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Scientific Reasoning, Critical Thinking, and Academic Performance in Science of Selected Filipino Senior High School Students

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ABSTRACT

This correlational study on quantitative in nature was conducted to determine the relationship of scientific reasoning skills, critical thinking skills, and performance in Science of senior high school (SHS) students at Tapaz National High School, Capiz, Philippines. The variables in this study are the six different strands in SHS, namely, Science, Technology, Engineering, and Mathematics (STEM); General Academic Strand (GAS); Accountancy, Business, and Management (ABM); Home Economics (HE); Information and Communications Technology (ICT); and Shielded Metal Arc Welding (SMAW). The study used three instruments to quantify its goal with the statistical tools used to analyse data, i.e. the mean, standard deviation, and Pearson's r correlation coefficient. All inferential tests were set at 0.05 alpha level. The findings of the study revealed that the level of scientific reasoning skills of SHS students when taken as a whole was "high", and when grouped according to strand, the STEM, GAS, ABM, HE, and ICT were "high" while the SMAW was on “average” level of critical thinking skills. While when taken as a whole is found "developed" and when grouped according to strand, the STEM, GAS, ABM, HE, and ICT are "developed" while the SMAW is "moderately developed"; and their level of performance in Science, when taken as a whole, is "very satisfactory" and when grouped according to strand, the STEM, GAS, ABM, and HE were "very satisfactory" while the ICT and SMAW are "satisfactory". A significant relationship among the variables was taken as a whole and grouped according to strand. Students should learn to engage in scientific argumentation to develop their scientific reasoning and critical thinking skills. Also, the teachers should build up certain students' skills to better their performance in Science and other subjects. The school administration should also look for more sustainable programs and workshops for the teachers and students to improve their studies and lives.

1. Introduction

Science teachers often wonder why most students find Science one of the most difficult subjects. This is manifested by the latter's poor performance in the subject, where most of them received low scores in their quizzes and periodical tests. According to UNESCO (2010), science education is an important key to success in today's global knowledge environment, which Science and technology profoundly shape. There is, however, a consensus that many places around the world have been facing serious challenges in terms of Science education.

In addition, Malipot (2019) reported that the quality of education in the Philippines was put under scrutiny in 2019 following the results of both local and international assessments on students’ performance that highlighted the low performance of Filipino learners. It was also observed that students had a low standing in their Science Achievement Test, as evidenced by their low mean percentage scores. Moreover, results of the 2018 National Achievement Test (NAT) showed that one region garnered an average score of 28.42 in Science, failing to reach the standard average score of 75 (Department of Education (DepEd) Region 2, 2018).

These findings only show that something must be done to improve student performance in Science. Thus, the researcher has decided to delve further into its course by involving the students’ scientific reasoning skills and critical thinking skills as these are critical elements of science literacy and the core learning

objectives of Science education, according to Dowd et al. (2018). Training and developing them is crucial in student academic performance (Berondo & Dela Fuente, 2021; Elisanti, Sajidan, & Prayitno, 2017).

In fact, the DepEd (2017) has an Alternative Learning System strand that outlined the competencies of each educational stage with the ultimate goal of enabling the learners to apply critical thinking skills and problem-solving skills in daily life situations in order to improve their lives and the quality of life of the people, the community, and the country as a whole. The objectives, competencies, and skills on critical thinking were sequenced so that the students will be able to experience success in learning. The sequencing—which follows a logical and sequential order from simple to complex, concrete to abstract, familiar to unfamiliar, specific to general, narrow to broad—helps the students move from easy to difficult by increasing the degree of complexity as the literacy level increased and as learning progressed.

Moreover, according to Ragma and Valdez (2017), the development of scientific reasoning skills in the K-12 curriculum has proven academic achievement. There are reports of positive correlations between students' scientific reasoning abilities and measures of students' gains in learning Science content support the consensus of the Science education community on the need for K-12 students to develop an adequate level of scientific reasoning skills along with a solid foundation of content knowledge. Nevertheless, poor scientific reasoning has almost been overdetermined in that numerous factors had negatively impacted performance, including reliance on fast and frugal heuristics, the influence of prior beliefs and motivations, poor numeracy and statistical reasoning, and misleading science communication. While the problem is clear, there is little consensus regarding potential solutions. However, one potential solution involves bridging disconnection between how students are taught to interpret Science in K-12 and how people interpret Science in reality (Bao, et., al, 2009; Brossard & Nisbet, 2008).

Conversely, performance in Science refers to students' engagement, involvement, and achievements in the Science subject, which is evaluated using different teaching and learning evaluation processes given by the teachers. Felasol (2014) study used the term to refer to how well the students were doing in their studies and classes. This supports one of DepEd's (2018) major objectives in science: to engage the students in all activities, such as performance tasks, science experimentations, scientific observations, and scientific argumentations. The American Association for the Advancement of Science (2008) reported that students' ability to reason from evidence and participate in scientific argumentation is considered a major objective of Science education reform. In line with this, the Department of Science and Technology (2018) has claimed that asking the students to participate during recitations, class reflections, and class debates where they are challenged to reason brightens the class and creates more innovation.

