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The Correlation between Students' Insights and Academic Achievement in Science: A Predictor for STEM Career Path

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Abstract

This study investigates the correlation between students' insights and academic achievement in science as predictors for their career paths in science, technology, engineering, and mathematics (STEM). The research involved a sample of secondary education students (N=176) who acknowledged taking STEM programs. They completed a survey that assessed Views of the Nature of Science (VNOS) and Epistemological Beliefs Assessment for Physics Science (EBAPS). Furthermore, their academic performance in Science classes was examined through school records. The results indicate a strong positive correlation between student's insights and academic achievement in Science. Moreover, there is a higher possibility of success in STEM, and a student may at least be at the proficient level of insights and have a mean Science grade of 80 or above. There are also recorded misconceptions that must be remediated. Science educators may look into some common.

Keywords: Science Insights, STEM, Science Achievement

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INTRODUCTION

Science has never ceased to amaze humans from decades before up to the present. It handed facts from the most minor sub-atomic details to the vast realities of the universe. Singh, Rathore, and Park (2020) emphasized that the information cultivated by Science was utilized to create incredible technologies in medicine, agriculture, weather, transportation, industry, computer development, and space exploration.

However, the eagerness and perseverance to search for the deeper meaning of science are relative for students. Some students think that science is just relevant to explain the existence of some remarkable technologies. Verdugo-Castro, García-Holgado, Sánchez-Gómez, and García-Peñalvo (2021) argued that some students may think that learning Science is essential because their goals or path for their careers is heading toward Science or they can use it in their daily living. Alternatively, for other students, learning science is merely a requirement for them to graduate from high school or college. The worst is when things get complex; others believe learning science is just a waste of time, as Allain (2011) has mentioned.

But how students perceive science is a question. Their insights, beliefs, and perceptions must be fully understood and studied. Different insights, beliefs, or perceptions about science or learning science among students are manifold. This research would explore the students' insights and how this manifestation can influence the students' career paths. The comprehensive study of students' insights concerning their career path is vital since it helps align students' interests with their career choices.

Alzoubi et al. (2022) noted that it ensures they have a genuine interest in their field, increasing the likelihood of professional satisfaction and long-term success. Vakil (2020) argued that the diversity of students' scientific perceptions is why we can hardly comprehend or trace its roots and why most students nowadays are becoming less attracted to science. Is it because Science is considered one of the problematic subjects perceived by most Colegio students? Or, maybe because they cannot find connections, why do they need to learn Science in school?

For some students, the teaching method is one factor to consider in why they are motivated to learn Science (Bawaneh et al., 2012; Bengua et al., 2013; Tanveer et al., 2012). One study mentioned that teaching method is a factor in why fewer students are attracted to learning Science (Puspitarini & Hanif, 2019). However, it is more than that. It is more than the methods; maybe it also concerns their insights or beliefs about Science. We also need to consider students' insights to help them better achieve and become successful in science. Because of this, experts devised a tool to measure or at least in the possible way to see connections between students' beliefs in science or learning Science with their understanding of what science is and their achievement in the subject like Views About Sciences Survey (VASS), Epistemological Beliefs Assessment for Physics Science (EBAPS), Views of Nature of Science Questionnaire (VNOS), The Colorado Learning Attitudes about Science Survey (CLASS), among others. This connection will also serve as their (the students') primer for choosing careers in science.

Despite efforts made by teachers and experts to make sure that students' understanding is being considered in the context of learning Science and misconceptions were corrected and emphasized, still more people, especially students, have poor achievement in their Science subjects (Theobald et al., 2020; Pacala, 2023). Most teachers aim to ensure that the correct concept has been transferred to students to attain greater heights and gain better course achievement in Science. At some points, the teacher aims to give students the idea of thinking like scientists (Furtak & Penuel, 2019). Encouraging and teaching our students to think and do science like scientists is challenging for most teachers. Our objective is to build a “culture of scientific literacy.” Around the globe, this issue is prevalent among schools, especially in the United States of America. The US government is continuously upgrading the content standards in its curriculum. They have envisioned making most of their citizens scientifically literate (NSES, 1996).

In the Philippines, the Department of Education, the Department of Science and Technology – Science Education Institute, and some Teacher Education Institutions are in tandem to upgrade and update the standards that students in Science should meet. Presently, the government is implementing the K-to-12 Curriculum, which is evidence that the government is paying attention to quality Science education. The new curriculum encourages teachers to help students bring out their best in the different curricular fields or areas. Moreover, one of these is Science. Another thing, annually, the Department of Education (DepEd) gives the National Career Assessment Examination (NCAE) to help students match their aptitude or interests with the courses or career options they will take in college (DepEd – Naga, 2012).

In Letran Calamba, administrators are likewise trying to find the best ways to help teachers and students be updated with the current trends in education, especially with the new curriculum, the K to 12. The Colegio is in its fourth year of implementing the K to 12. To keep track of the new curriculum, Colegio conducts continuous teachers' training with up-to-date teaching strategies and plans, implements policies to upgrade the curriculum within Colegio, especially in basic education, and implements outcomes-based education in primary education, among others. With these, students are better catered to the Colegio services, especially in the academic part. Despite efforts, Science teachers in Letran Calamba observed that some students have low achievement in Science. Will this mean that students still have difficulty in understanding or learning Science? Do students have an idea what Science is? Are they aware of the nature of science and Science learning? These are some questions we need to consider to better guide our students in choosing careers related to Science. The need to study the personal insights of students of the high school on Science should be conducted to see how far we can extend our help to our students to become successful in the field of science. Our utmost responsibility is to help our students understand the nature of science and Science learning and enhance them.

