historical behavioral learning theories, the word "cognitive competence" refers to what humans can do with their thinking (Sun & Hui, 2012). More importantly, cognitive skills are mental tools used in order to solve problems, remember tasks, and make concrete decisions that allow every learner to study more successfully and efficiently. One must work together in order to operate properly and to evaluate the effectiveness of a specific learning outcomes. In education, cognitive skills are widely recognized as the basis and most important instrument for effective learning (Amalia & Khoiriyati, 2018). It is a set of essential abilities to be processed by students themselves in order for them to be able to read, hear, think, prioritize, plan, and solve issues independently. Further, they have been organized as crucial way to assist the learner for better understanding its cognitive capacities and abilities. These cognitive skills include processing speed; visual processing; working memory; logic and reasoning; auditory processing; long-term memory; understanding and attention. These abilities enable the learner to see patterns, analyze issues and find solutions for comprehending and understanding information which are considered very valuable. Overall, developing the person's cognitive abilities will aid in the development of problem-solving solutions (Keen, 2011).

Processing speed as a skill helps the person to accurately perform a task. According to the results of the study of Peng & Namkung (2018), that through processing speed it enables one to speedily understand and execute the tasks at hand because with high processing speed, the brain's ability is to process and apply new information for a given task quickly after receiving it. Study conducted by Tikhomirova et al. (2020) found that information processing speed is the key predictor of fluid intelligence, working memory, and number sense, which in turn contribute to individual differences in academic success. However, it was found that cognitive processing speed have no impact on students' performance in organic chemistry (Nedungadi & Shenoy, 2023).

According to Peng and Namkung (2018) having this cognitive skill enables students to speedily understand and execute the tasks at hand since it is the brain's ability to process and apply new information to a given task after receiving it. It also provides students with authentic and complex cases, which challenge them to analyze, synthesize, and evaluate information from multiple sources. On visual processing, this skill would allow people to accurately interpret sights in daily situations. It examines designs, edit critical documents, and make sense of visual representations of data, such as graphs and tables, among other things (Frey & Bosse, 2018).

The working memory is a cognitive skill described as a retention of knowledge in a person's mind while they are actively employing it. According to Sánchez-Pérez et al. (2018), a strong working memory is critical if one wishes to complete a project without continually going back to the instructions. It is an excellent short-term memory described to remember a content that has recently been addressed. A strong positive correlation was found to exist between students' working memory capacity and their performance in the Chemistry. The research concludes on the need for open-ended problem-based learning of chemical concepts which could help students build a knowledge base that is required to engage with problems that have real-life applications (Upahi & Ramnarain, 2020). Case-based learning use less complex case-based or situational problem that is part of daily life of students. According to Shilna (2016), constructing structurally fewer complex items help the students with low working memory at par with the students with high working memory.

The concept of working memory is the person's retention of how he/she can manage and administer it. Recent research suggests that a possible modifiable factor for academic performance is working memory which is the ability to temporarily store and manipulate information in a mental workspace (Roberts et al., 2011; Alloway et al., 2009). Moreover, research shows that learners' working memory is a cognitive skill that utilizes strategies that can reflect upon and take account of a student's conceptual understanding and procedural actions. Working memory is a key predictor of academic success and that case-based learning can improve students' working memory skills by engaging them in active manipulation of information (Alloway & Copello, 2013). Moreover, case-based learning can help students connect new information to their existing knowledge and improve their memory.

Conversely, central to the function of cognitive abilities is logic and reasoning. Whenever problems are to be solved, new ideas are made easier by having good logic and reasoning skills. It is described that using logic and reasoning is to understand the needs of others that may lead to being creative to solve a problem (Bronkhorst et al., 2020). The study conducted by Huang et al., (2021) showed that video learning for auxiliary teaching can develop students' logical reasoning ability. Study conducted about students' logical reasoning skills to solve organic chemistry problems revealed a correlation between logical reasoning ability and the ability to solve problems of the basic concepts of Organic Chemistry (Amsad et al., 2022). Case-based learning approach provides an interactive learning environment for students. The development of reasoning skills in students is influenced by various factors, including prior knowledge, performance abilities, mindset, age, gender, intelligence, culture, and social status.

The researcher asserts that an engaging classroom environment, particularly in scientific laboratories or theoretical chemistry lessons, plays a crucial role in enhancing higher order thinking skills (Amir et al., 2022). Logical reasoning as a cognitive skill plays an important role in an individual's learning (Ayuningtyas & Pramudya, 2019; Chotimah et al.,2018). With the result, students exposed to CBL had a strong preference towards cognitive skill under logic and reasoning. Logic and reasoning skills can be enhanced by engaging in challenging activities such as case-based learning. CBL provides opportunities for students to practice and apply their logic and reasoning skills in authentic contexts, and to reflect on their learning processes and outcomes (Atwa et. al, 2018)

Auditory processing is an important cognitive skill which makes sense of what the ears are hearing, which includes evaluating, combining, and segmenting sounds for current or future use. According to Saito et al., (2020), auditory processing as a cognitive skill may benefit those who actively listen to others, leaders, and workers by comprehending and assisting them in making good use of the information they hear. The long-term memory is an important component of cognitive capacity for being able to execute everyday tasks independently and productively. When one speaks about long-term memory, it means the brain's capacity to store experiences, events, ideas, or abilities in order to remember them later. In the study conducted by Jones & Macken (2018), they concluded that highly productive individuals are able to be proficient in studying, or doing their tasks because they have high long-term memory cognitive skill. The stronger the long-term memory ability value, the more students can remember knowledge quickly and retain it over time (Liang et al., 2020). Long-term memory has more of an impact on students' performance where items are related to foundational chemistry concepts that students encounter very early on in organic chemistry (Nedungadi & Shenoy, 2023). This is an important

component in executing everyday tasks independently and productively. The use of long-term memory and highly productive individuals can simply complete their jobs with proficiency (Jones & Macken, 2018). According to Yildirim et al. (2020) CBL stimulates students' interest, motivation, and self-regulation, which are also important factors for long-term memory. CBL allows students to explore authentic and meaningful problems that are relevant to their goals and interests, and to receive feedback and reflection on their performance.