Moreover, Farrington et al. (2012) has observed how high school students' performance in Science was discoursing low, which posed a problem to stakeholders. In addition, there was also the problem of persistent absenteeism among students that resulted in student dropouts. While there was much attention given to closing the achievement gap among socioeconomically disadvantaged or ethnic/racial minority students, it should be realized that performance in school is also affected by several factors that include the quality of the school, the characteristics of each student's family such as socioeconomic status, the parent's educational level, and the characteristics of the child. Furthermore, research by Manolito (2012); Lainez, et, al., (2021) on the common difficulties experienced by high school students and teachers in Science classes reported that promoting in-depth learning appeared to be a tough task for the teachers, with the main challenge lying on the students' inability to demonstrate a good understanding of the very basic concepts of the subject. This is supported by international and local studies that revealed Filipino students to have low retention of concepts and limited reasoning and analytical skills (UP-NISMED, 2004), and the researcher's experiences inside the classroom that showed students' inability to provide evidence-based reasoning—prompting an investigation into the relationship between scientific reasoning skills, critical thinking skills, and SHS students' performance in Science.

The researcher analyzed the connection of the three variables quantitatively and collected the data using a purposive sampling technique. Data were gathered from only one school, considering the vast representation of the students from the said school and the difficulty of gathering data from other schools due to the COVID-19 pandemic. Only one grade level, Grade 12, was selected for the study to create uniformity of the measures, especially for performance in Science, as they have taken the same subject, Earth and Life Science. These students also come from different backgrounds.

Echoing the above explanations, this study attempted to ascertain the relationship among scientific reasoning skills, critical thinking skills, and performance in Science of SHS students of Tapaz National High School, Poblacion, Tapaz, Capiz, Philippines enrolled in School Year 2020–2021 and answer the following questions:

1) What is the level of the Senior High School students' scientific reasoning skills when taken as a whole and when grouped according to strand?
2) What is the level of the Senior High School students' critical thinking skills when taken as a whole and when grouped according to strand?

3) What is the level of the Senior High School students' performance in Science when taken as a whole and grouped according to strand?
4) Are there significant relationships among Senior High School students' scientific reasoning skills, critical thinking skills, and performance in Science when taken as a whole and grouped according to strand?

This study is unlike any others that had been done before. This studied the relationship of three entirely different variables but equally significant for the development of the Science curriculum and employing teaching strategies to promote better learning for the students.

Analysis of the students' current status has also been made that would direct the school administration and teaching staff on how to deal well with the current teaching and learning process challenges.

1.2 Hypothesis

Based on the problems stated above, this hypothesis was formulated:

There are no significant relationships among Senior High School students' scientific reasoning skills, critical thinking skills, and performance in Science.

1.3 Conceptual Framework

The variables in this study are the scientific reasoning skills, critical thinking skills, and performance in Science of the Senior High School students of Tapaz National High School, Poblacion, Tapaz, Capiz, Philippines enrolled in School Year 2020–2021. It also has antecedent variables, which are the different strands of the Senior High School students, namely: STEM, GAS, ABM, HE, ICT, and SMAW.

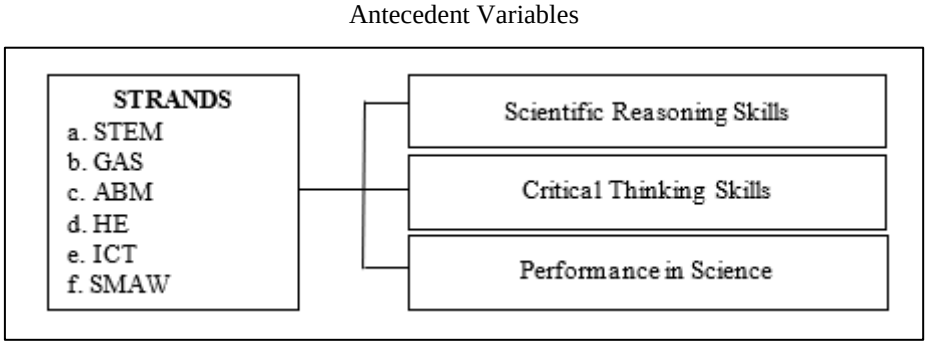

Figure 1. A schematic diagram shows the relationship between scientific reasoning skills, critical thinking skills, and performance in Science of the different strands of Senior High School students.

2. Methods

2.1 Research Design

The present study was conducted to determine the relationship among the scientific reasoning skills, the critical thinking skills, and the performance in Science of Senior High School students of Tapaz National High School, Poblacion, Tapaz, Capiz, Philippines enrolled in the School Year 2020–2021.