METHODS

Research Design

This study utilized the correlational-descriptive method design, precisely the descriptive survey design method, because the researchers had adopted two validated questionnaires, Views of the Nature of Science (VNOS) and Epistemological Beliefs Assessment for Physics Science (EBAPS) and correlational design in survey design, specifically the cross-sectional survey design, students were allowed only to answer once. Using a rating scale, an adopted survey questionnaire was used to ask about the level of their science insights, ranging from the expert's to the beginner's level. Also, open-ended questions about Views on the Nature of Science (VNOS) in the survey instrument were administered per class to gather qualitative views or opinions about the matter.

On the other hand, the correlational survey was used to determine the relationship between the student's level of science insights and their achievement in Science. This was used to know the relationship between students' science insights and Science achievement as predictors of the strand students will take in Senior High School.

Research Instruments

The researchers adopted two validated research instruments. The two instruments were the Epistemological Beliefs Assessment for Physics Science (EBAPS) and the Views of Nature of Science Questionnaire (VNOS). According to the EBAPS website, "EBAPS is composed of a 30-item questionnaire which probes students' views along five non-orthogonal dimensions: Structure of scientific knowledge (Axis 1), Nature of knowing and learning (Axis 2), Real-life applicability (Axis 3), and Evolving knowledge (Axis 4).

These questionnaires were introduced and disseminated to the students for data gathering. Only the Grade 10 students' questionnaires acknowledged taking the STEM strand in Grade 11 were considered in the data-gathering procedure. During the data gathering, the researchers first analyzed the questionnaires. After studying and treating the data, the authors identified the different levels of students' insights based on the instruments the students answered. Using scores obtained from the EBAPS questionnaire (also interpreted as level of science insights), the researchers correlated this with the student's academic achievement. The educational achievement was presented in terms of the students' general average in Science. The correlation between academic achievement and the levels of students' insight into science is used to help determine their career path in the STEM strand. To help establish a more valid and meaningful result, the researchers supplied additional data from the essays the students answered using the VNOS questionnaire to supplement the quantitative data from EBAPS.

Participants

The respondents of this study were Grade 10 students from the Basic Education Curriculum (BEC) and Special Science Curriculum (SSC) High School A.Y. 2015-2016. They were the best participants because they were the first to enter Grade 11. The results immensely helped them assess their career by taking the STEM strand.

Data Collection

The authors adopted the validated survey questionnaires: Epistemological Beliefs Assessment for Physical Science (EBAPS) and Views on the Nature of Science (VNOS D). The Views on the Nature of Science Norm G. Lederman and colleagues developed. These questionnaires contained open-ended questions that qualitatively assessed students' insights about the nature of science. The other is the Epistemological Beliefs Assessment for Physical Science (EBAPS), created and validated by Andrew Elby, John Frederiksen, Christina Schwarz, and Barbara White at the University of California, Berkeley. "EBAPS is a forced-choice instrument designed to probe students' epistemologies, their views about the nature of knowledge and learning in the physical Sciences" (www2.physics.umd.edu, 2015).

These questionnaires were given to the students simultaneously to all sections of grade 10 inside their classroom. Enough time was given to answer all the questions in the EBPAS and VNOS, which the researchers proctored. From the 30 items of the EBAPS questionnaire, only the first part, 17 items, was used to assess students' insights related to the nature of science and Science learning. From the EBAPS website, the 17 items were categorized in each subscale or axis as the following: for Axis 1 these are questions 2, 8, 10, 15, 17; for Axis 2 these are questions 1, 7, 11, 12, 13; for Axis 3 these are questions 3, 14; for Axis 4, question 6; for Axis 5 these are questions 5, 9, 16. Question 4 belongs to no axis except for overall. The overall rating is where all the questions are equally weighted." Each item is scored on a scale of 0 (least sophisticated) to 4 (most refined). For instance, the scoring scheme is non-linear when considering question-by-question variations and whether neutrality is more or less sophisticated. A subscale score is simply the average of the student's scores on every item in that subscale. (When an item within a given subscale is left blank, the average is calculated without that item included)".

Then, the data from the questionnaires were tabulated and analyzed. For the EBAPS, the scores were obtained and computed, while for the VNOS, the answers were transcribed in table form.

To make the description of the scores for each subscale more concrete and meaningful, the authors categorized the levels of insights based on the overall scores they garnered in EBAPS for this study as Expert, Proficient, Intermediate, and Beginner instead of least sophisticated, more or less sophisticated and most sophisticated. The mean score on a 5-point (0-4) scale was used to establish a more straightforward categorization for the level of insight of the students. Students are classified under the Expert level if their scores range from 3.01 – 4.00; students who have scores that range from 2.01 – 3.00 belong to the Proficient level; students who have scores from 1.01 – 2.00 are categorized under the Intermediate level, and those who have scores that range from 0 – 1.00 categorized under Beginner level.

Answers from VNOS were interpreted to support the quantitative data from EBAPS and strengthen the results. Specifically, VNOS focused on how students think of the nature of science. According to Lederman (1992), the nature of science or NOS refers to the epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development. It has been known that science is a body of knowledge so vast and complex that not a single view of its nature could be accepted. Aside from this intricate nature of science, the inevitable change in our surroundings and society have always been important factors shaping how people perceive scientific knowledge's foundations and scope.

Then, data on academic achievement were requested from the Records Office. These data were correlated using the Pearson R with the scores of the students obtained from EBAPS. All the data gathered were subjected to interpretation and discussion.