Comprehension is an important cognitive skill which is required to help students gain the information, abilities, and experiences they need to be good readers in the future (Srisang & Everatt, 2021). It is a very important skill for the students to achieve understanding required for them to answer and analyze complex science lessons. Mohammadian et al., (2018) points out that comprehension has a significant impact on the reading comprehension of learners through the use of video technology. Students' comprehension plays a crucial role in students' ability to acquire information and effectively understand it. The comprehension of the students is significantly related to their level of performance in chemistry along with substance, mixtures and solutions (Briones & Janer, 2023). Effective learning of chemistry requires good possession of reading comprehension skills. When students have reading comprehension difficulties, they have little or no ability of understanding written texts (Okanlawon, 2011). Srisang and Everatt (2021), assert that the primary goal of reading comprehension is to help students' gain the information, abilities and experience. And the learners achieved understanding for them to answer and analyze complex science lessons. A study by Qasrawi & BeniAndelrahman (2020) supported this claim and emphasized that CBL encourages students to collaborate and communicate with their peers and instructors, and to present and justify their solutions to the case problems. This may enhance their listening comprehension, oral communication, and social skills.

Attention cognitive skill is described as the capacity to choose and focus on significant information. In the study conducted by Child et al., (2019), in relation to attention, it contributed to the academic performance particularly in subjects such as Reading and Math. Here, one of the problems that occurs during the learning process is the difficulty of getting students' attention. As noted, the role of the teacher is to find ways to attract the learner's attention, when videos are used in the class (Sihotang et al., 2020). They reported that the use of videos in the delivery of instruction is effective and helpful in attracting students' attention.

One of the important processes that permits fundamental knowledge and learning is cognitive skills of the students. There are different indicators to assess these skills, one of which is processing speed that seeks to push students to perform a given task. Working memory, on how knowledge is retained. Logic and reasoning, to understand the needs of others that may lead to being creative and innovative, and comprehension, wherein students gain the information, abilities, and experiences they need to be good at what they are into.

B. Case-Based Learning

Case-Based learning (CBL) strategy has long been used in education literature since the 1900s. Towards the 1950s, there was an increased demand in using CBL in order to improve the teaching and learning process (Cam, 2009). Case-based learning has been used worldwide in different academic levels, from undergraduate to graduate. It has been also utilized in the field of medicine since 1912 by Dr. James Lorrain Smith in teaching pathology at the University of Edinburgh. There is no consensus internationally that case-based learning should be defined although it is closely related to problem-based learning structure. Research report indicates that CBL is a form of inquiry-based learning and fits on the continuum between structured and guided learning (McLean, 2016).

In most studies, CBL is not given to students as open inquiry which may be in the form of a problem or question. Information is presented together with the case and does not need to be completely new. In a modern context of case-based learning, it includes a clinical case, a question which should be solved, and learning objectives which describe the outcomes. Prior to and during the learning intervention, not all of the concepts are given. Some information will be explored when finding solutions and answering the questions. Some of the learning objectives can be achieved by the students in the implementation of case-based learning regardless of if it is live, web-based or on paper. On the other hand, if all information is given before the intervention in the absence of inquiry, it will be viewed as lecture or reading. It is an active learning strategy whereby learners apply their knowledge and analytical skills to complicated, real-life scenarios. It has been considered to be a good way to combine Problem Based Learning with traditional lectures as it promotes social interactions among learners and helps them to be autonomous. It has been proven to be helpful for improving the engagement and making relevance and organizing students' ideas as well as recognizing the gaps in knowledge. The complex situations that learners have to deal with requires decision by which the situations can be realistic and varies on the degree of complexity (Giancalone, 2016).

Case-based learning has been used in different areas of professional education which include law, medicine, clinical health, and business in order to be an alternative method for traditional lecture. It is commonly used in business schools in which they use cases as basis for teaching across curriculum. Teachers create cases intended for education and facilitation of activities (Lee et al., 2009). The cases could be in the form of stories to read and explore interactively. It directs the leaners to discuss contexts, interpret, analyze, inquire about ideas, and solve problems. It emphasizes problem-centered cases, situations, and scenarios which are used to examine and clarify the complexities of practices (Rourke & Anderson, 2002). Further, case-based learning stresses the significance of the design of cases and appropriate facilitation to enable students to expose students to

connections between theory and practice before they engage in real-world experiences.

Williams (2004) stated that successful implementation of CBL needs teachers to have questioning techniques and discussions in ways of feedback and scaffolding which are necessary ingredients for facilitation. Such techniques questioning, feedback, scaffolding, or guidance also assist students in activating their metacognition and exploring the implications of what they endorse with peer students and instructors.

A study conducted by Lee et al. (2009) examined the level of interaction in online case-based learning. Class discussions, self-case studies, individual write-ups, role playing, and team projects were found to be the most common case activities employed. Findings show that whole-class discussion was the most popular instructional activity with cases. On the other hand, in some courses, students explored given cases individually and conducted case studies in collaborative teams, The students' level of engagement varied in group instruction and for these activities, 15 percent were leading participants. It was also emphasized that managing feedback and arguments is another key element in facilitating CBL especially in online learning. The study made the implementation of CBL in an online environment and argued that it is as effective in online environments than in traditional face-to-face classroom settings. It was found to bring around students' perceptions to be positive on the activity of case-based learning in online environments. The study emphasized that students could learn efficiently if their online activities for case-based learning are created and addressed cautiously by giving feedback to carry on learning activities based on cases, collaborative discussions to improve case-based learning, using different technology to brace the strategy and using technological attributes in order to make potent cases.

Massouh and Kantar (2015) studied the perceptions of nursing students utilizing case-based learning in their two subjects during junior year in Lebanon. Their findings highlighted the students' experiences in utilizing CBL in their classroom which involved looking into patient data, complete comprehension of every detail of the patient, and clinical inventiveness. Also, the emphasis on patients was enhanced by utilizing real-life scenarios, on the other hand, the skill of relating information is undirected on how students perform or manipulate the data to make sense of it and make it meaningful. An all-inclusive analysis of the responses supported a series of activities that students apply to interpret patient data. Moreover, CBL encourages visualization of the actions in the cases and the operations of the decisions in the mind. Further analysis revealed that the student activities helped develop the skill of reacting in a clinical situation.

In contrast with the improved results brought about by case-based learning, Majeed (2014) indicated that the knowledge of students is not significantly improved by this strategy, as learners' examination performance was better with the didactic method. Students experienced an uttered dissatisfaction in utilizing case-based learning which also includes faculty student anticipations, lacking faculty, student tutorials and independent learning approaches, lack of coalescence into the curriculum and not enough time. The findings showed that the nursing students favored interactive case-based deliberations than the traditional lectures in their Physiology class even though their performance in the examination was not improved by the strategy. One reason for this result is because it was their first time to be exposed in this type of teaching.