This study utilized the correlational method. According to Fraenkel, Wallen, & Hyun (2012), correlational research investigates the possibility of relationships between only two variables, although investigations of more than two variables are common. Correlational research is also sometimes referred to as descriptive research because it describes an existing relationship between variables. However, the way it describes this relationship is quite different from the descriptions found in other types of studies. A correlational study describes the degree to which two or more quantitative variables are related, and it does so by using a correlation coefficient.

This research design was appropriate for this study because the correlational study was used to ascertain the relationship among the scientific reasoning skills, the critical thinking skills, and the performance in Science of the SHS students.

In this study, the variables correlated with each other were the scientific reasoning skills, critical thinking skills, and the performance in Science of the SHS students. The antecedent variables were the different SHS strands: STEM, GAS, ABM, HE, ICT, and SMAW.

The descriptive statistics used in the study were the frequency count, percentage, mean, and standard deviation. The inferential statistics used was the Pearson r correlation coefficient that determined the significant relationships among the variables. The alpha level of significance was set at 0.05.

2.2 Respondents

The respondents of this study were the purposively selected 257 Grade 12 Senior High School students of Tapaz National High School, Poblacion, Tapaz, Capiz, Philippines, enrolled in School Year 2020–2021.

The participants were chosen through purposive sampling. This sampling technique refers to a type of non-probability sampling where the target participants meet specific practical criteria, such as easy accessibility, availability at the given time, or the willingness to participate are included for the study (Etikan, Musa, & Alkassim, 2016). The selection criteria for the participants of this quantitative study were the following: (a) currently enrolled in the chosen school, (b) enrolled in Grade 12, (c) have taken the Earth and Life Science course, and (d) enrolled under one of the six strands offered by the school. The respondents' socio-demographic profiles include the different strands in which they were enrolled. All respondents were Grade 12 students.

Table 1 presents the distribution of the respondents according to their strands. The majority of the respondents were enrolled in GAS (31.13%), followed by HE (20.23%) and SMAW (15.57%). Both ABM and ICT have the same number of respondents at 30 (11.67%), while those enrolled in STEM (9.73%) have the lowest number.

Table 1. Distribution of the Respondents by Strand

Strand	n	Percentage (%)
STEM	25	9.73
GAS	80	31.13
ABM	30	11.67
HE	52	20.23
ICT	30	11.67
SMAW	40	15.57
ENTIRE GROUP	**257**	**100**

2.3 Data Gathering Instruments

The data needed for the study were gathered using the following instruments: Part 1 – Scientific Reasoning Test; Part 2 – Critical Thinking Test, and Part 3 – Performance in Science Test.

These instruments were used and adapted as they are seen to effectively measure the needed answers of the researcher as given in the statement of the problem. They were taken into great consideration and were adapted from other researchers, except for the researcher-made Performance in Science Test, which experts validated before it was used in the conduct of the study.

The reliability analysis was taken during the implementation of the study from the scores measured by the three instruments. It was determined by obtaining the proportion of systematic variation in a scale, which can be done by determining the association between the scores obtained from different scale administrations. Furthermore, after gathering from the respondents their scores, it was analyzed using the scale Cronbach's alpha in the Statistical Package for Social Sciences (SPSS), and it gave the following results: Scientific Reasoning Test = .7615, Critical Thinking Test = .7360, and Performance in Science Test = .8276. All of which are reliable as the scores are high.

Scientific Reasoning Test. To determine the respondents' level of scientific reasoning skills, the researcher adopted the 25-item multiple-choice test by Alshamali and Daher (2015).

Table 2. The following scale was used in interpreting the result of the Scientific Reasoning Test:

Scale	Descriptive Rating
20.01 – 25.00	Very High
15.01 – 20.00	High
10.01 – 15.00	Average
5.01 – 10.00	Low
0.00 – 5.00	Very Low

Critical Thinking Test. The 21-item test was adopted from Sarigoz (2012) study to determine the respondents' level of critical thinking skills. Each item in the instrument was answerable with any of the following responses: “Always”, “Often”, “Sometimes”, “Rarely", and “Never”.

Table 3. For statistical purposes, the following numerical weights were assigned to the respective responses:

Weight	Responses
5	Always
4	Often
3	Sometimes
2	Rarely
1	Never

Table 4. To determine the level of the respondents’ critical thinking skills, the following scale of means was used:

Scale	Descriptive Rating
4.21 – 5.00	Highly Developed
3.41 – 4.20	Developed
2.61 – 3.40	Moderately Developed
1.81 – 2.60	Less Developed
1.00 – 1.80	Least Developed

Performance in Science Test. A summative test was utilized to gather data on the students’ performance in Science. It was a 50-item researcher-made test based on the Earth and Life Science lesson, taught to all Grade 12 students regardless of their strand. A table of specifications (TOS) was made prior to the test construction and was validated by experts in the field.

Table 5. To interpret the results of the 50-item Performancein Science Test, the following scale was used:

Scale	Descriptive Rating
40.01 – 50.00	Outstanding
30.01 – 40.00	Very Satisfactory
20.01 – 30.00	Satisfactory
10.01– 20.00	Fairly Satisfactory
0.00 – 10.00	Did Not Meet Expectations

2.4 Data Collection Procedure

After the experts validated the researcher-made 50-item multiple-choice Performance in Science Test, the data gathering procedure was material. The experts who validated the instruments were teachers in both Junior and Senior High Schools and actively handled science subjects. Two of them taught Earth and Life Science subjects in the Senior High School Department.