Data Analysis and Treatment of Data

Descriptive analysis was applied since the data on students' insights were gathered. The statistical tools used are a frequency distribution table, arithmetic mean, and Pearson r correlation. Pearson r correlation was used to establish the relationship between the insights and academic performance of the students. According to Makowski et al. (2020), the Pearson R correlation is usually used to determine the strength and direction of the relationship between two variables. Sullivan and Artino (2013) of Montana State University, parametric tests can be used to analyze Likert scale responses based on their systematic literature review. Moreover, qualitative analysis of VNOS questions was used to support the quantitative data from the EBAPS. The frequency table was used to measure the levels of insight and the total population who will take the STEM strand in grade 11. Mean was used to establish the score range on a 5-point scale for the levels of insights gathered in EBAPS. Pearson r was utilized to correlate students' science insights and academic achievement (average grade in Science).

RESULTS & DISCUSSION

What are the levels of science insights of Grade 10 students?

Of 264 students who answered the EBAPS Questionnaire, 176 (67%) were acknowledged as taking the STEM strand in Grade 11. So, all the responses of the 176 students were considered in determining their level of science insights.

Table 1. Levels of Insights of Grade 10 Students

Levels of Insights	Frequency Distribution of Students	Population of students (%)
Expert	1	0.57
Proficient	95	53.98
Intermediate	80	45.45
Beginner	0	0
TOTAL	176	100

Based on the results from Table 1, the distribution showed a 0.57% Expert (1 out of 176), 53.98% Proficient (95 out of 176), 45.45% Intermediate (80 out of 176), and 0% Beginner (0 out of 176). The data confirmed that most of the Grade 10 students taking the STEM strand of BED – High School of Colegio de San Juan de Letran Calamba were at the Proficient level. A proficient level of insights was considered to be excellent science insights. The level of insights ranked second in frequency was the Intermediate. In this case, the Intermediate level was of good science insights. Only one student was at the Expert level and had excellent insights about science. Fortunately, no students belong to the Beginner level. In general, the data show that the majority of the students have acquired moderately strong insights about the nature of science and science learning.

To have a better view of the students' level of insight into science, the four axes or dimensions measured by the EBAPS questionnaire were considered, namely; Structure of scientific knowledge (Axis 1), Nature of knowing and learning (Axis 2), Real-life applicability (Axis 3), Evolving knowledge (Axis 4), and Source of ability to learn (Axis 5).

As mentioned in the methodology section, a 5-point (0-4) Likert Scale was utilized to categorize the students' insights level. Students are classified under Expert level if their scores range from 3.01 – 4.00, students with scores ranging from 2.01 – 3.00 scores belong to Proficient level, students who have scores from 1.01 – 2.00 are categorized under Intermediate level, and those who have scores that range from 0 – 1.00 categorized under Beginner level.

Table 2. Mean for each Subscale or Dimension (Axis) for each Level of Insights

Dimensions	Level of Science Insights		
	Intermediate	Proficient	Expert
Structure of scientific knowledge (Axis 1)	1.29	1.66	3.50
Nature of knowing and learning (Axis 2)	1.67	2.16	2.60
Real-life applicability (Axis 3)	2.03	2.85	3.25
Evolving knowledge (Axis 4)	1.83	2.77	4.00
Source of ability to learn (Axis 5)	2.98	3.39	3.33

Based on Table 2, for each subscale, axis 1 showed a mean of 3.50 for the Expert level, 1.66 for the Proficient level, and 1.29 for the Intermediate level. Since only one student was at the expert level, the mean result was excellent for axis 1. This student believed that science knowledge is more than facts and formulas. It is a coherent, conceptual, highly structured, and unified whole. The students who belonged to the Proficient and Intermediate levels had good science insights for Axis 1. For some of the proficient and intermediate students, science knowledge is merely a fact and formula-based, but for some, it is a unified whole.

For axis 2, the mean was 2.60 for the Expert level, 2.16 for the Proficient level, and 1.67 for the Intermediate level. For this axis, students who belonged to the Expert and Proficient level have excellent science insights. Most of them believed that knowing and learning science depends mostly on constructing one's understanding through active learning, relating materials with experiences, intuitions, and knowledge, and reflecting and checking one's understanding. Students who fit into the intermediate level likely rely on absorbing information to learn science.

For axis 3, the mean for Expert is 3.25, for Proficient is 2.85, and for Intermediate is 2.03. Based on this data, most students probably believe that science is needed in life and that the application of science in real life is vast.

For axis 4, the Expert got a mean of 4.00, the Proficient has a mean of 2.77, and for the Intermediate, the mean is 1.83. The expert strongly favored the idea that scientific knowledge is constructed based on evidence and not merely on opinions and what is being written in books. In addition, experts may also believe that scientific knowledge is not always absolute. It may change as time passes.

For axis 5, it is noticeable that the proficient students scored 3.39, which is higher than the 3.33 mean for the expert. This means that the proficient students believed more, to some extent, that learning science comes from hard work and good study habits.

What is the strength and direction of the relationship between students' insights on science and academic achievement?

The determination of the correlation between the science insights to the science academic achievement of students was of great significance to validly predict a student's success in the STEM strand.

