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Exploring the Structure and Level of Senior High School Students' Scientific Higher-order Thinking Skills in Science Education

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Abstract. This study aimed to determine the level of Scientific Higher Order Thinking Skills (S-HOTS) of the Grade 11 students in selected schools of Zamboanguita Districts 1 and 2, Negros Oriental. The researcher utilized a descriptive-correlational survey and employed systematic random sampling. The respondents of the study were the 148 senior high school students from the two public high schools in Zamboanguita, Negros Oriental. The researcher used a validated survey questionnaire and employed percent, weighted mean, mean, and Spearman Rank Correlation Coefficient in treating the data. Findings showed that students exhibit high levels of S-HOTS across multiple dimensions, including critical thinking, creative thinking, metacognition, science self-efficacy, and scientific reasoning. The data also unveiled that students' overall Earth and Life Science and Physical Science performance is categorized as 'satisfactory'. Moreover, the study found that the students' metacognition and science self-efficacy are significantly correlated to their academic performance. However, no significant relationships were observed between academic performance and the following variables: critical thinking, creative thinking, and scientific reasoning. Educators might focus on improving students' abilities to integrate and reorganize information creatively, encouraging more practice in activities like problem-based learning, project work, or tasks that require reimagining concepts in new ways.

Keywords: Critical thinking; Metacognition; Science self-efficacy; Scientific reasoning; Scientific Higher-Order Thinking Skills (S-HOTS).

1.0 Introduction

The current era of technological advancements, known as "Industrial Revolution 4.0," has profoundly influenced the field of education. It led to a shift in acquiring knowledge and information from rote learning to engaging in higher-order thinking. The Industrial Revolution 4.0 has transformed education to prepare students for the changing job market and industry needs. Moreover, these developments necessitate that learners cultivate a strong sense of self to handle the challenges of the twenty-first century. As Arifiyyati et al. (2022) noted, students must develop a sense of intellectual accountability to themselves and their communities. Education and training are vital connections between societal deficiencies and the progress communities aspire to achieve, as highlighted by Kareem (2022). A survey by the American Management Association (2019) further emphasizes this shift in educational priorities, revealing that 75% of employers believe fostering critical thinking, communication, creativity, and real-world problem-solving skills should take precedence in college curricula. Additionally, 93% of these employers consider these skills more important than traditional academic competencies.

The Philippine educational system aims to achieve quality education; despite numerous efforts, results from the Programme for International Student Assessment (PISA) indicate that Filipino students continue to rank among the least proficient in math, reading, and science. The average PISA 2022 results in these subjects showed a slight improvement compared to 2018 (Acido & Caballes, 2024). Compared to the OECD average of 76%, only over 23% of Filipino students attained Level 2 or higher in science. Furthermore, almost no Filipino students attained the highest performance levels in science, specifically Levels 5 or 6, while the OECD average is 7% (PISA, 2022). Muhibbuddin (2023) suggests that one way to address this issue is to innovate science teaching by strengthening students' critical thinking skills. Additionally, it is essential to cultivate the ability to think critically, develop creativity, construct knowledge, solve problems, and master the subject matter during the learning process to promote scientific literacy (Arifiyyati et al., 2022).

Numerous studies emphasize inference, concluding, deduction, induction, and analysis skills to assess higher-order thinking skills (Rashel & Kinya, 2020). Scientific higher-order thinking skills (S-HOTS) have long been a research focus, particularly in science education, with studies emphasizing their crucial role in the learning process. However, much of the current research has overlooked a comprehensive exploration of S-HOTS and has not sufficiently defined its distinctive characteristics (Sun et al., 2022). Therefore, this study aims to determine the level of Scientific higher-order thinking (S-HOT) skills of grade 11 students. Understanding and measuring these skills will help educators, especially in the Philippine setting, to select appropriate teaching strategies to enhance students' scientific literacy. Teaching science innovatively will foster students' critical and creative thinking, knowledge construction, problem-solving skills, and mastery of the subject matter.