The validation process of the Performance in Science Test involved the experts' rating on content and structure coupled with comments and suggestions for each test item. A validation rating sheet was given to each expert, and wherein each gave their ratings,

comments, and suggestions as to what should be done in each item. Data gathering was then conducted after the panel members approved the validated instruments.

Prior to conducting the study, a permission letter was first secured from the principal of the chosen school. Upon approval, the researcher then distributed the Scientific Reasoning Test, the Critical Thinking Test, and the Performance in Science Test with the letter of approval and parental consent, giving the respondents a choice to voluntarily join the study. The distribution was done when the Grade 12 students had gone to school to pass their modules and follow up on their immersion duties. Some students, however, were visited at home so they could also participate in the study. It had been made sure that while the respondents were taking the tests, the researcher was closely monitoring them to ensure that they were not sharing their answers and guarantee that the tests' results would be credible and reliable.

The students were given about 1 hour and 30 minutes to finish answering the tests upon close monitoring from the researcher. The test was administered within ten days at school and two days for exclusive visits to students who could not come to school. The students' scientific reasoning skills, critical thinking skills, and performance in Science were then measured after gathering and checking the data. The data obtained from the study were then processed, encoded, and analyzed using the SPSS.

2.5 Data Analysis Procedure

The following data analysis procedure was used during the conduct of the study:

Mean. It was used to determine the respondents' mean in their scientific reasoning skills, critical thinking skills, and performance in Science.

Standard Deviation (SD). It was used to determine the homogeneity and heterogeneity of the scores obtained by the respondents.

Pearson's r correlation coefficient. Set at 0.05 level of significance, it was used to determine the relationship among scientific reasoning skills, critical thinking skills, and performance in Science when taken as a whole and grouped according to strand.

3. Results

3.1 Descriptive Data Analysis

Table 2 presents the mean and the standard deviation of the students' scientific reasoning skills. Results show that the students' scientific reasoning skills, when taken as a whole, is "high" (M= 16.17, SD=3.80). When grouped according to strand, STEM got the highest mean of 18.40 and standard deviation of 2.81, followed by ABM with the mean of 17.70 and standard deviation of 3.68, and GAS with the mean of 16.59 and standard deviation of 3.72. A small difference exists between HE and ICT, with ICT having a mean of 15.70 and a standard deviation of 3.12 and HE having a mean of 15.33 and a standard deviation of 4.01. Lastly, SMAW got the lowest mean of 14.23 and the standard deviation of 3.60, corresponding to "average".

Table 2. Descriptive Results of Scientific Reasoning Skills

	Mean	Standard Deviation	Descriptive Rating
STEM	18.40	2.81	High
GAS	16.59	3.72	High
ABM	17.70	3.68	High
HE	15.33	4.01	High
ICT	15.70	3.12	High
SMAW	14.23	3.60	Average
ENTIRE GROUP	**16.17**	**3.80**	**High**

Note: 20.01–25.00 – Very High; 15.01 – 20.00 – High; 10.01 – 15.00 – Average; 5.01–10.00 – Low; 0.00 – 5.00 – Very Low

Table 3 presents the descriptive results of the students' critical thinking skills. When taken as a whole, it shows that students have a "developed" (M=3.68, SD=0.84) level of critical thinking skills. When grouped according to strand, STEM obtained a mean of 4.20 and a standard deviation of 65, followed by ABM with a mean of 4.07 and a standard deviation of 78. Thirdly, GAS obtained a mean of 3.83 and a standard deviation of 76. HE and ICT mean 3.50 with standard deviations of 85 and .78, respectively. SMAW obtained the lowest mean of 3.18 and a standard deviation of 84, interpreted as "moderately developed."

Table 3. Descriptive Results of Critical Thinking Skills

	Mean	Standard Deviation	Descriptive Rating
STEM	4.20	.65	Developed
GAS	3.83	.76	Developed
ABM	4.07	.78	Developed
HE	3.50	.85	Developed
ICT	3.50	.78	Developed
SMAW	3.18	.84	Moderately Developed
ENTIRE GROUP	**3.68**	**.84**	**Developed**

Note: 4.21 – 5.00 – Highly Developed; 3.41 – 4.20 – Developed; 2.61 – 3.40 – Moderately Developed; 1.81 – 2.60 – Less Developed; 1.00 – 1.80 – Least Developed

Table 4 presents the descriptive results of the students' performance in Science. Results show that the students' performance in Science is "very satisfactory" (M=32.78, SD=7.69) when taken as a whole. When grouped according to strand, STEM got the highest mean of 37.72 and standard deviation of 4.99, followed by ABM with a mean of 36.17 and standard deviation of 6.45. GAS ranked third with a mean of 34.63 and standard deviation of 6.58, followed by HE with a mean of 31.27 and a standard deviation of 8.08. ICT got a mean of 29.83 and a standard deviation of 7.55, while SMAW got the lowest mean of 27.65 and a standard deviation of 7.64, both interpreted as "satisfactory".