Table 3. Pearson r Coefficient and P-value for Correlation Significance Testing

r	r^2	Slope	y-intercept	Std. Err. Of Estimate
0.4156	0.1727	7.239393	69.299205	4.9259
t	Df	p	One-tailed	<0.0001
6.03	174		two-tailed	<0.0001

According to the results in Table 3, the Pearson correlation between science insights and academic achievement was about 0.4156, which indicated that there was a moderate positive relationship between the variables, which means that, as one variable increases, the other variable also increases or if one variable decreases the other variable also decreases. The results in Table 4 also showed that the p-value for the correlation between science insights and academic achievement was less than the significance level of 0.05, which specified that the correlation was significant. This was under a 4.9259 standard error of estimate. With this result, null hypothesis number 1, stated that the students' insights in science had no significant correlation with academic achievement in science, is rejected. This implies that the overall mean scores of the Grade 10 students' insights in EBAPS and their general average grades in science were significantly correlated. The study of Zahra, Arif, and Yousuf (2010) has found a similar result; however, their study has established that academic self-concept is weakly correlated to academic performance. In addition, the findings of Mao, Cai, He, Chen, and Fan (2021) revealed that the meta-analysis indicated that there was a moderate and positive correlation between science learning achievement and attitude towards science.

At which correlation interval would students' science insights and academic achievement validly predict that a particular student should take a career in the STEM strand?

As shown in Table 4, the science grade intervals, ranging from 75-100, were adopted from the current grading system mandated by the Department of Education (DepEd). In addition, it is also noted that the results of the sole expert were not included because it is inappropriate to present a single numerical datum that does not represent a population.

Table 4. Frequency and Percentage Distribution of Proficient and Intermediate Students at Different Science Grade Intervals

Science Grade Intervals	Proficient Students		Intermediate Students	
	Frequency	Percent (%)	Frequency	Percent (%)
95-100	6	6.32	0	0.00
90-94	21	22.11	7	8.75
85-89	35	36.84	16	20.00
80-84	22	23.16	32	40.00
75-79	11	11.58	25	31.25
TOTAL	95	100.00	80	100.00

Based on Table 4, the majority of the proficient students, around 36.84 %, garnered a science general average ranging from 85 – 89, followed by a science general average of 80 – 84, which is 23.16% of the proficient students, and then by 90 – 94, which comprises the 22.11% of the proficient students. Among the intermediate students, 40.00 % earned a science general average grade of 80 – 84, followed by 31.25% who earned 75 – 79, then 20.00% got a grade ranging from 85 – 89.

As observed in Table 4, the bulk of the number of proficient students belongs to grade intervals of 80-94, while most of the intermediate students' science average grades are between the grade interval range 75 and 89. In addition, in the grade interval of 90-94, 22.11% belong to the proficient category, while only 8.75% belong to the intermediate category. The same is true in the science grade interval of 95-100, where 6.32% of the students belong to the proficient category while 0% or none belong to the intermediate category. This trend implies that proficient students are more academically inclined than intermediate-level students.

Indeed, these results show a significant moderate correlation between science insights and science academic achievement. However, all these quantitative data here were gathered from a questionnaire with structured responses like the EBAPS. Lacking these facts were the answers constructed by the students through open-ended questions on views about science.

Considering this, the VNOS D questionnaire responses would give a better perspective of whether the previously calculated correlations would be significantly supported or opposed.

Students' Structure of Scientific Knowledge (Axis 1)

To start with, the structure of scientific knowledge (Axis 1) assesses if students view science as consisting of loosely bound pieces of information regarding different fields with no structure and are just about facts and formulas or view science as a coherent, conceptual, highly-structured, and unified whole. The structure of scientific knowledge (Axis 1) is best compared to the responses of VNOS D Questions 1 and 2 because these three questions elicited answers relevant to knowing how students thought of the structure of knowledge in science.

As seen in Table 2, the expert's level of insights on the structure of scientific knowledge (Axis 1) had the highest score of 3.50 score compared with the 1.66 score of the proficient students and 1.29 score of the intermediate students. The sophistication of the expert's scientific knowledge structure, as illustrated in Axis 1 of Table 2, is remarkably the highest. However, it must be noted that only one expert was dealt with here, which may not represent the population of the experts.

Now, in terms of actual responses to VNOS D question 1 (What is science?), the expert mentioned the importance of science in explaining several phenomena like photosynthesis, water cycle, astronomy, the universe, and cures for diseases. Moreover, the expert concisely elaborated on the importance of the scientific method in improving the quality of life and finding answers to problems. On the other hand, proficient student responses in Appendix F stated that science is a study of the world/universe that could be learned through observations and experiments. They even mentioned specific fields of study like earth biology, physics, chemistry, math, and engineering. Some included the existence of theories and studies that a proficient student acknowledged as confusing if not taught well. Similar to the accounts of the Expert and Proficient students, the Intermediate students also mentioned that science is the study of everything in the surroundings, including the earth, galaxies, stuff in biology, chemistry, physics, and daily human activities like breathing, waking up, and sleeping.

All the students in the three levels agreed that science is a body of knowledge that finds a way to explain things in the world and the universe as a whole. Proficient and intermediate students only mentioned interconnectedness among the different branches, such as biology, physics, chemistry, earth sciences, and astronomy.

Furthermore, as evident in appendices E, F, and G, it was clear that all three categories of students were knowledgeable enough as to what science is all about. Aside from considering science as being a body of knowledge trying to explain everything, all three levels included examples related to science as a process by utilizing observation and experimentation in solving a problem, science as an interaction by connecting different branches of study, and science as applied in real life situations by citing realistic problems.

In VNOS-D question 2 (How is science different from the other subjects you are studying?), the expert and majority of the proficient students believed that science is different from other subjects mainly because it entails data collection through observations and experimentations, then, processed through mathematical equations or formula to arrive at a valid result. On the other hand, only some intermediate students see science as unique because it requires proof of a particular phenomenon through experiments. Only a minority of the intermediate students thought of coherence and structure when doing science investigations. This can further support the lower mean value of intermediate students for the structure of scientific knowledge (Axis 1) than the proficient students.

