Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
Volume 2 Issue 5 (2026)

Enhancing Science Performance of Junior High School Through Trimodal Strategies: A Study in Layugan Intergrated School

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Publication Date: May 5, 2026
DOI: **10.5281/zenodo.20040569**

Abstract

The study aimed to investigate the science performance of Junior High school Grade 7 and 8 students in trimodal strategies. Specifically, it sought to answer the following: (1) what is the level of science performance of Junior High school in Layugan Integrated School before and after the application of Inquiry-based, Project-based learning, and Laboratory in teaching the fourth quarter lessons in Science; (2) Is there a significant difference between the level of science performance of Junior High school in Layugan Integrated School before and after the trimodal strategies; (3) Which among the trimodal strategies was found most effective in teaching the fourth quarter lessons in Science; (4) What tool guide can be recommended based on the result of the study.

The study used pre-test- posttest design to assess the effectiveness of Inquiry-, Project-, and Laboratory-Based strategies. Both tests examined the performance level of the Grade 7 and 8 students in Science.

The collected data were evaluated statistically using the following tools: mean, t-test for two samples, Analysis of Variance (ANOVA) Pre-HAVOC and Post-HAVOC test.

Based on the data gathered, the following were the results: (1) The application of active learning strategies such as Inquiry-Based, Project-Based, and Laboratory-Based Learning resulted in notable improvements in Grade 7 students' performance across all targeted Science competencies; (2) Integrating IBL, PBL, and Laboratory into Science instruction significantly enhances student performance by promoting deeper understanding, engagement, and critical thinking across diverse learning competencies of the Grade 7 and 8 student; (3) There was a significant difference between the Science performance of the Grade 7 students after the application of the trimodal strategies (Inquiry-based learning, Project-based learning, and Laboratory-based learning) as the mean difference went from 9.13 and a t-value of 13.686; (4) There was a significant difference between the Science performance of the Grade 8 students after the application of the trimodal strategies (Inquiry-based learning, Project-based learning, and Laboratory-based learning) as the mean difference went from 12.07, with a highly significant t-value of 14.508; and (5) The Laboratory-Based learning was the most effective strategy among the trimodal strategies used in the study.

With the results, these recommendation were drawn: (1) Teachers may continuously integrate these strategies, Inquiry-Based Learning (IBL), Project-Based Learning (PBL), and especially Laboratory-Based Learning (LBL), across the Science curriculum; (2) With the effectiveness of the Laboratory-based learning strategy, there is now a need for proper planning and support to solve problems such as lack of laboratory equipment and safety concerns; and (3) The output of the study which is a Laboratory Manual for Grade 7 and 8 Fourth Quarter Science may be adopted and utilized as supplementary instructional materials in science classes.

Keywords: *Trimodal strategies, Science subject, Inquiry-Based Learning, Project-Based Learning, Laboratory-Based Learning*

Online ISSN: 3082-5121
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https://journals.aloysianpublications.com
Volume 2 Issue 5 (2026)

I. INTRODUCTION

Science education prepares learners to with the global education by developing various science skills such as research-oriented, problem-solving, and scientific literacy. However, in today's digital era, science education worldwide faces numerous challenges particularly in terms of pedagogy, learning outcomes, as well as assessment. The challenge for educators of science is to continually think of innovative ways to make science more responsive and relevant. In a study by Rogayan (2019), it has been reiterated that science education is confronting a myriad of changes in terms of curricular approach brought about by the globalization, the industry 4.0, Association of Southeast Asian Nations (ASEAN) integration, and the complete implementation of the K to 12 curriculum. In such curriculum, science and innovation are stressed to be placed in common human issues. The curriculum to be precise, requires active student participation and dynamic engagement in the learning process.

The Philippines performed abysmally in PISA 2018 science literacy assessment with only 22 percent of the 7,233 15-years old Filipino students achieved the minimum level of competency (Level 2) in science literacy (Organization for Economic Cooperation and Development (OECD 2019). This performance places the Philippines near the bottom of the (79) seventy-nine countries and economies that participated. The poor performance of Filipino students is indicated as more or less 77 percent of them was not able to reach the minimum proficiency level. Within the lowest proficiency levels (1A and 1B), students are only able to use everyday content and procedural knowledge to explain familiar or simple phenomena, their ability to understand data and even to design scientific inquiry is highly limited.

It is also notable that Filipino students' poor performance in the 2018 PIS is consistent with their results in the 2019 Trends in International Mathematics and Science Study (TIMSS). TIMSS assesses how well they apply scientific knowledge. To be precise, Filipino fourth graders scored an average of 249 which is below the international average of 491 and the lowest among 58 countries. Only 19 percent reached the Low benchmark or higher, indicating that most students had limited understanding of basic science concepts (Mullis et al., 2020). However, there are certain studies that identified some predictors of Filipino students learning and achievement in physics, chemistry, biology, or some specific science lessons. Such predictors fall into two types of inquiries: (a) those that looked into student motivations and other student level variables that are non-cognitive and (b) those that investigate the instructional strategies' learning outcome.