Table 4. Descriptive Results of Performance in Science

	Mean	Standard Deviation	Descriptive Rating
STEM	37.72	4.99	Very Satisfactory
GAS	34.63	6.58	Very Satisfactory
ABM	36.17	6.45	Very Satisfactory
HE	31.27	8.08	Very Satisfactory
ICT	29.83	7.55	Satisfactory
SMAW	27.65	7.64	Satisfactory
ENTIRE GROUP	**32.78**	**7.69**	**Very Satisfactory**

Note:40.01 – 50.00 – Outstanding; 30.01 – 40.00 – Very Satisfactory; 20.01 – 30.00 – Satisfactory; 10.01 – 20.00 – Fairly Satisfactory; 0.00 – 10.00 – Did Not Meet Expectations

3.2 Inferential Data Analysis

Science education aims to develop scientific literacy among students by teaching them various skills that will be beneficial to the subject matter. Tables 5 to 11 show the correlation among scientific reasoning skills, critical thinking skills, and performance in Science of SHS students enrolled in School Year 2020–2021. The results in Table 5 explain significant relationships among scientific reasoning skills, critical thinking skills, and performance in Science of the Senior High School students when taken as a whole. Scientific reasoning skills have the highest correlation with critical thinking skills with the computed p-values of r=.95, p<0.05, while scientific reasoning skills are directly related to performance in Science with the computed p-values r=.92, p<0.05. Critical thinking skills is also highly correlated with performance in Science with computed p-values of r=0.95, p<0.05, which is lower than the 0.05 alpha level.

Table 5. Correlation of Scientific Reasoning Skills, Critical Thinking Skills, and Performance in Science when Taken as a Whole

	1	2	3
1. Scientific Reasoning Skills	-		
2. Critical Thinking Skills	.95(**)	-	
3. Performance in Science	.92(**)	.95(**)	-

***correlation is significant at the 0.05 level (2-tailed).*

When grouped according to strand, Table 6, Table 7, Table 8, Table 9, Table 10, and Table 11 show that there are significant relationships among the variables, disproving the hypothesis of the study, which states that there are no significant relationships among scientific reasoning skills, critical thinking skills, and performance in Science of the Senior High School students.

Carefully examining the data shown in Table 6, in the STEM strand, critical thinking skills highly correlate with performance in Science with the computed p-values of r=.95, p<0.05, and both scientific reasoning skills and critical thinking skills and scientific reasoning skills and performance in Science correlate with each other with the computed p-values of r=.94, p<0.05.

Table 6. Correlation of Scientific Reasoning Skills, Critical Thinking Skills, and Performance in Science in STEM

	1	2	3
1. Scientific Reasoning Skills	-		
2. Critical Thinking Skills	.94(**)	-	
3. Performance in Science	.94(**)	.95(**)	-

***correlation is significant at the 0.05 level (2-tailed).*

The data in Table 7 show that, in GAS, critical thinking skills highly correlate with scientific reasoning skills with the computed p-values of r=.97, p<0.05, which is followed by critical thinking skills and performance in Science with computed p-values of r=.96, p<0.05 and scientific reasoning skills and performance in Science with computed p-values of r=.94, p<0.05.

Table 7. Correlation of Scientific Reasoning Skills, Critical Thinking Skills, and Performance in Science in GAS

	1	2	3
1. Scientific Reasoning Skills	-		
2. Critical Thinking Skills	.97(**)	-	
3. Performance in Science	.94(**)	.96(**)	-

***Correlation is significant at the 0.05 level (2-tailed)*

The data in Table 8 shows that, in the ABM strand, critical thinking skills highly correlate with performance in Science with the computed p-values of r=.96, p<0.05, which is followed by critical thinking skills and scientific reasoning skills with computed p-values of r=.95, p<0.05 and scientific reasoning skills and performance in Science with computed p-values of r=.89, p<0.05.

Table 8. Correlation of Scientific Reasoning Skills, Critical Thinking Skills, and Performance in Science in ABM

	1	2	3
1. Scientific Reasoning Skills	-		
2. Critical Thinking Skills	.95(**)	-	
3. Performance in Science	.89(**)	.96(**)	-

***Correlation is significant at the 0.05 level (2-tailed)*

Table 9 presents that, in the HE strand, critical thinking skills highly correlate with scientific reasoning skills with the computed p-values of r=.96, p<0.05, which is followed by scientific reasoning skills and performance in Science with computed p-values of r=.93, p<0.05 and performance in Science and critical thinking skills with computed p-values of r=.91, p<0.05.