2.0 Methodology

2.1 Research Design

The study used a descriptive-correlational research design, which is a flexible method for depicting the characteristics of a population or phenomenon and examining the relationships between variables (Miksza et al., 2023). This design was suitable for the study as it described the current state of students' higher-order thinking skills in science education and explored the various factors that influence these skills.

2.2 Research Locale

The research was conducted in the two public high schools of Zamboanguita, Negros Oriental. The study included grade 11 students of Santiago Delmo Memorial High School of District 1 and Jose Marie Locsin Memorial High School of District 2. The primary sources of income for the people living in Zamboanguita are agriculture and fisheries. Both schools receive limited learning resources from the Department of Education (DepEd), such as books, self-learning modules, science and mathematics equipment packages, and DepEd Computerization Program packages. Each classroom has a smart or non-smart television, funded by the School Maintenance and Other Operating Expenses (MOOE) fund and other stakeholders.

2.3 Research Participants

The research respondents of this study were the grade 11 students of Jose Marie Locsin Memorial High School of Zamboanguita District 2 and Santiago Delmo Memorial High School of Zamboanguita District 1 during the school year 2023-2024. Of the 283 total population, only 148 were the representatives, comprising 64 females and 84 males. Every second on the list was a respondent, and these students were selected using systematic random sampling.

2.4 Research Instrument

The researcher used a questionnaire and the class academic performance of the grade 11 students in Earth and Life Science and Physical Science during the school year 2023-2024. Earth and Life Science and Physical Science are core subjects in senior high school, particularly in grade 11. The student's performance in Earth and Life Science and Physical Science was correlated with their level of S-HOTS. The level of S-HOT is divided into five areas: critical thinking, creative thinking, metacognition, science self-efficacy, and scientific reasoning. The indicators in the survey questionnaire used to evaluate critical thinking skills were adapted from the research instrument of Kobylarek et al. (2022), and the indicators used in assessing Metacognition were taken from the study of Ajaja and Agboro-Eravwoke (2017). In addition, the indicators from the study of Lehmkuhl et al. (2021) and Sun, Xie, and Lavonen (2022) were also used in evaluating students' scientific reasoning skills. Furthermore, indicators used to measure science self-efficacy were from Van Zyl et al. (2022).

The researcher composed a letter to the cited authors requesting authorization to utilize their research instruments in this study. The entire questionnaire was shown to three experts in science education for content validity and to verify if the items corresponded with the study's specific questions. The recommendations from the experts were taken into account during the enhancement of the questionnaire. An item reliability test was carried out through a dry run. Thirty students not included as respondents in the study were selected during the dry run. The reliability of the items was assessed through Cronbach's alpha test. Its theoretical range is from 0 to 1 and measures how positively each variable in the scale relates to all other variables. Although 0.70 is considered satisfactory, larger alpha values are preferred. This study established a threshold of 0.70 as the minimum acceptable level for reliability, consistent with common standards in educational research. Additionally, items with alpha values below 0.70 were reviewed and subsequently revised or removed to further enhance the instrument's reliability. The results of these adjustments are shown in Table 1.

Table 1. *Reliability test result*

S-HOTS	Cronbach's Alpha Coefficients
Analysis	0.724
Evaluation	0.704
Synthesis	0.720
Creative thinking	0.701
Metacognition	0.740
Science Self-Efficacy	0.764
Scientific Reasoning	0.700

2.5 Data Gathering Procedure

Following the design hearing, the researcher incorporated all the panel members' corrections, suggestions, and other comments for improvement. With approval from the dean of Foundation University Graduate School, a request letter to float the questionnaire to the respondents was forwarded to the Superintendent of the Schools Division in Negros Oriental through the Public Schools District Supervisors of Zamboanguita districts 1 and 2. The approved letters were given to the school principals and students' advisers for the final floating questionnaire schedule. The researcher discussed the significance and objectives of the study with the students during the distribution of the questionnaires. Also, the researcher read aloud each item to them. As soon as the students had completed answering all the items in the survey questionnaire, the researcher personally retrieved them. The researcher collected the students' Earth and Life Science and Physical Science grades from their advisers and the students themselves. The researcher tallied the data gathered using MS Excel, followed by analysis and interpretation carried out by the statistician.