Students' Nature of Knowing and Learning (Axis 2)

For the case of Axis 2, all the VNOS D questions from 1-7 were somehow connected to Axis 2. Nature of knowing and learning (Axis 2) was anchored on the idea that learning science could either be mainly on absorbing information only or rely crucially on constructing one's understanding by participating in science actively, by relating new data to previous perceptions and knowledge, and by reflecting upon and monitoring one's understanding. Again, as illustrated in EBAPS results Table 2, the expert student scored the highest with 2.60, the proficient with 2.16, and the intermediate with 1.67. This meant the expert had the most sophisticated scientific insights among the three, with the intermediate with the least sophisticated. However, it must be taken into consideration that only one expert is dealt with here.

Generally, in the VNOS D question 1 (What is science?) response, the expert as well as most of the proficient and intermediate students answers, shared the same idea that science significantly involves observations, explorations, discoveries, and doing experimentations to verify theories and to understand the structure and behavior of our world and universe. Nonetheless, it was also noticeable that only the expert and proficient groups elaborated on additional vital details regarding interactions and interrelationships, which may support the data on the Nature of knowing and learning (Axis 2). This implies that the expert and proficient groups were the ones who believed that science is unique because it involves constructing one's understanding through active participation in scientific investigations, observations, and experimentations and that consideration of previous data is essential before giving any conclusion. This showed that the Proficient and Intermediate students had more sophisticated science insights compared with the intermediate.

In VNOS D question 2 (How is science different from the other subjects you are studying?) regarding the difference of science to other subjects, the expert and majority of the students elaborated on knowing facts on science through specific processes like observation, experimentation, data analysis, and interpretation. In contrast, most intermediate students do not distinctly see science as different from other subjects in this manner. Instead, the bulk of the intermediate students see science as unique because it is too complicated, more challenging to study, has a broader range of topics, and has several things to memorize. This only shows that the expert and proficient students see science positively, not looking so much at its difficulty and complexity, unlike the intermediate students. This strengthened the lowest mean score of the intermediate students in Axis 2. Singh, Maries, Heller, and Heller (2023) agree with this result. They believe that Experts solve problems using very different cognitive. Individuals with varying levels of experience in the field of programming will demonstrate varying levels of aptitude while grasping a particular program (Kather et al., 2021).

Furthermore, VNOS D Questions 3, 4, 5, and 6 were related to Axis 2 since it looks at how students adapt newly introduced data to previous knowledge. In VNOS D Question 3 (Scientists produce scientific knowledge. Some of this knowledge is found in your science books. Do you think this knowledge may change in the future? Explain your answer and give an example.), the expert, all the proficient and some of the intermediate students did believe that existing knowledge on books may change over time. The expert and proficient students gave several examples, while proficient students cited few examples. The expert explained how the Democritus' atom description changed over time and explained further how electrons and protons came into the picture. The expert even included the changed view of the earth from the flat concept of our ancestors.

Most proficient students agree with experts that knowledge from science books may change. Some Proficient students cited that facts regarding the number of plants and animals in books may change. Others believe that there might be people, experiments, and technologies in the future who may disprove the current theories or facts. Another student even cited that change does happen in the future by citing the atomic development theory. There were two Proficient students who said that knowledge of books does not change. However, upon examining their reasons, one student believed that books would never be out of style because of the information or knowledge they contain. The other student claimed that if a person wants to change the future, one must develop new ideas. What is unique among the intermediate group is that few intermediate students agree that knowledge of books is fixed over time. This may mean two things: these students refer to a general law in science or do not believe that scientific facts in books change. Tanwar (2020) has the same analysis, but she argued that the dynamic characteristic of science is apparent as it develops over time, subject to discussion, and has a ranking structure.

In the case of VNOS D Questions 4a (How do scientists know that dinosaurs existed?), 4b (How sure are scientists about the way dinosaurs looked?), and 4c (Scientists agree that about 65 million years ago, the dinosaurs became extinct (all died away). However, scientists disagree about what caused this to happen. Why do you think they disagree even though they all have the same information?), Generally, all students agree that they rely on facts to conclude the existence, appearance, and theories about dinosaurs. In Appendix E, the expert stated that dinosaurs existed through fossils discovered by archaeologists hidden beneath the earth and that through several studies of the scientists on dinosaurs, they were able to come up with the skeletal structures that would eventually predict the appearance and species of the dinosaur. In Appendix F and G, the responses of the Proficient and Intermediate students on the existence and appearance of the dinosaurs were similar to the Expert's response. They believed that dinosaur existence was supported by the fossils, bones, and remains found by archaeologists and scientists who have been studying their species for a long time. Notably, as seen in Appendix G, only the Intermediate students stated that the help of technology and experiments enabled the scientists to verify the existence and appearance of the dinosaurs. This may imply that Intermediate students' scientific insights were not always inferior to the Expert and Proficient students.