Case-based learning is a variant of problem-based learning but there were distinctions as to how these two learning strategies differ indicated in the study of McLean (2016) in order to understand its meaning. The two strategies were compared in terms of goal, focus, advanced study, role of learner and teacher and outcomes. In goals, Problem-based learning is implemented to promote problem solving, information gathering, and collaboration. It focuses on how to go about solving the problem presented, not as much as the content of the problem. On the other hand, case-based learning is implemented because students can learn about cases. Problem solving is often required but may be aided. Problem-based learning focuses on problem solving in which little advanced study is needed.

Learners have active participation by asking questions and exploring the topic during the session while the teacher provides case information as requested. The teacher can observe and impart the method of problem solving or information gathering. Case-based learning focuses on how to solve specific problems or manage/identify problems which need advanced studies and are expected to participate, have advanced study. Learners are expected to participate while teachers provide cases and guide discussion or if written or online, guide content so that specific learning objectives are met. One also keeps discussion on track without allowing much tangential discussion and ensures that correct answers are known. With case-based learning, it promotes deeper learning that goes beyond simple identification of correct answers and is more aligned with either evidence of critical thinking or changes in behavior and generalizability of learning to new cases.

C. Research Paradigm

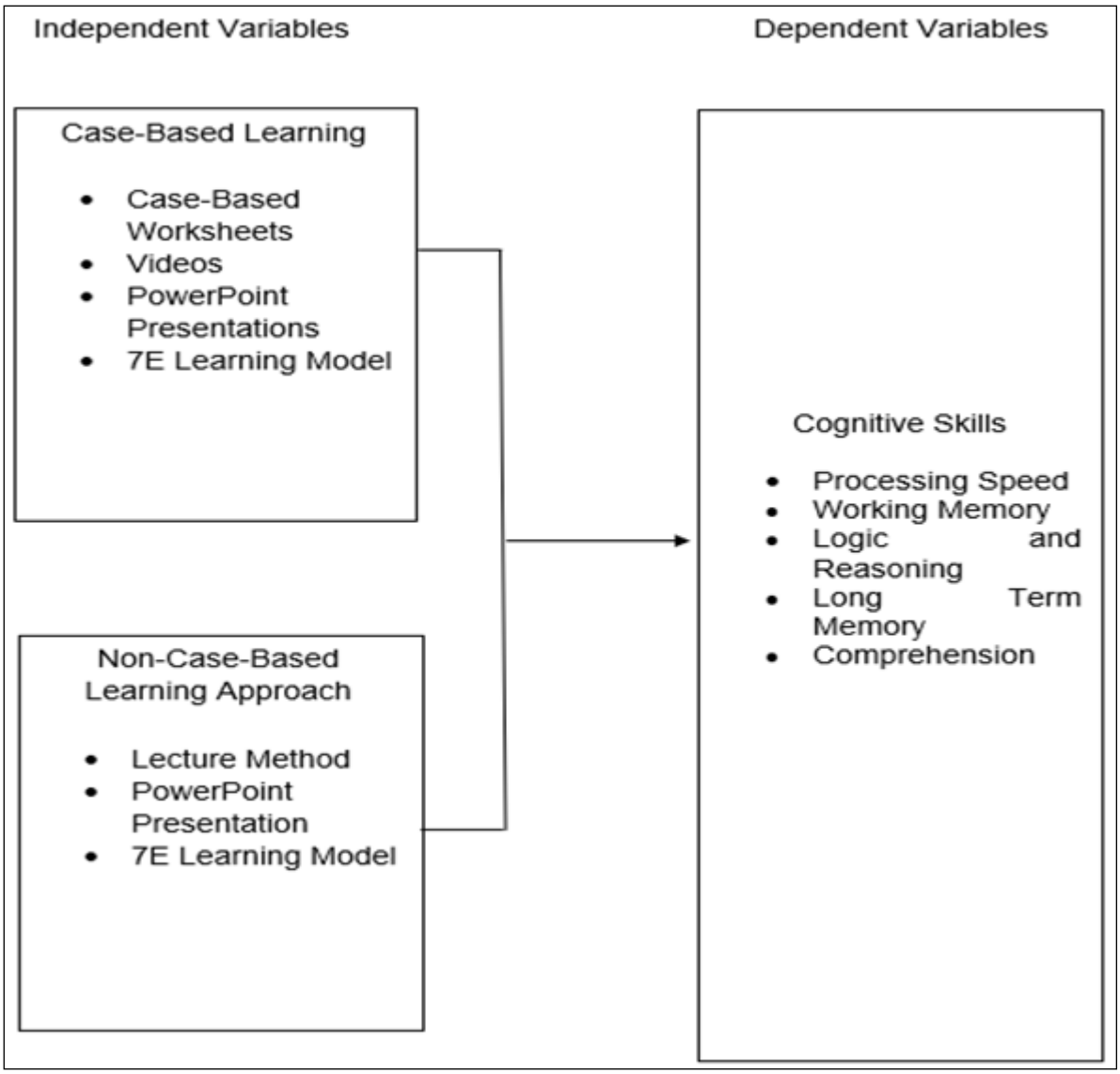

Fig 1. Schematic Diagram Showing the Variables Involved in the Study

D. Hypothesis

Ho_1. There is no significant difference in students' cognitive skills before and after exposure to case-based learning approach.

III. METHODOLOGY

A. Research Design

The study utilized a quasi-experimental research design to assess the effectiveness of the case-based learning approach on students' performance and perceived cognitive skills in Chemistry.

Two intact classes were selected in Grade 9 from two (2) selected schools in Region 10, Philippines. One section from each school was exposed to the CBL approach using interactive worksheets embedded with case-based problems and PowerPoint Presentation based on the 7E Lesson Plan. The other section was exposed to the conventional lecture method

B. Research Instrument

There are fifteen (15) statements that determine the students' cognitive skill preference which included the processing speed, visual processing, working memory, logic and reasoning, auditory processing, long-term memory, comprehension and attention skill.

The five (5) point Likert rating scale was used to analyze the preferred cognitive skills of the Grade 10 students. The following scale was used for the interpretation of data.

Scale	Weighted Mean	Descriptive Rating	Qualitative Description
5	4.51-5.00	Strongly Agree	Very High Cognitive Skills
4	3.51-4.50	Agree	High Cognitive Skills
3	2.51-3.50	Undecided	Moderate Cognitive Skills
2	1.51-2.50	Disagree	Low Cognitive Skills
1	1.00-1.50	Strongly Disagree	Very Low Cognitive Skills

C. Data Gathering Procedure

A letter of permit was submitted to the principal of School A and School B to get approval to conduct the research study. An informed consent was given to inform the participants about the purpose and nature of the study.