2.6 Ethical Considerations

The researcher was exceptionally cautious in managing the data given by the students, guaranteeing that the confidentiality of the information was preserved strictly to respect the dignity and privacy of the learners. During this research, the researcher adhered to all required protocols set by the Ethics Committee of Foundation University to guarantee that the research topic is meaningful, clearly valid, and ethically appropriate. Furthermore, the researchers obtained informed consent from all study respondents via a disclosure statement before its execution. The first part of the questionnaire includes the disclosure statement, which was read aloud by the researcher to the respondents. The study highlighted the respondents' anonymity, confidentiality, and self-determination rights.

3.0 Results and Discussion

3.1 Scientific Higher-Order Thinking Skills (S-HOTS)

In terms of Critical Thinking

The findings (see Table 2) indicate that students scored highly in the analysis, evaluation, and synthesis sub-skills, as reflected in their respective weighted means of 3.42, 3.77, and 3.35. The overall rating of 3.51, with a confidence interval of 3.39 to 3.63, spans the boundary between moderate to high critical thinking. Table 1 presents the data on the level of students' S-HOTS in terms of critical thinking. In this study, the critical thinking skills factors measured are analysis, evaluation, and synthesis skills.

Table 2. *Level of students' S-HOTS in terms of critical thinking (n=147)*

Components of Critical Thinking	$\bar{x}$	**VD**	**LoCT**	**CI**
Analysis				
1. I am drawn to exploring more profound interpretations of reality.	3.55	A	H	3.44 – 3.67
2. I can pick out the most important parts of a science lesson.	3.47	A	H	3.37 – 3.58
3. I like researching for a relationship between the information the science lesson contains and other topics I have read.	3.45	A	H	3.33 – 3.56
4. I enjoy finding connections between phenomena that appear unrelated.	3.43	A	H	3.31 – 3.55
5. I can break down a scientific problem into smaller parts and determine the most effective solution.	3.18	MA	M	3.05 – 3.31
Composite	***3.42***	***A***	***H***	***3.30 – 3.53***
Evaluation				
1. I try to check if the scientific information that interests me is accurate.	3.91	A	H	3.80 – 4.02
2. I double-check important scientific information, even if it seems true.	3.85	A	H	3.73 – 3.97
3. I look at different sources when I am checking scientific information.	3.84	A	H	3.73 – 3.96
4. During a science class discussion, I focus on explaining my thoughts clearly and trying to understand the other person's viewpoint.	3.74	A	H	3.61 – 3.86
5. I can find the most helpful scientific information to solve problems.	3.53	A	H	3.40 – 3.65
Composite	***3.77***	***A***	***H***	***3.65 – 3.89***
Synthesis				
1. I like discussing new meanings in texts that I already know.	3.59	A	H	3.46 – 3.72
2. I like combining scientific ideas from different sources.	3.44	A	H	3.31 – 3.57
3. I form my understanding by merging various bits of scientific information.	3.41	A	H	3.29 – 3.52
4. I can create logical/sound inferences from all scientific information.	3.17	MA	M	3.06 – 3.28
5. I can see the structure of the text, and I could change it.	3.14	MA	M	3.03 – 3.25
Composite	***3.35***	***MA***	***M***	***3.23 – 3.47***
Overall	**3.51**	**A**	**H**	**3.39 – 3.63**