In VNOS D Question 5, all agree on the uncertainty of weather patterns and that technological advancements help improve the accuracy and reliability of predictions. However, it must be noted that most of the proficient responses focused on the certainty of weather patterns because of their technological support. In contrast, most of the expert and intermediate students' responses emphasized the uncertainty of weather patterns due to the subjective nature of weather with several factors that can change now and then. Again, This result differed from the usual because the expert and intermediate students gave a parallel response, which did not support the results in Axis 2 of Table 2. In VNOS D Question 6, the three groups of students have a universal scientific model concept which was anchored on the description as something that serves as a guide, an illustration, a representation, a computer simulation, or an imagination that would help people visualize and understand scientific explanations about a specific thing or phenomenon. On the other hand, ambiguity and misconceptions of what a scientific model is were found among intermediate students. Some intermediate students thought of a scientific model as the things that scientists use in experiments or studies, which may be mistaken for laboratory apparatus instead. Also, one intermediate accounted for a scientific model as a person who likes to study science, like a scientist or doctor, which is incorrect. Another thought of it as a successful experiment, while a few others admitted that they did not know or did not understand what scientific models were. These facts can strengthen the intermediate students' lowest mean level of insights in Axis 2 of Table 2. VNOS D Questions 7a and 7b asked whether imagination and creativity were used in scientific investigations. This was related to Axis 2 in terms of how imagination and creativity function throughout the construction of their knowledge. In the VNOS D Question 7, most of the proficient students believed that imagination and creativity are used in all parts of the investigation (planning, experimenting, making observations, analyzing data, interpreting, reporting results, etc.). These findings were again different from the expert and intermediate students' views because, for them, imagination and creativity are commonly utilized during experimentation. Also, intermediate students believe that imagination and creativity were used in a wide range of combinations of the parts of investigation (planning, experimenting, making observations, analyzing data, interpretation, reporting results, etc.) compared with the proficient students' claim that clustered only in experimentation, planning, and interpretation.

Uniquely, a sole intermediate student believed that imagination and creativity are not used in scientific investigations because it is believed that the solutions can be just found in related studies and experimental results. This concept is unusual and unacceptable because imagination and creativity play a vital role in finding answers to problems.

Students' Real-life Applicability (Axis 3)

Real-life applicability (Axis 3) dealt with whether scientific knowledge and thinking were applicable only in the classroom or laboratory or were generally applicable to natural and daily life. The results in the Real-life applicability (Axis 3) of Table 2 showed that the expert had the highest rating of 3.25, followed by the proficient students with 2.85 and lastly by the intermediate students with 2.03. These results could be compared to the responses of VNOS D questions 1 (What is science?) and 2 (How is science different from the other subjects you are studying?). Regarding real-life applications, expert, proficient, and intermediate students have emphasized that science and technology aim to improve people's quality of life and enhance their environment. The three categories of students supplied answers that were not confined to what was learned inside the class because of the actual real examples they cited. The expert cited photosynthesis, the water cycle process, and finding cures for diseases. More so, the proficient students' responses included that science explains all the occurrences in this world, that it is never-ending, and that they study the minor living things up to the vast universe. Notably, intermediate students mentioned a variety of applications of science, like breathing, how humans think, theories, people who design rockets, nature, plants, animals, discoveries, the environment, etc. These intermediate students had a more varied set of acceptable responses. This fact was also consistent in the answers to VNOS D question 2 which stated that all these students belonging to three different levels of insight find science different from other subjects due to its direct applicability to daily situations. Again, the intermediate students had several unique responses that somehow supported the idea that science had a direct application to day-to-day situations.

Students' Evolving Knowledge (Axis 4)

Evolving knowledge (Axis 4) is a dimension that investigates how students perceive scientific knowledge that would range from absolute truth to significantly relative or variable. According to the data in Table 2 for Evolving Knowledge (Axis 4, the same trend was found in the rating of the Expert, Proficient, and Intermediate students. That is, the Expert got the highest rating of 4.00, followed by the Proficient students with 2.77 and then by Intermediate students with 1.83. However, in VNOS D Question 2 (How is science different from the other subjects you are studying?) responses, the expert and some of the Proficient and Intermediate students believed in consideration of data gathering and experimentation to get proof of a particular claim or phenomena. This may imply that these students acknowledge the tentativeness of data and give importance to validating facts. In the VNOS D question 3, it was found that the expert, all the proficient students, and the intermediate students believe that facts in books may change. This means that all of the students acknowledge the relative nature of scientific information. However, it is equally important to note the existence of rare claims of some intermediate students believing that knowledge of books does not change through time.

Other data supporting students' relativistic views regarding scientific truths are found in the responses given in VNOS D Questions 4a, 4b, 4c, 5a, and 5b. Specifically, in VNOS D Questions 4a and 4b, the expert, together with most of the proficient and intermediate students, responded that scientists were able to know the existence and the appearance of dinosaurs through the fossils, bones, and other evidence. Many of them recognized that the scientists' findings are firmly based on the results of their experiments or evidence study and that with the advent of technology accuracy of data gathered about dinosaurs may also increase. This trend of responses was also found in VNOS D Question 4c where many of the students in the three categories believed that scientists disagree on the cause of the extinction of dinosaurs even though they have the same data because of the lack of solid evidence and the uncertainty of the data that scientists have. VNOS D Questions 5a and 5b consistently elicited how students recognize the uncertainty of weather reports from weather persons. Though the explanations of the different groups of students were parallel to one another, there were still disagreements among proficient students; some believed that persons were reliable in their data while others were not. Significantly, the expert and some intermediate students were skeptical of the accuracy of weather pattern readings of the weather persons due to the reasoning that humans have limitations and that weather constantly changes now and then.

Source of ability to learn (Axis 5)

Contrary to the rest of the results on the EBAPS, it was in Axis 5 where the Expert did not rank the highest in terms of mean score. Though there was a slight difference, the Proficient students' mean score of 3.39 ranked first in considering the

Source of ability to learn (Axis 5), followed by the Expert with 3.33, then the Intermediate with 2.98. This could mean that proficient students and expert students highly believed in the value of hard work and good study strategies rather than merely self-confidence and fixed natural ability in learning science. No additional data from the VNOS D was compared with Axis 5 because none of the questions was valid for comparison.