Participants were given an informed consent indicating the nature and purpose of the study as well as the duration. They were provided with clear and comprehensible information about the research, its purpose, risks, benefits, and their right to withdraw at any time without consequences. The researchers made sure that there will be no unnecessary discomfort, distress, or harm. Researchers took steps to protect the privacy and confidentiality of research participants. This includes using anonymized data, safeguarding personal information, and ensuring that data is stored securely.

The researcher oriented the students on how Case-Based Learning will be implemented. The experiment was conducted during the second grading period. In the group, the integration of Case-Based Learning was used as the instructional approach which includes different forms of instructional materials such as case-based activity sheets, pictures, videos, and PowerPoint presentations. Students' cognitive skill questionnaire was given to the group under study to find out their cognitive skills as exposed to case-based learning at the end of the experimental period.

➢ *Implementation of Case-Based Learning Approach*

The following phases was employed in implementing a case-based blended learning approach.

- *Case Development.*

Prior to class meetings, cases were developed by the researcher with an expert's guidance. It was outlined from the case development flowchart of Kulak and Newton (2014) which starts with defining the learning objectives and selection of CBL type which in this case is directed in small group format. The researcher selected parts of the case which may include setting and characters. It was followed by developing a real-life context and writing learning issues or questions.

- *Elicit.*

The learners were introduced to the topic by presenting questions of their experiences and a picture activity.

- *Case Orientation.*

The students were engaged in preparation for the case-based blended learning approach. They were advised to read the case and note on important words or phrases which they think are relevant and potential learning issues.

- *Explore.*

In explore phase, the students were grouped into six to seven members for peer instruction. In their small group discussion, their solutions to the case were compiled and decisions were done to arrive at a correct solution by explaining their answers as needed.

- *Large Group Case Review.*

Each group presented their solutions to the class during face-to-face meeting. The teacher facilitated consensus so the whole class will have access to the same unifying answers.

- *Evaluation.*

The learners presented their solutions to the case in the class through a large case review. They were evaluated as a group based on a rubric. In extend phase, the students were given an activity about the topic.

Extend. To deepen student's understanding, the students were tasked to extend the concepts and skills in new but similar situation in a form of assignments.

D. Statistical Analysis

The following techniques was used for the statistical analysis of the data:

Descriptive statistics such as weighted means was utilized to determine the students' perceived cognitive skills as exposed to Case-Based Learning and non-Case-Based Learning. The independent sample t-test was used to ascertain the significant difference between students perceived cognitive skills as exposed to CBL and non-CBL.

IV. RESULTS AND DISCUSSION

A. Students Perceived Cognitive Skills

Table 1 presents the students' mean scores for cognitive skills from school B under processing speed as exposed to case-based learning.

As can be seen, two indicators for the CBL class reflect "High Perceived Cognitive Skills" in their order of preference such as "completely answered assignments on time" (4) and "preferred to solve chemistry problems" (3.68). Of these indicators, a "Moderate Perceived Cognitive Skill" on the indicator "" students work quickly to finish the tasks" (3.36).

Table 1. Students Perceived Cognitive Skills From School An in Relation To Processing Speed.

Indicators	CBL		Non-CBL	
	MEAN	QUALITATIVE INTERPRETATION	MEAN	QUALITATIVE INTERPRETATION
1. I complete answering all assignments immediately.	4.00	High Perceived Cognitive Skills	3.84	High Perceived Cognitive Skills
2. I like to solve chemistry problems.	3.68	High Perceived Cognitive Skills	2.97	Moderate Perceived Cognitive Skills
3. I generally finish tasks the soonest possible.	3.36	Moderate Perceived Cognitive Skills	3.38	High Perceived Cognitive Skills
WEIGHTED MEAN	3.68	High Perceived Cognitive Skills	3.40	Moderate Perceived Cognitive Skills

Meanwhile, students under non-CBL group had a high perceived cognitive skill to "completely answered assignments on time" (3.84), "students work quickly to finish the tasks" (3.38), and moderate perceived skills in "solving chemistry problems" (2.97). As shown, the overall mean of score for the CBL class was 3.68 which indicate "High Perceived Cognitive Skills" while the overall mean score for the non-CBL class was 3.40 which indicate "Moderate Perceived Cognitive Skills".

These results show that students' exposure to case-based approach were found "High Cognitive Perceived Cognitive Skill" which means the learners preferred to be processed and organized their tasks and accomplish on time. According to Peng and Namkung (2018) having this cognitive skill enables students to speedily understand and execute the tasks at hand since it is the brain's ability to process and apply new information to a given task after receiving it.

Table 2 displays the students perceived cognitive skills from school B in relation to processing speed.

Table 2. Students Perceived Cognitive Skills from School B in Relation to Processing Speed.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. I generally finish tasks the soonest possible.	4.14	High Perceived Cognitive Skills	3.79	High Perceived Cognitive Skills
2. I like to chemistry mathematical problems.	4.14	High Perceived Cognitive Skills	4.12	High Perceived Cognitive Skills
3. I complete answering all assignments immediately.	4.07	High Perceived Cognitive Skills	3.98	High Perceived Cognitive Skills
Weighted Mean	4.12	High Perceived Cognitive Skills	3.96	High Perceived Cognitive Skills

As presented, students under CBL group had a high perceived cognitive skill to "I completely answering assignments immediately" (4.07), "I generally finish tasks the soonest possible." (4.14), and "I like to solve chemistry problems." (4.14). Overall weighted mean (4.12) indicates high perceived cognitive skills in relation to processing speed. Meanwhile, students under non-CBL group had a high perceived cognitive skill to "I completely answering assignments immediately" (3.98), "I generally finish tasks the soonest possible." (3.79), and "I like to solve chemistry problems." (4.12). Overall weighted mean (3.96) indicates high perceived cognitive skills in relation to processing speed. CBL had moderate perceived skills in terms of processing speed.

The mean scores of students in relation to processing speed towards learning science are shown in Table 2. The weighted mean of the students exposed to CBL was 4.12, while those in non-CBL were 3.96. Both groups obtained high perceived cognitive skills towards chemistry. However, there is a 0.21 difference between the CBL and non-CBL group. However, there is a 0.16 difference between the CBL and non-CBL group.

As observed from the results, exposure to CBL promoted students' self-directed learning, which encourages them to monitor and regulate their own learning processes and strategies (Quang et al., 2016). It also provides students with authentic and complex cases, which challenge them to analyze, synthesize, and evaluate information from multiple source. The students' cognitive skills from School A in terms of working memory is presented in Table 3.