Legend: *Scale*	*Verbal Description (VD)*	*Level of Critical Thinking (LoCT)*
4.21 – 5.00	*Strongly Agree (SA)*	*Very High (VH)*
3.41 – 4.20	*Agree (A)*	*High (H)*
2.61 – 3.40	*Moderately Agree (MA)*	*Moderate (M)*
1.81 – 2.60	*Disagree (D)*	*Low (L)*
1.00 – 1.80	*Strongly Disagree (SD)*	*Very Low (VL)*

The result suggests that students are proficient in analyzing information, identifying patterns, and understanding the components of a problem. In addition, it also depicts that they can effectively break down complex situations into manageable parts, which is essential for problem-solving and decision-making. According to Fitriani et al. (2020), students must acquire critical thinking skills to be capable of problem-solving, analysis, and decision-making. All students should be able to think critically because it is a valuable intellectual skill. Furthermore, Jayanti (2020) stated that analysis is a higher-order thinking skill in which students attempt to break down a given piece of information into its components and identify the relationships between them. Moreover, Muhibbuddin (2023) suggested that science teachers must innovate how science is taught to strengthen students' scientific critical thinking skills. The results indicate that students are powerful at evaluating information. They can assess data or arguments' credibility, accuracy, and relevance in a given problem. This skill is crucial in scientific reasoning, ethical decision-making, and forming sound judgments. In the words of (Sunarti et al., 2021), an option for problem-solving is to evaluate claims, opinions, or arguments for better understanding. Darmaji et al. (2022) also stated that in problem-solving or decision-making, a person with critical thinking abilities can evaluate a statement by looking at logical and rational relevant issues.

As emphasized in the study of Arifiyyati et al. (2022), teachers are essential in helping students think critically, be creative, build knowledge, solve problems, and become experts in the topic to promote scientific literacy. Jayanti (2020) posited that as part of the higher-order thinking skill of creating, students organize how to create a design to finish a task. All students should be able to integrate different knowledge components to provide a convincing explanation of concepts and ideas, particularly on Earth and Life Science and Physical Science. Although students also performed well in synthesis (composite mean of 3.35), the findings suggest a slightly weaker ability to generate new ideas or reconfigure existing information in novel ways. Specifically, the "moderate" ability to create logical inferences and restructure texts may indicate that while they can understand and process information well, they might struggle with higher-order tasks like creating innovative solutions or writing well-organized scientific answers. Additionally, the lack of emphasis on developing students' critical thinking skills contributes to their "moderate" level of synthesis skills. Students lack exposure to opportunities to synthesize their ideas, engage in classroom activities that foster these skills, and are often exposed to assessment tests that focus on rote memorization and understanding. The "moderate" level of synthesis suggests a need for targeted instructional strategies. Educators might focus on improving students' abilities to integrate and reorganize information creatively, encouraging more practice in activities like problem-based learning, project work, or tasks that require reimagining concepts in new ways. Moreover, engaging students in collaborative learning allows them to discuss and synthesize information. Students must be exposed to assessments focusing on synthesis skills and application, and teachers must provide immediate feedback to students to continuously develop these skills.

The result of the study aligns with the finding of Farillon (2021), which revealed that the students taking up HUMSS, HE, and ICT had "developed" levels of critical thinking abilities, while those taking up SMAW had "moderately developed" levels. As Himmatussolihah et al. (2020) stressed, critical thinking can produce strong thinkers and problem-solvers. People with strong critical thinking abilities can complete projects with fewer errors than those with weaker critical thinking abilities. The results manifest that the respondents are critical thinkers and consider all rational choices in decision-making, particularly in Earth and Life and Physical Science subjects. While students have strong critical thinking skills, particularly in evaluation, more emphasis could be placed on improving their creative thinking and inference skills to ensure they can excel in traditional and innovative tasks.