As seen in Table 2, the expert's level of insights on the structure of scientific knowledge (Axis 1) had the highest score of 3.50 score compared with the 1.66 score of the proficient students and 1.29 score of the intermediate students. The sophistication of the expert's scientific knowledge structure, as illustrated in Axis 1 of Table 2, is remarkably the highest. However, it must be noted that only one expert was dealt with here, which may not represent the population of the experts. The determination of the correlation between the science insights to the science academic achievement of students was of great significance to validly predict a student's success in the STEM strand.

Inference on Students' Structure of Scientific Knowledge (Axis 1)

The sophistication of the expert's scientific knowledge structure, as illustrated in Axis 1 of Table 2, was remarkably the highest followed by proficient students and then by the intermediate students. However, it must be noted that only one expert was dealt with here, which may not represent the population of the experts.

Axis 1 is hugely related to VNOS D questions 1 and 2 responses. The responses to VNOS D question 1, which came from the expert, proficient, and intermediate students, regarding science, were generally similar. For them, science is a body of knowledge that finds ways to explain things in the world and the universe, and it connects many fields of study to find the truth. They also favored the idea that science involves the scientific processes involved in the scientific method, such as making observations and doing experiments. Most importantly, they believed that science could be applied to real-life situations.

In VNOS-D Question 2 (How science is different from the other subjects you are studying?), the Expert, majority of the Proficient and Intermediate students believed that science is unique from different subjects because it requires data collection through observations and experimentations, then, processed through mathematical equations or formula to arrive at a valid result.

Thus, lower mean scores in the EBAPS do not conclusively say that students do not have sound scientific insights.

Inference on Students' Nature of Knowing and Learning (Axis 2)

As illustrated in EBAPS Table 2, the expert student scored the highest, followed by the proficient and the intermediate. This meant the expert had the most sophisticated science insights on Axis 2 among the three and the intermediate with the least sophisticated. However, it must be taken into consideration that only one expert is dealt with here.

One focus of Axis 2 was on students' views on how learning science is done to optimize learning, ranging from learning it passively to actively doing it. Generally, the three levels, the Expert, Proficient, and the Intermediate, had similar responses to all of the VNOS D Questions. They all share the same insights on science, which is a body of knowledge that requires participation from scientists or students through observations, analysis, and experimentation.

Another emphasis of Axis 2 was on how students adapt newly introduced data to previous knowledge. This aspect is directly related to the responses to VNOS D Questions 3, 4, 5, and 6. In VNOS D Question 3, the Expert, most of the Proficient and

Intermediate students agreed on the idea that facts in the book may change over time. What is unique is that few intermediate students agree that knowledge of books was fixed over time. This may mean two things: these students refer to a general law in science or do not believe that scientific facts in books change.

In VNOS D Question 5, all the students agreed on the uncertainty of weather patterns and that technological advancements help improve the accuracy and reliability of predictions. However, it must be noted that most of the proficient responses focused on the certainty of weather patterns because of their technological support. In contrast, most of the expert and intermediate students' responses emphasized the uncertainty of weather patterns due to the subjective nature of weather with several factors that can change now and then.

In VNOS D Question 6, the three groups of students have a universal scientific model concept which is anchored on the description as something that serves as a guide, an illustration, a representation, a computer simulation, or an imagination that would help people visualize and understand scientific explanations about a specific thing or phenomenon.

Among intermediate students, misconceptions of what a scientific model is include the idea that a scientific model is the thing that scientists use in experiments or studies. Another thought is that a person likes to study science, citing a scientist or a doctor as examples. Another believed that a scientific model is a successful experiment—surprisingly, around three students admitted that they do not know or do not understand what scientific models are.

VNOS D Questions 7a and 7b emphasized how vital imagination and creativity are in scientific investigations, which is related to Axis 2 in terms of how these two cognitive functions help construct their scientific knowledge.

In the VNOS D Question 7, most proficient students believed that imagination and creativity are used in all investigation parts (planning, experimenting, making observations, analyzing data, interpreting, reporting results, etc.). However, among expert student and intermediate students, imagination and creativity are usually applicable during experimentation. Also, proficient students have a more coherent response on where imagination and creativity are commonly used in a scientific investigation clustered only on experimentation, planning, and interpretation. In contrast, intermediate students believed in a broad combination of planning, experimenting, making observations, analyzing data, interpreting, reporting results, etc., that requires imagination and creativity.

Uniquely, a sole intermediate student thought that imagination and creativity are not used in scientific investigations since solutions can be found in related studies and experimental results. This view on science is quite unusual because the student here only accepts data wit.

Inference on Students' Real-life Applicability (Axis 3)

In the case of VNOS D Questions 4a, 4b, and 4c, generally, all students agree on the reliance on facts to conclude the existence, appearance, and theories about dinosaurs. Even if the proficient and intermediate groups responded similarly, intermediate students' responses were not as profoundly explained as the proficient students.

In VNOS D Question 5, all students acknowledge the idea that the weather has a tentative nature in reality, which allows people to improve their technology and knowledge through adaptation to newly acquired data.

In VNOS D Question 6, the three groups of students have a universal scientific model concept which is anchored on the description as something that serves as a guide, an illustration, a representation, a computer simulation, or an imagination that would help people visualize and understand scientific explanations about a specific thing or phenomenon. On the other hand, ambiguity and misconceptions of what a scientific model is were found among intermediate students. Some intermediate students thought of it as something scientists use in experiments or studies, which may be mistaken for laboratory apparatus. Also, one intermediate accounted for a scientific model as a person who likes to study science, like a scientist or doctor, which is incorrect. Another thought of it as a successful experiment, while a few others admitted that they did not know or did not understand what scientific models were. These facts can strengthen the intermediate students' lowest mean level of insights in Axis 2 Table 2.