Table 9. Correlation of Scientific Reasoning Skills, Critical Thinking Skills, and Performance in Science in HE

	1	2	3
1. Scientific Reasoning Skills	-		
2. Critical Thinking Skills	.96(**)	-	
3. Performance in Science	.93(**)	.91(**)	-

***Correlation is significant at the 0.05 level (2-tailed)*

The data in Table 10 shows that, in the ICT strand, critical thinking skills highly correlate with performance in Science with the computed p-values of r=.94, p<0.05, which is followed by critical thinking skills and scientific reasoning skills with computed p-values of r=.93, p<0.05 and scientific reasoning skills and performance in Science with computed p-values of r=.90, p<0.05.

Table 10. Correlation of Scientific Reasoning Skills, Critical Thinking Skills, and Performance in Science in ICT

	1	2	3
1. Scientific Reasoning Skills	-		
2. Critical Thinking Skills	.93(**)	-	
3. Performance in Science	.90(**)	.94(**)	-

***correlation is significant at the 0.05 level (2-tailed)*

Lastly, after careful examination, the data in Table 11 shows that, in the ICT strand, critical thinking skills highly correlate with performance in Science with the computed p-values of r=.96, p<0.05, which is followed by scientific reasoning skills and performance in Science with computed p-values of r=.93, p<0.05 and scientific reasoning skills and critical thinking skills with computed p-values of r=.92, p<0.05.

Table 11. Correlation of Scientific Reasoning Skills, Critical Thinking Skills, and Performance in Science in SMAW

	1	2	3
1. Scientific Reasoning Skills	-		
2. Critical Thinking Skills	.92(**)	-	
3. Performance in Science	.93(**)	.96(**)	-

***Correlation is significant at the 0.05 level (2-tailed)*

The Pearson's r correlation coefficient results reveal that the students' scientific reasoning skills, critical thinking skills, and performance in Science are directly related when taken as a whole and grouped according to strand. Therefore, the null hypothesis that there are no significant relationships among scientific reasoning skills, critical thinking skills, and performance in Science of Senior High School students is hereby rejected.

4. Discussion

4.1 The level of the Senior High School students' scientific reasoning skills

The level of Senior High School students' scientific reasoning skills, when taken as a whole, is "high", and when grouped according to strand, the STEM, GAS, ABM, HE, and ICT strands are "high", while the SMAW strand is "average".

This finding aligns with Khoirina et al. (2018), which states that reasoning is not an innate ability but is influenced by many factors. Some factors that can influence the development of scientific reasoning are the teachers' approach, models, and teaching methods. Scientific reasoning involves activities to produce, test, and revise hypotheses and help with decision-making in solving problems. This result shows that the teaching strategies employed by the teachers of the chosen school were effective in fostering the scientific reasoning skills of their students. It can also be noted that the learners' scientific reasoning skills are high because of their efforts to increase their skills and perform better.

Brossard and Nisbet (2008) cited that poor scientific reasoning is almost overdetermined. Numerous factors have negatively impacted performance, including reliance on fast and frugal heuristics, the influence of prior beliefs and motivations, poor numeracy and statistical reasoning, and misleading science communication. While the problem is clear, there is little consensus regarding potential solutions. However, one potential solution involves bridging the disconnection between how learners are taught to interpret Science in K-12 curriculum and how people interpret Science in reality. Thus, considering the favourable results, the chosen school's performance in developing scientific reasoning skills in their students is good.

Moreover, scientific reasoning denotes consistent, logical thought patterns employed during the scientific inquiry, which enable individuals to propose relationships between observed phenomena. It is also used to determine all possible alternatives and outcomes, consider probabilities of occurrences, predict logical consequences, weigh evidence or proofs, and use a number of instances to justify a particular conclusion. The development of scientific reasoning skills in the K-12 curriculum has been proven to impact students' academic achievement. There are reports of positive correlations between students' scientific reasoning abilities and measures of students' gains in learning Science content support the consensus of the Science education community on the need for K-12 students to develop an adequate level of scientific reasoning skills along with a solid foundation of content knowledge (Ragma & Valdez, 2017). Tapaz National High School upheld this design properly and created students who have high scientific reasoning skills. As the study progresses, we can then find evidence of how these particular results affected the outcome of the other variables that led to a very favourable change in the respondents and school community.

4.2 The level of the Senior High School students' critical thinking skills

The level of Senior High School students' critical thinking skills, when taken as a whole, is "developed", and when grouped according to strand, the STEM, GAS, ABM, HE, and ICT strands are "developed", while the SMAW strand is "moderately developed".

The results may be due to the kind of exposure the students had in learning Science and the types of assessment tools used to evaluate their knowledge and skills. The learners knew when and where to use and apply what they have learned. Furthermore, the results showed that the learners could recall what they had learned and create a new point of view. The learners' critical thinking skills may be due to mastery teaching as an important component in learning, which means that teachers can deliver the lesson even without the aid of a teaching guide to answer the learners' queries and enumerate examples on their own.