In terms of Creative Thinking

Table 3 shows the data on the level of S-HOTS of the students in terms of creative thinking. Overall, the students have "high" creative thinking skills, as evident in the composite mean of 3.67, with a confidence interval of 3.56 to 3.77. This interval falls entirely within the high classification of creative thinking skills. Specifically, the students have a "high" level of curiosity about how things work ($\bar{x}$ = 4.22), participate in science experiments to learn new things ($\bar{x}$ = 4.06), and enjoy adding artistic touches to their science homework or projects ($\bar{x}$ = 3.54). Madyani et al. (2020) stated that creative thinking is one of the 4Cs students need to possess.

Table 3. *Level of students' S-HOTS in terms of creative thinking (n=148)*

Indicators	$\bar{x}$	VD	LoCT	CI
1. I am a curious about how things work.	4.22	A	H	4.12 – 4.31
2. I like to participate in science experiments to learn new things.	4.06	A	H	3.94 – 4.18
3. I enjoy adding artistic touches to my science homework or projects.	3.54	A	H	3.43 – 3.65
4. I can understand and interpret scientific problems.	3.31	MA	M	3.21 – 3.41
5. I can see multiple ways to solve a scientific problem.	3.21	MA	M	3.11 – 3.31
Composite	**3.67**	**A**	**H**	**3.56 – 3.77**

The study's findings contrast with those of Sugiharto et al. (2020), who revealed that urban and rural senior high school students manifest low creative thinking skills. The research findings imply that students possess creative thinking skills and can develop or construct solutions to problems, specifically in Earth, Life, and Physical Science. Furthermore, Kareem (2022) also discovered that creativity is a key technique for solving problems when there are no simple solutions and the standard or popular solutions are ineffective. Consequently, Anggraeni and Sole (2019) stressed that creative thinking skills are the ability to use one's thought process to generate fresh, reasonable, and constructive ideas that incorporate one's instincts. The research findings imply that students possess creative thinking skills to develop or construct solutions to problems, specifically in Earth and Life and Physical Science. It can be observed from the data that students have a "moderate" level in understanding and interpreting scientific problems and seeing multiple ways to solve a scientific problem. The results agree with the PISA 2022 results, which revealed that Filipino learners scored an average of 14 points in terms of creative thinking, which was second to the worst (PISA, 2022). The presented research findings imply that students must be given targeted educational interventions and supportive environments, specifically in Earth and Life and Physical Science subjects, which can significantly enhance their creative thinking abilities.

In terms of Metacognition

Table 4 reveals the data on the level of students' S-HOTS in terms of metacognition. The results disclosed that the respondents have "high" metacognition skills, as manifested in the value of the composite mean of 3.55, with a confidence interval of 3.44 to 3.67. This interval exclusively falls under the high level of metacognition. It is evident in the table that the students have a "high" level of metacognitive skills wherein they try to relate what they learn in science with real-world experience ($\bar{x}$ = 3.78), adjust their level of concentration depending on the learning situation ($\bar{x}$ = 3.65), can sense when they are about to face a learning challenge in their science class ($\bar{x}$ = 3.59), and change their approach if they are not progressing as expected in a learning task related to science ($\bar{x}$ = 3.45).

Table 4. *Level of students' S-HOTS in terms of metacognition (n=148)*

Indicators	$\bar{x}$	VD	LoM	CI
1. I try to relate my science learning with real-world experiences.	3.78	A	H	3.66 – 3.91
2. I adjust my level of concentration depending on the learning situation.	3.65	A	H	3.54 – 3.76
3. I can sense when I am about to face a learning challenge in a science class.	3.59	A	H	3.48 – 3.71
4. I change my approach if I am not progressing as expected in a science-related learning task.	3.45	A	H	3.34 – 3.56
5. I am confident in understanding even the most complicated topics in a science course.	3.29	MA	M	3.17 – 3.41
Composite	**3.55**	**A**	**H**	**3.44 – 3.67**