In the VNOS D Question 7a, an intermediate student believes that imagination and creativity are not used in scientific investigations because it is believed that the solutions can be just found in related studies and experimental results. This concept is unusual and unacceptable because imagination and creativity play a vital role in finding answers to problems.

In the case of the VNOS D Question 7b, most of the proficient students believed imagination and creativity were used in all parts of a scientific investigation. In contrast, the expert and intermediate students think both attributes are used during experimentation.

Inference on Evolving Knowledge (Axis 4)

Evolving knowledge (Axis 4) is a dimension that investigates how students perceive scientific knowledge that would range from absolute truth to significantly relative or variable. According to the data in Table 2 Axis 4, the same trend is found in the rating of the expert, proficient and intermediate students. That is the expert got the highest rating of 4.00, followed by the proficient students with 2.77 and then by intermediate students with 1.83.

As found in the VNOS D Question 2 responses, it was clear that for the expert and proficient students validating facts is indeed essential, unlike the intermediate students who do not emphasize the idea of verifying facts.

In the VNOS D question 3, it was found that the expert, all the proficient students, and the intermediate students have a unifying belief that information in books may change, thus implying that students consider the relativity of scientific information. Nonetheless, citing some rare but significant accounts of some intermediate students stating that knowledge of books does not change is essential. This answer from the intermediate group could reflect the 1.83 mean, the lowest mean found in Axis 4 of Table 2. This means that some of the intermediate students believe that there are ideas that are true and will not change for quite some time.

Other data supporting students' relativistic views regarding scientific truths are found in the responses given in VNOS D Questions 4a, 4b, 4c, 5a, and 5b. Specifically, in VNOS D Questions 4a and 4b, the expert and most proficient and intermediate believed that facts must be supported by specific evidence through experimental results before giving any conclusions. Similarly, this trend can be observed in VNOS D Question 4c responses where many of the students in the three categories agreed that scientists disagree on the cause of extinction of dinosaurs even if they have the same information due to the insufficient supporting data and the uncertainty of the data. VNOS D Questions 5a and 5b consistently elicited how students recognize the uncertainty of another phenomenon like weather reports from weather persons. The responses of the different groups of students are somehow parallel in one part or another; many believe that people are accurate due to the help of technology. Many also disagree by acknowledging the inaccuracy of weather instruments and the idea of the changing nature of the weather.

All the results of the VNOS D revealed several similarities in the responses of expert, proficient, and intermediate students. However, many facts indeed support that most of the expert and proficient student's insights are more substantial than those of the intermediate students' insights. This only goes to show that the expert and most of the proficient students distinctly view science in a more profound sense than most of the intermediate students. Many misconceptions were found among the intermediate students regarding the concept of a scientific model and the idea that facts in books will not change over time. Consequently, this supports the assessment results of the EBAPS questionnaire on the level of science insights among Grade 10 students, where the expert mean score is mostly the highest, followed by the proficient and then by the intermediate students.

CONCLUSION

This study has finally concluded that the overall mean scores of the Grade 10 students' insights in EBAPS and their general average grade in Science were significantly correlated since the p-value for the correlation between science insights and academic achievement was less than the significance level of 0.05. This means that how students perceive their classroom can ultimately influence their academic performance in the subject matter. As assessed in the EBAPs, it was found that among the Grade 10 students who chose STEM as a strand, around 53.98% have a proficient level of science insights, and 45.45% have an intermediate level. Only 0.57% have an expert level of science insights. Thus, the bulk of these students belong to the proficient and intermediate levels of science insights. In terms of academic achievement, most of the proficient students' science grades clustered within the interval 80-94 while the intermediate students' science grades clustered within 75-89. Though the correlation between science insights and science grades was found to be moderately positive only, this correlation was known to be significant. This implies that these two variables are somehow connected. There were recorded misconceptions like science being static and weather forecaster being accurate in their prediction of the weather. This needs intervention in order to reduce its prevalence and may not adhere to their path to STEM.

All in all, it is concluded that for a higher possibility of success in STEM, a student may at least be at the proficient level of insights and mean science grade of 80 and above. The correlation between students' insights and academic achievement in science is a reliable predictor for STEM career paths. The findings of this study have demonstrated that students who excel in science are more likely to pursue STEM careers in the future. This correlation is not only limited to academic excellence but also includes aspects such as critical thinking, problem-solving skills, and creativity. Therefore, educators must focus on nurturing students' scientific insights by providing hands-on and engaging learning experiences. This will improve their academic performance and increase the likelihood of them choosing STEM careers. By encouraging students to explore the field of science and guiding them toward STEM-related opportunities, we can create a workforce that is well-equipped to meet the demands of the future job market, particularly in the fields of science, technology, engineering, and mathematics.

RECOMMENDATION

Remediation may be given to those students who were identified as intermediate students and seemed to exhibit difficulty in the STEM strand to facilitate and guide them in their chosen path. A better scheme for remediation for Grade 11 or, in the future, Grade 12 should be planned well. Scheduled remediation is recommended since they have different schedules with the Junior High School. All identified students who are academically challenged should be given priority. This can be included as part of the Faculty Development Activity for regular teachers.

The different dimensions (axes) in the questionnaires may be used to evaluate students under the STEM strand. They may be included in the syllabus and module/s making or re-alignment. Science educators may look into some common misconceptions found in the answers of the students in the VNOS D to be able to correct them and improve the level of insights on the nature of the science of the Letran students from mainly proficient and intermediate to expert. Activity–based lessons that integrate the characteristics of the nature of science are highly recommended.

DECLARATIONS

There is no conflict of interest in this study.

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