ISSN No:-2456-2165

Table 3. Students Perceived Cognitive Skills from School An in Relation to Working Memory.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. I have a healthy study or work habits.	4.00	High Perceived Cognitive Skills	3.41	Moderate Perceived Cognitive Skills
2. I solve multiplication problem in my head and "carry over" the remainders accurately.	3.28	Moderate Perceived Cognitive Skills	2.91	Moderate Perceived Cognitive Skills
3. I can read a phone number from the phone book then look away and dial it accurately.	2.82	Moderate Perceived Cognitive Skills	3.19	Moderate Perceived Cognitive Skills
WEIGHTED MEAN	3.40	Moderate Perceived Cognitive Skills	3.17	Moderate Perceived Cognitive Skills

As shown in the data table, the mean scores for the CBL class were 3.40 while the non-CBL was 3.17 which both indicate "Moderate Perceived Cognitive Skill". The indicators for the CBL class showed "High Perceived Cognitive Skill"; in relation to "work and study habits" (4), and "Moderate Perceived Cognitive Skill" for the indicators "can mentally solve multiplication problem" (3.28) and "reading accurately a phone book number" (2.58). On the other hand, students in non-CBL group had moderate perceived cognitive skills to "read phone number from the phone book then look away and dial it accurately" (3.19), "solve multiplication problem in my head and "carry over" the remainders accurately" (2.91), and "have a healthy study or work habits" (3.41). Overall mean (3.17) reveals that students exposed to non-CBL had moderate perceived cognitive skills in relation to working memory.

The concept of working memory is the person's retention of how he/she can manage and administer it. Recent research suggests that a possible modifiable factor for academic performance is on working memory which is the ability to temporarily store and manipulate information in a mental workspace (Roberts et al., 2011; Alloway et al., 2009). Moreover, research show that learners' working memory is a cognitive skill that utilized strategies that can reflect upon and take account on student's conceptual understanding and procedural actions.

Table 4 displays the students' perceived cognitive skills from school B in relation to working memory. As presented, students under CBL group had a high perceived cognitive skill to "I can read a phone number from the phone book then look away and dial it accurately." (4.17), "I solve multiplication problem in my head and "carry over" the remainders accurately." (4.21), and "I have a healthy study or work habits." (4.26). Overall weighted mean of 4.21 indicates high perceived cognitive skills in relation to processing speed. Meanwhile, students under non-CBL group had a high perceived cognitive skill "I can read a phone number from the phone book then look away and dial it accurately." (4.12), "I solve multiplication problem in my head and "carry over" the remainders accurately." (3.67), and "I have a healthy study or work habits." (4.21). Overall weighted mean 4.00 indicates high perceived cognitive skills in relation to processing speed. CBL had moderate perceived skills in terms of processing speed.

Table 4. Students Perceived Cognitive Skills from School B in Relation to Working Memory.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. I have a healthy study or work habits.	4.26	High Perceived Cognitive Skills	4.21	High Perceived Cognitive Skills
2. I solve multiplication problem in my head and "carry over" the remainders accurately.	4.21	High Perceived Cognitive Skills	3.67	High Perceived Cognitive Skills
3. I can read a phone number from the phone book then look away and dial it accurately.	4.17	High Perceived Cognitive Skills	4.12	High Perceived Cognitive Skills
WEIGHTED MEAN	4.21	High Perceived Cognitive Skills	4.00	High Perceived Cognitive Skills

The weighted mean of the students exposed to CBL was 4.21, while those in non-CBL were 4.00. Both groups obtained high perceived cognitive skills towards chemistry. However, there is a 0.21 difference on the weighted mean between the CBL and non-CBL group. This implies that CBL fosters students' motivation, interest, and self-regulation, which are also related to working memory performance. CBL allows students to explore authentic and meaningful problems that are relevant to their goals and interests, and to apply their knowledge and skills in various contexts.

Based on the results, working memory is a key predictor of academic success and that case-based learning can improve students' working memory skills by engaging them in active manipulation of information (Alloway & Copello, 2013). Moreover, case-based learning can help students connect new information to their existing knowledge and improve their memory.

Table 5 shows the students' perceived cognitive skills from school A in relation to logic and reasoning. As reflected, two indicators in the CBL class were found "High Perceived Cognitive Skill" in their order of preference which pertains to logic and reasoning specifically on "planning and solving problems" (3.68) and the decision to select the best length measurement" (3.64). And "Moderate Perceived Cognitive Skill" on "organization of thoughts and systematic arrangement of materials" (3.05). Meanwhile, students under non-CBL had a moderate perceived skill "when confronted with a choice between choosing two lengths of screws to assemble shelf, I can easily choose the best length." (3.19), "I am good in planning steps to solve problems." (2.78), and "I organize my thoughts and materials systematically." (3.34). As shown in the table, students from CBL class were 3.81 which indicates "High Perceived Cognitive Skill" while the non-CBL o mean was 3.10 which indicates "Moderate Perceived Cognitive Skill". Logical reasoning as a cognitive skill plays an important role in individual's learning (Ayuningtyas & Pramudya, 2019; Chotimah et al.,2018). With the result, students exposed to CBL had a strong preference towards cognitive skill under logic and reasoning.

TABLE 5. Students Perceived Cognitive Skills from School A in Relation to Logic and Reasoning.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. I am good in planning steps to solve problems.	3.68	High Perceived Cognitive Skills	2.78	Moderate Perceived Cognitive Skills
2. When confronted with a choice between choosing two lengths of screws to assemble shelf, I can easily choose the best length.	3.64	High Perceived Cognitive Skills	3.19	Moderate Perceived Cognitive Skills
3. I organize my thoughts and materials systematically.	3.05	Moderate Perceived Cognitive Skills	3.34	Moderate Perceived Cognitive Skills
WEIGHTED MEAN	3.81	High Perceived Cognitive Skills	3.10	Moderate Perceived Cognitive Skills

Table 6 displays the students' perceived cognitive skills from school B in relation to logic and reasoning. As presented, students under CBL group had a high perceived cognitive skill to "When confronted with a choice between choosing two lengths of screws to assemble shelf, I can easily choose the best length." (4.43), "I am good in planning steps to solve problems." (4.24), and "I organize my thoughts and materials systematically." (4.29). Overall weighted mean of 4.32 indicates high perceived cognitive skills in relation to processing speed. Meanwhile, students under non-CBL group had a high perceived cognitive skill "When confronted with a choice between choosing two lengths of screws to assemble shelf, I can easily choose the best length." (4.33), "I am good in planning steps to solve problems." (4.21), and "I organize my thoughts and materials systematically." (4.24). Overall weighted mean of 4.26 indicates high perceived cognitive skills in relation to processing speed.

The mean scores of students in relation to logic and reasoning towards learning science are shown in Table 6. The weighted mean of the students exposed to CBL was 4.32, while those in non-CBL were 4.26. Both groups obtained high perceived cognitive skills towards chemistry.