Notably, the respondents have a "moderate" level of confidence in their ability to understand the most complicated topics in a science course. The finding suggests that the students are mindful and continuously monitor their progress in Earth, Life, and Physical Science subjects. In addition, they can understand and control their learning and relate the topics and concepts they have learned in science to their day-to-day lives. However, the students have not yet fully developed their confidence in their ability to understand the most difficult science topics. The result corroborates the findings of Hindun et al. (2020), which reported that most students' metacognitive awareness was "satisfactory." According to Monika and Sambyal (2023), metacognition is an essential skill to develop in students because it can help them become more critical thinkers, especially about how they learn and how to use their prior experiences and knowledge (schemata) appropriately to increase their capacity for learning across cognitive strategies. Mohammadi et al. (2022) also stressed that metacognition supports learners in being more self-aware of their performance while gaining the necessary skills and helping them become more independent learners.

In terms of Self-Efficacy

Table 5 depicts the data on students' S-HOTS regarding science self-efficacy. Generally, the respondents have "high" science self-efficacy skills, as manifested in the composite mean of 3.64 with a confidence interval of 3.52 to 3.76. This interval is fully contained within the high classification of science self-efficacy. It is further exhibited in the table that the students have a "high" level of belief in themselves that 'if others can do it, so can they' ($\bar{x}$ = 3.99), belief that with enough effort, they can succeed in the exams ($\bar{x}$ = 3.80), stay calm during exams because they trust their knowledge to solve problems in science ($\bar{x}$ = 3.48), confident in their ability to stay focused in their goals ($\bar{x}$ = 3.64), and can manage to solve complex science problems if they try hard enough ($\bar{x}$ = 3.45).

Table 5. *Level of students' S-HOTS in terms of science self-efficacy (n=148)*

Indicators	$\bar{x}$	VD	LoSSE	CI
1. I believe in the saying *"If others can do it, so can I"* when studying science.	3.99	A	H	3.86 – 4.12
2. I believe I can succeed in science exams with enough effort throughout the semester.	3.80	A	H	3.69 – 3.92
3. I know I will stay calm during exams because I trust my knowledge to solve problems in science.	3.48	A	H	3.36 – 3.60
4. I am confident in my ability to stay focused and achieve my goals in my science studies.	3.47	A	H	3.35 – 3.60
5. I can solve complex science problems if I try hard enough.	3.45	A	H	3.32 – 3.57
Composite	**3.64**	**A**	**H**	**3.52 – 3.76**

The result implies that the students feel confident in their ability to succeed in science-related tasks, which could help them perform well in academics and behave positively in challenging learning environments. Defiño et al. (2022) claimed that students with high self-efficacy are confident in completing complex tasks and adhering to the requirements while demonstrating positive behavior.

In terms of Scientific Reasoning

Table 6 reflects the data on the level of students' S-HOTS in terms of scientific reasoning. It divulges that the students have "high" scientific reasoning skills, as presented in the composite mean of 3.49, with a confidence interval of 3.38 to 3.61. This interval suggests an overlap between the classifications of moderate to high levels of metacognition. The table further unveils a "high" level of student's consideration of scientific information from various sources before making a decision ($\bar{x}$ = 3.64), carrying out investigations to test their ideas ($\bar{x}$= 3.59), using their scientific knowledge and investigative skills to solve real-life problems ($\bar{x}$ = 3.51), and recognizing the authenticity of the scientific information they obtain from the internet ($\bar{x}$ = 3.37).