In addition, Hader (2005) also believed that critical thinking could provide people with a more insightful understanding of themselves, allowing them to be objective, less emotional, and more open-minded as they appreciate other people's views and opinions. By thinking ahead, people can gain the confidence to present fresh perspectives and new insights into burdensome concerns. Critical thinking will also boost creativity and enhance the way people use and manage their time. Furthermore, many experts consider critical thinking as a liberating force in education, a precondition for maintaining the ideals of a democratic society, a source of civic engagement, decision-making, and the ability to respond rapidly to the changing world (Ennis, 2011; Facione, 2011; Halpern, 2007; Paul & Elder, 2014), which corresponds to the mission of many universities in the world and is also embedded in the international frameworks for the competences of the 21st century (Sustekova, Kubiatko, &Usak, 2019).

According to Marquez (2017), critical thinking can be taught to students when they are allowed to raise questions, explore possibilities, and engage in meaningful discussions, which can be done through reflective teaching. The problem, however, is that teaching in the Philippines is constrained to the didactic approach and has barely enough room to be reflective. This may be because: (a) teachers are guilty of the misconceptions in teaching for thinking; (b) the quantity of information given is prioritized over the development of critical thinking; (c) didactic teaching is easier than reflective teaching considering all the other things that a teacher is expected to do (lesson planning, checking and grading of exams, Etc.); (d) many teachers are not used to the reflective approach; and (e) the government is bent on producing skilled labourers more than critical thinkers. Despite these reasons supporting the didactic approach in teaching, there is a need to make room for reflective teaching in every grade level and in all subject areas to facilitate the development of the critical thinking aptitude of Filipino students.

Critical thinking skills are important and necessary in facing the challenges and demands of the 21st century to effectively deal with social, scientific, and practical issues in the future. They accommodate activities that can improve higher-order thinking skills and incline one to make and conduct assessments of evidence-based conclusions. Students who have high critical thinking skills will strive to provide logical reasoning in understanding and to make complex choices and understanding the interconnections among systems. In addition, students with high critical thinking skills may also have the ability to compose, disclose, analyze, and resolve problems. Therefore, these skills need to be familiarized and included in the teaching-learning process so that students acquire these

skills, which will enable them to face the future and the demands of the 21st century (Saputri, Sajidan, & Rinanto, 2018).

It is notable when students are equipped with critical thinking skills to face the challenges of 21st-century learning, especially when they are dependable in any situation that will require them to solve problems and think critically. Teachers are great forces in developing this skill in the students, so they must be equipped with the appropriate teaching pedagogies. The school administrators' programs in honing skills in both the teachers and the students must also be given attention.

4.3 The level of the Senior High School students' performance in Science

The level of Senior High School's performance in Science, when taken as a whole, is "very satisfactory", and when grouped according to strand, the STEM, GAS, ABM, and HE strands are "very satisfactory", while the ICT and SMAW strands are "satisfactory".

Performance in Science might be affected by the learners' poor engagement and lack of motivation in the Science subject: students who have less motivation to study Science subjects may develop a negative attitude toward it. A certain study (Ragma & Valdez, 2017) found that some factors that influence poor performance were an inadequate number of teachers and poor teaching methods. Due to the inadequate number of teachers, some schools end up hiring teachers without looking at their qualifications, which gives science subjects to teachers whose expertise is not Science. With this, these teachers may teach learners poorly and settle for basic teaching methods and strategies in teaching the subject, resulting in poor learning and performance.

This is why the chosen school's very satisfactory performance could be attributed to the fact that the Science teachers are indeed Science majors. It could also be that they were top-performing teachers and could enable their students to be better learners.

Furthermore, Appletion (2008) stated that the importance of student engagement in school is recognized by educators and school administration, as is the observation that several learners easily get bored, uninterested, and uninvolved—disconnected from the academic and social aspects of school life. The results show that the students of the chosen school were attentive and interested in studying Science. They were also active participants and favourably showed high involvement in the conduct of the study, which is reflected in their high results and good performance.

The results are contrary to the claim of Farrington et al. (2012) that high school students' performance in Science has been discoursing low, but it is in support of Ragma and Valdez's (2017) report that the development of scientific reasoning skills in the K-12 curriculum has been proven to have a long-term impact on student's academic achievement. As there are reports of positive correlations between students' scientific reasoning abilities and measures of students' gains in learning Science content support the consensus of the Science education community on the need for K-12 students to develop an adequate level of scientific reasoning skills along with a solid foundation of content knowledge. The chosen school believed this study and produced students with satisfactory performance in their Science subject.

4.4 The relationships among Senior High School students' scientific reasoning skills, critical thinking skills, and performance in Science

There is a significant relationship among Senior High School students' scientific reasoning skills, critical thinking skills, and performance in Science when taken as a whole and grouped according to strand. The study results appeared as they are because of the closely related skills of scientific reasoning and critical thinking that require six levels of thinking, which according to Bloom's Taxonomy, are remembering, understanding, applying, analyzing, evaluating, and creating. The results show an example of a chain of events that are needed for students' success: to perform well academically in the Science subject, students must be able first to remember what they have learned, then understand it, apply it to further their learning, analyze it, evaluate it, and create something out of or in line with it achieve scientific reasoning skills and critical thinking skills. In other words, students can never reason out what they know without critically thinking about the subject matter.