Table 6. Students Perceived Cognitive Skills From School B In Relation To Logic And Reasoning.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. When confronted with a choice between choosing two lengths of screws to assemble shelf, I can easily choose the best length.	4.43	High Perceived Cognitive Skills	4.33	High Perceived Cognitive Skills
2. I organize my thoughts and materials systematically.	4.29	High Perceived Cognitive Skills	4.24	High Perceived Cognitive Skills
3. I am good in planning steps to solve problems.	4.24	High Perceived Cognitive Skills	4.21	High Perceived Cognitive Skills
WEIGHTED MEAN	4.32	High Perceived Cognitive Skills	4.26	High Perceived Cognitive Skills

The result implies that CBL enhances students' metacognition and reflection, which are essential for logic and reasoning. CBL encourages students to monitor and evaluate their own learning processes, to identify and correct their errors, and to learn from their experiences. CBL also promotes students' collaboration and communication, which can improve their logic and reasoning skills by exposing them to different perspectives and arguments. This shows that logic and reasoning skills can be enhanced by engaging in challenging activities such as case-based learning. CBL provides opportunities for students to practice and apply their logic and reasoning skills in authentic contexts, and to reflect on their learning processes and outcomes (Atwa et. al, 2019).

Table 7 presents the students' mean scores for their perceived cognitive skills from school A in relation to long memory for the CBL and non-CBL group.

Table 7. Students Perceived Cognitive Skills From School A In Relation To Long Term Memory.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. I find it very easy to remember important facts and events.	3.68	High Perceived Cognitive Skills	3.59	High Perceived Cognitive Skills
2. I can easily produce a previous information for comparison with new incoming information.	3.36	Moderate Perceived Cognitive Skills	3.25	Moderate Perceived Cognitive Skills
3. I do not ask someone to repeat the words of the same sound correctly	3.14	Moderate Perceived Cognitive Skills	3.44	Moderate Perceived Cognitive Skills
WEIGHTED MEAN	3.39	Moderate Perceived Cognitive Skills	3.43	Moderate Perceived Cognitive Skills

The given statements on the CBL class on "significant events and facts (3.68) was found High Perceived Cognitive Skills while "can simply compare previous and new information" (3.36) and "confidence on sounding words correctly" (3.14) where both found Moderate Perceived Cognitive Skills. Meanwhile students under non-CBL had a "High Perceived Cognitive Skill" on the statement "I find it very easy to remember important facts and events." (3.59), and "Moderate Perceived Cognitive Skill" as indicated "I do not ask someone to repeat the words of the same sound correctly." (3.44) and "I can easily produce a previous information for comparison with new incoming information." (3.25). As shown, the overall mean of score of the CBL group was 3.39 which indicate "High Perceived Cognitive" while the overall mean score of the non-CBL group was 3.43 which indicate "Moderate Perceived Cognitive".

As gleaned from table 7, long- term memory as a cognitive skill is an important component in executing everyday tasks independently and productively. The use of long-term memory and highly productive individuals can simply complete their jobs with proficiency (Jones & Macken, 2018).

Table 8 displays the perceived cognitive skills from school B in relation to long term memory.

Table 8. Students Perceived Cognitive Skills from School B In Relation To Long Term Memory.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. I find it very easy to remember important facts and events.	4.24	High Perceived Cognitive Skills	4.19	High Perceived Cognitive Skills
2. I can easily produce a previous information for comparison with new incoming information.	4.45	High Perceived Cognitive Skills	4.45	High Perceived Cognitive Skills
3. I do not ask someone to repeat the words of the same sound correctly.	4.17	High Perceived Cognitive Skills	3.81	High Perceived Cognitive Skills
WEIGHTED MEAN	4.28	High Perceived Cognitive Skills	4.15	High Perceived Cognitive Skills

As presented, students under CBL group had a high perceived cognitive skill to "I don't ask someone to repeat the words of the same sound correctly." (4.17), "I find it very easy to remember important facts and events." (4.24), and "I can easily produce a previous information for comparison with new incoming information." (4.45). Overall weighted mean of 4.28 indicates high perceived cognitive skills in relation to long term memory. Meanwhile, students under non-CBL group had a high perceived cognitive skill "I don't ask someone to repeat the words of the same sound correctly." (3.81), "I find it very easy to remember important facts and events." (4.19), and "I can easily produce a previous information for comparison with new incoming information." (4.45). Overall weighted mean of 4.15 indicates high perceived cognitive skills in relation to long term memory.

The mean scores of students in relation to long term memory towards learning science are shown in Table 8. The weighted mean of the students exposed to CBL was 4.28, while those in non-CBL were 4.15. Both groups obtained high perceived cognitive skills towards chemistry. However, there is a 0.13 difference on its weighted mean between the CBL and non-CBL group.

Based on the results, CBL fosters active learning, inquiry, and knowledge transfer, which require students to encode new information in meaningful ways and connect it to their prior knowledge (Prescher & Zumbach, 2021). Hence, this can improve the durability and accessibility of information in long-term memory. In connection to the study of Yildirim et al. (2020) which states that CBL stimulates students' interest, motivation, and self-regulation, which are also important factors for long-term memory. CBL allows students to explore authentic and meaningful problems that are relevant to their goals and interests, and to receive feedback and reflection on their performance.

Table 9. Students Perceived Cognitive Skills From School A In Relation To Comprehension.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. Sequencing past events is very easy.	3.68	High Perceived Cognitive Skills	3.09	Moderate Perceived Cognitive Skills
2. I easily clarify ideas or objects according to its similarities and similarities.	3.50	Moderate Perceived Cognitive Skills	3.13	Moderate Perceived Cognitive Skills
3. I easily comprehend contents of written materials.	3.36	Moderate Perceived Cognitive Skills	3.66	High Perceived Cognitive Skills
WEIGHTED MEAN	3.52	High Perceived Cognitive Skills	3.29	Moderate Perceived Cognitive Skills

Table 9 presents the students' mean scores for their perceived cognitive skills from school A in relation to comprehension for the CBL and non-CBL group.

As gleaned from the table in the CBL class, the underlying concept of comprehension is "High Perceived Cognitive Skill" on the indicator "sequencing past events" (3.68); and "Moderate Perceived Cognitive Skill" for indicators "clarify ideas between similarities and dissimilarities" (3.50) and "easy to comprehend written contents" (3.36). While the students under non-CBL had "High Perceived Cognitive Skill" on comprehend contents of written materials." (3.66) and "Moderate Perceived Cognitive Skill" on "easily clarify ideas or objects according to its similarities and similarities." (3.13) and "sequencing past events is very easy." (3.09).