Table 6. *Level of students' S-HOTS in terms of scientific reasoning (n=148)*

Indicators	$\bar{x}$	VD	LoSR	CI
1. I consider scientific information from various sources before making a decision.	3.64	A	H	3.54 – 3.75
2. I carry out investigations to test my ideas.	3.59	A	H	3.49 – 3.70
3. I use my scientific knowledge and investigative skills to solve real-life problems.	3.51	A	H	3.38 – 3.63
4. I can recognize the authenticity of the scientific information I obtain online.	3.37	A	H	3.25 – 3.49
5. I can explain natural events using my scientific knowledge.	3.34	MA	M	3.23 – 3.46
Composite	**3.49**	**A**	**H**	**3.38 – 3.61**

A "high" level of scientific reasoning among students indicates that they possess a strong capacity to approach scientific problems, hypothesize, analyze data, and draw conclusions in a structured and logical manner. This skill is foundational for success in science-related fields and essential for navigating complex issues in modern society. Zimmerman, as cited by Klemm et al. (2020), stated that children who engage in scientific thinking are said to be using the methods or concepts of scientific investigation to reasoning or problem-solving situations. On the other hand, it is notable in the presented data that the respondents have a "moderate" ability to explain natural events using their scientific knowledge. The result unveils that while students are proficient in thinking through scientific problems, they may struggle with applying their theoretical understanding to real-world phenomena. This moderate ability to connect knowledge with practical explanation suggests a gap between knowing scientific facts and effectively communicating or contextualizing them in everyday experiences.

3.2 Performance of the Students in Earth and Life Science and Physical Science Subjects

Table 7 shows the students' performance in Earth and Life Science and Physical Science subjects. In Earth and Life Science. The findings show that 11.49% of students achieved an outstanding rating, 28.38% attained a very satisfactory rating, 43.92% received a satisfactory rating, and 16.21% earned a fairly satisfactory rating. Similarly, in Physical Science, 10.14% of students achieved an outstanding rating, 26.35% attained a very satisfactory rating, 48.65% received a satisfactory rating, and 14.86% earned a fairly satisfactory rating. Additionally, the students' performance in Earth and Life Science has the highest spread in its data points (SD = 4.44), while their performance in Physical Science is slightly less spread (SD = 4.32). This performance distribution indicates that most students—nearly half in both subjects—fall within the "satisfactory" category, with fewer students achieving "outstanding" ratings. Moreover, the learners showed a "satisfactory" performance, reflected in its overall mean rating of 83.68%. Overall, the data indicates that students' performance in Earth and Life Science and Physical Science is "Satisfactory," which means that they have acquired essential knowledge and skills and can apply the S-HOTS in the said subjects (DepEd Order No. 73, s. 2012).

Table 7. *Performance of students (n=148)*

Rating	Verbal Description	Earth and Life Science		Physical Science		Overall	
		f	%	f	%	f	%
90%-100%	Outstanding (O)	17	11.49	15	10.14	17	11.49
85% - 89%	Very Satisfactory (VS)	42	28.38	39	26.35	45	30.40
80% - 84%	Satisfactory (S)	65	43.92	72	48.65	67	45.27
75% - 79%	Fairly Satisfactory (FS)	24	16.21	22	14.86	19	12.84
Mean		**83.57 (S)**		**83.78 (S)**		**83.68 (S)**	

This result, however, contradicts the findings of Suminguit and Despojo (2023), which revealed that students' performance in Earth and Life Science is on the "very satisfactory" level. Moreover, Despojo (2024) reported that the students' performance in Earth and Life and Physical Science subjects is generally on the "outstanding" level. The performance data suggest that students meet basic competency standards but may not consistently excel in applying S-HOTS in scientific contexts, such as analysis, evaluation, and synthesis. This may reflect the challenges in mastering the more abstract and complex concepts in Earth and Life Science (which often require understanding geological processes, ecosystems, and biological systems) and Physical Science (which deals with physics, chemistry, and their applications).

3.3 Relationship Between Students' S-HOTS and their Performance in Science Subjects

Table 8 presents the data determining the relationship between the S-HOTS of the students and their performance in Science subjects. It shows a significant relationship between the student's metacognition and performance in Science subjects ($p = 0.029$). The results mean that students who monitor their learning tend to acquire better academic performance. This implies that metacognitive abilities enable students to become independent learners aware of their progress, adjust to different learning situations, and overcome various learning challenges, specifically in Earth and Life Science and Physical Science. The finding agrees with the statement of Khairinaa et al. (2023) that metacognitive awareness and critical thinking abilities impact knowledge-learning outcomes in scientific learning. This has also been agreed by Pucillo and Perez (2023) when they confirmed that metacognitive and self-regulated learning strategies can accurately predict academic performance.