The results agree with Ragma and Valdez's (2017) report that the development of scientific reasoning skills in the K-12 curriculum has been proven to have a long-term impact on students' academic achievement. Furthermore, enhancing the students' critical thinking skills has led to developments in their performance in Science, proving that the skills acquired by the students are directly related to their performance in the Science subject.

The results support the statement of Griffiths & Oxford (2008) that in a world where changes occur at a rapid pace, students need to acquire skills to cope with the demands of the 21st century. Innovation in the educative process, initiative, and striving for excellence should be fostered in any endeavour. DepEd's mission of attaining quality education, quality output, and quality student performance is a very salient feature of today's educational system and even beyond. Achieving different skills in the students' learning process will eventually help them and will show positive results in their performances, whether inside the classroom or outside.

The results are opposite to the study by the National Center for Education Statistics (2007), which reported

that for generations, Science teaching has relied on methods that train students to follow directions with little connection to doing authentic scientific research. Although students have become accustomed to this learning method, most do not form a deep conceptual understanding of Science. However, the students of the chosen school have a high conceptual understanding of the Science subject because they were more likely trained to foster their scientific reasoning skills and critical thinking skills, which are important in Science literacy and are core learning objectives of Science education according to Dowd et al. (2018). Also, the teachers could apply different strategies to teach the students and train them to face the challenges of the 21st century.

The results show that the Grade 12 students of the chosen school have high results in their scientific reasoning skills, critical thinking skills, and performance in Science, which might be due to their dedication and diligence despite the pandemic. As their teachers have noted, this batch of students is truly top-performing for they are diligent students that when contests in Science arise, they bring home honours to the school, be in the district level or the division level. These students' test results are high because they have answered them seriously and are hard-working students. It could also be that the chosen school's teaching force is doing well in training these students to be competent and well-equipped individuals who can face the challenges of the 21st century. The teachers are more likely proficient and well-trained in Science, as they have fostered good scientific reasoning skills and critical thinking skills.

Moreover, the school administration will be very proud of these results that show their students and teachers doing well compared to the rest of the population. The administrators could be given credit in producing well-rounded teachers and students through the implementation of different academic programs and workshops that aim to develop the skills of the teachers and students, assignment of competent teachers employing teaching strategies that benefit the students and the school community, and creation of sustainable programs and conducive working and learning spaces. Also, the respondents' homes have most likely been conducive for the learners to study with their parents helping them out effectively.

5. Conclusions

Because the students obtained high reasoning skills, developed critical thinking skills and satisfactory performance in Science, they have varied stored ideas and Science-related concepts that they can further elaborate into Science-related problems and situations. Moreover, this means that the students have a good understanding of Science that they will need in explaining different phenomena and Science-related problems. They could also be good students who are very interested in scientific argumentation and discourse, and they perform well in-class debates, which is evident in their skills in scientific reasoning and critical thinking.

Still, there is a need for the students to elevate their skills from their current level to an even higher level, which can be addressed through the help of their respective Science teachers and different personal experiences. If they are already performing well in their classes, they can learn more and be more developed. In order to lift the students' performance in Science, they should learn and study more ideas, skills, and concepts to enhance their understanding of Science, which they can apply to real-life situations. This could mean that whatever they have thought critically is also what they have already applied using their scientific reasoning and critical thinking skills, thus improving their performance. Awareness of this can also benefit the school system, knowing that increasing students' specific skills will improve their general performance.

6. Recommendations

Based on the findings and conclusions of the study, the following recommendations were made:

1. The school administrators may conduct sustainable professional development programs for their teachers and students. This can be done yearly to continuously develop the abilities and skills of both the teachers and students. One of the goals is to help them adapt, understand, evaluate, and use the continually emerging innovations.
2. Teachers should start using effective strategies to improve students' scientific reasoning and critical thinking skills as these skills have been proven to improve their performance in Science efficiently. Moreover, teachers may encourage students to engage in scientific argumentation and discourse to improve their scientific reasoning and critical thinking skills.
3. The parents' supportive role is influential and contributory to the development of their children, so they should be encouraged to upgrade their knowledge and skills. They should motivate and encourage their children to use technology to improve interpersonal communication skills and not only for recreational purposes.
4. Students should learn to engage in scientific argumentation and discourse to develop their scientific reasoning and critical thinking skills. Extemporaneous speaking and debates are examples that will enhance their ability to identify problems, formulate hypotheses, test hypotheses, and interpret and generalize situations as the components of scientific reasoning skills.
5. The other researchers may conduct similar studies to develop instruments that can measure the learners' scientific reasoning skills, critical thinking skills,

and performance in Science. As the results have shown, this study may be a basis for experiments that test the effectiveness of instructional activities focused on scientific reasoning skills and critical thinking skills to improve the learners' performance in Science.

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