As shown, the overall mean of score of the CBL group was 3.52 which indicate "High Perceived Cognitive" while the overall mean score of the non-CBL group was 3.29 which indicate "Moderate Perceived Cognitive". There is a 0.23 difference between the CBL and non-CBL group. The result indicates that the comprehension skill is enhanced to students exposed to CBL.

Srisang and Everatt (2021), assert that the primary goal of reading comprehension is to help students' gain the information, abilities and experience. And the learners achieved understanding for them to answer and analyze complex science lessons.

Table 10 Displays The Perceived Cognitive Skills From School B In Relation To Comprehension.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
1. I easily comprehend contents of written materials.	4.52	Very High Perceived Cognitive Skills	4.50	High Perceived Cognitive Skills
2. Sequencing past events is very easy.	4.52	Very High Perceived Cognitive Skills	3.76	High Perceived Cognitive Skills
3. I easily clarify ideas or objects according to its similarities and similarities.	4.43	High Perceived Cognitive Skills	4.43	High Perceived Cognitive Skills
WEIGHTED MEAN	4.49	High Perceived Cognitive Skills	4.23	High Perceived Cognitive Skills

As presented, students under CBL group had a high perceived cognitive skill to "I easily clarify ideas or objects according to its similarities and similarities." (4.43), "I easily comprehend contents of written materials." (4.52), and "Sequencing past events is very easy." (4.52). Overall weighted mean of 4.49 indicates high perceived cognitive skills in relation to comprehension. Meanwhile, students under non-CBL group had a high perceived cognitive skill "I easily clarify ideas or objects according to its similarities and similarities." (4.43), "I easily comprehend contents of written

materials." (4.50), and "Sequencing past events is very easy." (3.76). Overall weighted mean of 4.23 indicates high perceived cognitive skills in relation to comprehension. The mean scores of students in relation to comprehension towards learning science are shown in Table 10. The weighted mean of the students exposed to CBL was 4.49, while those in non-CBL were 4.23. Both groups obtained high perceived cognitive skills towards chemistry. However, there is a 0.26 difference between the CBL and non-CBL group.

Based on the results, CBL stimulates students' curiosity and interest in learning, which can motivate them to improve their comprehension cognitive skills and seek feedback and guidance from peers and teachers. It also provides opportunities for students to practice and apply their comprehension cognitive skills in authentic contexts, and to reflect on their learning processes and outcomes (Prescher & Zumbach, 2022).

A study by Qasrawi & BeniAndelrahman (2020) supported this claim ad emphasized that CBL encourages students to collaborate and communicate with their peers and instructors, and to present and justify their solutions to the case problems. This may enhance their listening comprehension, oral communication, and social skills.

Table 11. Summary Table of Students Perceived Cognitive Skills From School A.

Indicators	**CBL**		**Non-CBL**	
	Mean	**Qualitative Interpretation**	**Mean**	**Qualitative Interpretation**
Processing Speed	3.68	High Perceived Cognitive Skills	3.39	Moderate Perceived Cognitive Skills
Comprehension	3.52	High Perceived Cognitive Skills	3.29	Moderate Perceived Cognitive Skills
Logic and Reasoning	3.45	Moderate Perceived Cognitive Skills	3.10	Moderate Perceived Cognitive Skills
Working Memory	3.40	Moderate Perceived Cognitive Skills	3.17	Moderate Perceived Cognitive Skills
Long Term Memory	3.40	Moderate Perceived Cognitive Skills	3.43	Moderate Perceived Cognitive Skills
WEIGHTED MEAN	4.49	High Perceived Cognitive Skills	4.23	High Perceived Cognitive Skills

Table 11 presents the summary of students' level of cognitive skills in the CBL and non-CBL class in science. It can be gleaned from the findings of the study that the overall mean result of the CBL class was 3.49 which indicate "Moderate Perceived Cognitive Skill" while the non-CBL was 3.29 with "Moderate Perceived Cognitive Skill".

Data reflects, the five cognitive skills exhibited by the learners on the mean scores in the CBL and non-CBL group. As shown in their order of cognitive preferences in the CBL group are as follows: processing speed (3.68); working memory (3.40); logic and reasoning (3.45); long term memory (3.40); and comprehension (3.52). While in the non-CBL group: processing speed (3.39); working memory (3.17); logic and reasoning (3.10); long term memory (3.43); and comprehension (3.29). It showed that the weighted mean for the CBL group is 3.49 (High Perceived Cognitive) and 3. 28 (Moderate Perceived Cognitive). A mean difference of 0.21 between the CBL class and non-CBL class.

These research results were found consistent with the study of Ilhan-Beyaztas & Özdemir (2018) that case-based learning approach allows students to improve cognitive skills of students.

Table 12. Summary Table of Students Perceived Cognitive Skills from School B.

Indicators	CBL		Non-CBL	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
Comprehension	4.49	High Perceived Cognitive Skills	4.23	High Perceived Cognitive Skills
Logic and Reasoning	4.31	High Perceived Cognitive Skills	4.26	High Perceived Cognitive Skills
Long Term Memory	4.28	High Perceived Cognitive Skills	4.15	High Perceived Cognitive Skills
Working Memory	4.21	High Perceived Cognitive Skills	4.00	High Perceived Cognitive Skills
Processing Speed	4.11	High Perceived Cognitive Skills	3.96	High Perceived Cognitive Skills
Grand Weighted Mean	4.29	High Perceived Cognitive Skills	4.12	High Perceived Cognitive Skills

Table 12 presents the summary of students' level of cognitive skills in the CBL and non-CBL group.

The findings of the study shows that the overall mean result of the CBL class was 4.29 which indicate "High Perceived Cognitive Skill" while the non-CBL was 4.12 with "High Perceived Cognitive Skill".

Among all the five (5) indicators of cognitive skills, CBL group shows higher grand weighted mean compared to non-CBL group though both groups have "high perceived cognitive skills".

The result implies that CBL group had more exposure to diverse and complex cases, which may have challenged their existing conceptions and stimulated their curiosity and interest. CBL fostered their critical thinking, problem-solving, and self-directed learning skills by exposing them to real-life situations and challenges. This may have improved their cognitive flexibility, metacognition, and transfer of learning, which are essential for cognitive skills.

A study by Cam and Geban (2011) also supported these findings and accordingly, student cognitive skills towards science is correlated to student achievement were enhanced during case-based learning since it emphasized students' ideas and demonstrates real life situations.