Table 8. *Relationship between S-HOTS and performance in science subjects (n=148)*

Variables Correlated to Performance	r_s	p-value	Decision	Remark
Critical Thinking	0.091	0.273	Accept H_{o1}	Not significant
Creative Thinking	0.136	0.099	Accept H_{o1}	Not significant
Metacognition	0.180	0.029	Reject H_{o1}	Significant
Science Self-Efficacy	0.324	<.000	Reject H_{o1}	Significant
Scientific Reasoning	0.097	0.244	Accept H_{o1}	Not significant

Spearman Rank-Order Correlation at 5% Level of Significance

The result further reveals a significant relationship between students' Science self-efficacy and their performance in Science subjects ($p < .001$). This signifies that the higher the students' science self-efficacy, the better their performance in science subjects. This infers that the students have high confidence levels and can perform scientific tasks successfully during their Earth and Life Science and Physical Science classes. The result corresponds with the statement of Hayat et al. (2020) that academic self-efficacy has a considerable effect on students' academic performance, learning, and motivation. Furthermore, Defiño et al. (2022) noted that students with high academic self-efficacy typically perform well academically. Meanwhile, the following variables have no significant relationship with students' performance: critical thinking, creative thinking, and scientific reasoning. All their p-values are more significant than the significance level (0.05). This connotes that whether students have high or low levels of the aforementioned areas of S-HOTS, their performance remains constant.

This finding is consistent with Shirazi and Heidari (2019), who discovered in their study that there is no significant relationship between students' performance and critical thinking skills. This suggests that the degree to which academic achievement and critical thinking are related may differ based on the specific skills and conditions measured. The results negate the findings of Cyril (2023), Akpur (2020), Hamzah et al. (2022), Fitriani et al. (2020), and Musa (2020), who claimed that there is a significant relationship between students' higher-order thinking skills and their performance. Furthermore, Akpur (2023) noted that the different results of the studies show how complicated and multidimensional higher-order thinking skills are and how hard it is to show the different factors that make them relate to each other. This implies that scientific higher-order thinking skills do not necessarily predict students' academic achievement in science education due to the complexity of the relationships among the variables.

4.0 Conclusion

Exploring the structure and level of Scientific Higher-Order Thinking Skills (S-HOTS) is vital in understanding how students engage with complex scientific concepts, particularly in subjects like Earth and Life Science and Physical Science. S-HOTS, which includes critical thinking, creative thinking, metacognition, science self-efficacy, and scientific reasoning, is important in developing students' ability to analyze, evaluate, and synthesize scientific information. These skills enable students to approach scientific problems with a more profound understanding and apply their knowledge in real-world contexts. Educators might focus on improving students' abilities to integrate and reorganize information creatively, encouraging more practice in activities like problem-based learning, project work, or tasks that require reimagining concepts in new ways. Students must be given targeted educational interventions and supportive environments, specifically in Earth and Life and Physical Science subjects, which can significantly enhance their higher-order thinking abilities. The result unveils that while students might be proficient in thinking through scientific problems, they may struggle with applying their theoretical understanding to real-world phenomena. This moderate ability to connect knowledge with practical explanation suggests a gap between knowing scientific facts and effectively communicating or contextualizing them in everyday experiences. This reflects the challenges students face in mastering the more abstract and complex concepts in Earth and Life Science and Physical Science.

5.0 Contributions of Authors

The authors confirm their equal contribution to every part of this research. All authors reviewed and approved the final version of this paper.

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7.0 Conflict of Interests

This study has no conflict of interest of any sort.

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