B. Comparison of Students' Perceived Cognitive Skills Between Case-Based Learning and Non-Case Based Learning

Table 13 illustrates the comparison of students perceived cognitive skills from school A. Students exposed to CBL obtained a mean score on the following indicators namely processing speed (3.68), working memory (3.38), logic and reasoning (3.45), long term memory (3.39), and comprehension (3.52). Students exposed to non-CBL on the following indicators namely processing speed (3.40), working memory (3.17), logic and reasoning (3.10), long term memory (3.43), and comprehension (3.29). The groups obtained an overall mean of 3.49 and 3.23, respectively.

Table 13. Summary Table of Students Perceived Cognitive Skills From School A.

	CBL		Non-CBL			
INDICATORS	**MEAN**	**SD**	**MEAN**	**SD**	**t-value**	**p-value**
Processing Speed	3.68	.466	3.40	.695	5.124	.028**
Comprehension	3.52	.561	3.29	.603	.301	.586
Logic and Reasoning	3.45	.530	3.10	.576	0.414	.523
Long Term Memory	3.39	.521	3.43	.673	2.276	.137
Working Memory	3.38	.575	3.17	.776	4.084	.048**
Overall	3.49		3.23	.590	4.531	.264

Students exposed to CBL obtained a mean score on the following indicators namely processing speed (3.68), working memory (3.38), logic and reasoning (3.45), long term memory (3.39), and comprehension (3.52). Students exposed to non-CBL on the following indicators namely processing speed (3.40), working memory (3.17), logic and reasoning (3.10), long term memory (3.43), and comprehension (3.29). The groups obtained an overall mean of 3.49 and 3.23, respectively.

There was a mean difference of 0.26 between two groups. The mean difference between their mean scores suggests that the class exposed to case-based learning (CBL), students have attained higher perception of their cognitive skills. The result is consistent with the study of Sadaf et al., (2021) that students perceived cognitive presence, learning and satisfaction were significantly higher in class exposed to case-based learning than non-case-based learning.

As gleaned on the table, there was a significant difference in the two indicators namely processing speed and working memory between CBL and non-CBL. However, the overall comparison of the perceived cognitive skill shows a t-value of 4.531 with a *p*-value of 0.264 indicating no significant difference between perceived cognitive skills at 0.05 level. Similar results with the conducted by Dankbaar et al. (2016) which reported that acquired cognitive skills did not differ between groups. Thus, on the basis of the students' cognitive skills the stated null hypothesis fails to rejects that there is no significant difference on the cognitive skills between the CBL class and non-CBL.

Table 14. Summary Table of Students Perceived Cognitive Skills from School B.

	CBL		Non-CBL			
INDICATORS	**MEAN**	**SD**	**MEAN**	**SD**	**T-Value**	**P-Value**
Comprehension	4.49	0.571	4.23	0.543	2.264	0.026
Logic and Reasoning	4.31	0.504	4.26	0.544	0.485	0.629
Long Term Memory	4.28	0.469	4.15	0.473	1.313	0.193
Working Memory	4.21	0.422	4.00	0.477	2.181	0.032
Processing Speed	4.11	0.434	3.96	0.443	1.658	0.101
Overall	4.29		4.12	0.490	1.562	0.196

Table 14 shows the comparison of students perceived cognitive skills from School C. Processing speed cognitive skills of the CBL group has 4.11 mean and 3.96 for non-CBL group with t-value of 1.658. Working memory cognitive skills of the CBL group has 4.21 mean and 4.00 for non-CBL group with t-value of 2.181. Logic and reasoning cognitive skills of the CBL group has 4.31 mean and 4.26 for non-CBL group with t-value of 0.485. Long term memory cognitive skills of the CBL group have 4.28 mean and 4.15 for non-CBL group with t-value of 1.313. Lastly, comprehension cognitive skills of the CBL group have 4.49 mean and 4.23 for non-CBL group with t-value of 2.26.

Among the five (5) indicators of cognitive skills, only working memory and comprehension cognitive skills shows a significant difference with a p-value of 0.032 (working memory) and 0.026 (comprehension).

This implies that CBL group had more opportunities to apply their comprehension and working memory skills to authentic problems, which may have increased their relevance and transferability. This is also supported by the study of Bonifacci et al. (2022) which states that comprehension and working memory cognitive skills enable students to apply their knowledge and skills to authentic problems, which require them to analyze, synthesize, and evaluate information from various sources.

Based on the findings, two classes exposed to non-case-based learning and case-based learning in chemistry show both high perceived cognitive skills, but the group exposed to case-based learning in chemistry has a higher mean, it could imply that CBL group had more exposure to diverse and complex cases and had more interactions and discussions with their peers and instructors, which may have fostered their critical thinking and problem-solving abilities (Jamari et al., 2021).

V. SUMMARY AND CONCLUSION

- *For School A*

The students' cognitive skills in the CBL group were found "High Perceived Cognitive Skill" in their order of preference such as processing speed and comprehension while "Moderate Perceived Cognitive Skill" for long term memory, working memory and logic and reasoning. While for the non-CBL group, all of the five cognitive domains were "Moderate Perceived Cognitive Skill".

The students' perceived level of cognitive skills was found no significant difference between the CBL and non-CBL group. With exposure to case-based learning, the specific cognitive skills identified and preferred, had demonstrated high cognitive learning among the learners and had improved their learning experiences in Chemistry.

- *For School B*

The level of students perceived cognitive skills in science for both CBL and non-CBL group in the following domains; processing speed, working memory, logic and reasoning, long term memory and comprehension were "highly perceived cognitive skills".

There is a significant difference between students perceived cognitive skills when exposed to CBL and non-CBL, rejecting the null hypothesis. Moreover, the CBL group had significantly higher scores in working memory and comprehension than the non-CBL group, implying that CBL improved their ability to hold and manipulate information in the mind and to understand and interpret information from different sources.

RECOMMENDATION

Integrating case-based learning in teaching science may lead to improve the learner's cognitive skills. Hence, science teachers, educators and curriculum makers may investigate how these skills are used and enhanced while exposed to this learning approach. For further studies, researchers may consider the relationship of cognitive skills and students' performance.

The study suggests that case-based learning (CBL) is an effective teaching method that can improve the cognitive skills of students in science, especially in working memory and comprehension. Therefore, it is recommended that teachers use CBL as a complementary or alternative approach to traditional teaching methods, such as lectures, textbooks, or worksheets, in science education.

ACKNOWLEDGMENT

The authors would like to extend their heartfelt thanks to Central Mindanao University especially the Professional Education Department, Science Education Department and the College of Education as a whole and together with the partner schools: Dologon National High School, Department of Education-Schools Division of Bukidnon and Xavier University, Cagayan de Oro City.

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