Additionally, the National Achievement Test (NAT) (2019) revealed gaps in science learning outcomes. The report indicated that science was one of the subjects with the lowest passing rate among the academic disciplines, signaling significant challenges faced by students in mastering fundamental scientific concepts. One major difficulty faced by students was in grasping complex and abstract scientific concepts, especially in areas such as **Physics**, **Chemistry**, and **Biology**. These subjects often require higher-order thinking skills, such as synthesis and analysis, which many students struggle with. Moreover, science topics often build upon each other, meaning that a gap in one foundational area can lead to difficulty in understanding subsequent lessons. This low performance has been attributed to study engagement (Schleicher, 2018), and failure to integrate Information Communication Technology into teaching and learning (Munjen & Jita, 2020). Research on science education reveals that student engagement was positively connected with students' academic performance (Delfino

2019) and is also directly correlated with technology integration. Most studies regarding science education on the Philippines focused merely on curriculum, beliefs, knowledge, practices of science teachers, and perceptions of science learning (Walag, et al, 2020). The recalibration of the curriculum in Science draws from and supports the Department of Education's MATATAG agenda, which is resolving the challenges of the basic education through the four critical components: (1) Making the curriculum relevant to produce competent and job-ready, active, and responsible citizens; (2) Taken steps in order to accelerate delivery of basic education facilities and services; (3) Taking good care of the learners by promoting learner well-being, inclusive education, and a positive learning; (4) Giving support to teachers to teach better. The Science curriculum is supporting Filipino learners to engage with science-related issues, and with the ideas of science, as a citizen. The overall goal of the Grade 3 to 10 Science curriculum is the achievement of scientific, environmental, and technology and engineering literacy of all learners.

In Grade 7 science curriculum, learners are expected to demonstrate skills to plan and conduct a scientific investigation making accurate measurements and using standard units. They are also expected to employ scientific techniques, concepts, and models to investigate forces and motion, and describe their findings using scientific language, force diagrams, and even distance-time graphs. They use their curiosity, knowledge, and skills to propose solutions to problems related to motion and energy. Therefore, to address the poor performance of science, there should be the application of teaching approaches that stimulate engagement and the utilization of technology that can aid learning (Olila, 2021).

However, according to Orbe (2023), there are still a number of teachers in the Philippines who still rely on. While these methods can effectively transmit factual information, they are often insufficient in promoting **critical thinking**, **problem-solving abilities**, and **scientific inquiry skills**—competencies that are vital for students to truly master scientific concepts (SEI-DOST & UP NISMED, 2022). Passive learning approaches limit opportunities for students to engage actively with the material, to ask questions, explore ideas, and conduct experiments.

With such gap, this study aimed to introduce strategies that are designed to enhance science skills. One of the common teaching strategies being applied in science is the Project-based learning. Project-based learning has an immense potential to enhance twenty-first century skills and engage students in real-world task (Kingston, 2018). The transversal competencies or 21st century skills are common denominators for various skills necessary for success in daily life, such as problem-solving, critical thinking, communication, collaboration, and self-management skills (Viro & Joursenlahti, 2020). Research evidence indicates that PBL can promote student learning in acquiring deeper content knowledge and skills in mathematics and in science. In addition, some studies have reported improved attitude towards learning, increased attendance, , and self-reliance, on the part of the students.

However, researchers such as from Condliffe et al (2017), have identified the common challenges in the implementation that focused on the design principle of PBL. These include teachers' skills, knowledge, and attitude related issues such as (1) teachers' resistance to student-centered learning, (2) inability to motivate students to work I collaborative teams, (3) confusing inquiry-based with hands-on activities, (4) the development of authentic assessment, and (5) scaffolding instruction. Meanwhile, other challenges related to students' resistance to employing critical thinking are lack of motivation, unsatisfactory group working, and readiness for student-centered approaches in integrated science education. In addition, teachers struggle with time constraints and inadequacy of the resources that will support in-depth student investigations that are needed for constructing knowledge (Viro et al, 2020).

Meanwhile, inquiry-oriented teaching ensures creativity by increasing curiosity and motivates students to learn. However, high stakes testing and the new focus on accountability have already impacted the way educators in Science subjects deliver instruction. According to PASCO (2024), transitioning from traditional learning environment and strategies such as lecture-focused instruction to that of authentic scientific inquiry is a key step in developing students' scientific literacy. Authentic scientific inquiry actively engages the learners in the pursuit of knowledge, rather than memorizing the facts, to facilitate the development of critical 21st century competencies.

Research by Connors & Perkins (2019), stated that the inquiry-based method can even improve test scores and academic skills by aligning an experienced-based science curriculum with the types of questions found on exams given by the state. Meanwhile, an inquiry-based curriculum in the subject earth science was adopted in five urban schools to teach fifth-grade students. The data were collected from their pretest, post-test, the NAEP and the TIMSS. In this, the students showed significant improvement on science standardized-test scores (Lambert, 2018). A similar study of inquiry-based activities in biology classroom emphasized understanding of scientific concepts, competence in conducting scientific inquiry and understanding inquiry, and the relationship between nature and the history of science (Stephen, 2019).

Another teaching strategy that is commonly applied in the area of science is the laboratory teaching. As asserted by Ugwoke (2023), the laboratory method is known as a hands-on and minds-on approach in science instruction in which the learners have the opportunity to gain some experience with phenomena associated with their course of study. Laboratory method is a unique source of quality teaching and learning in science as science students are able to observe and manipulate materials to demonstrate certain aspects of the subject matter which has been learned in class through lectures, discussions, and textbooks. Hence, it provides them with opportunities to engage in the processes of investigation and inquiry which is believed to enhance quality education.

Science is regarded as a fundamental discipline across all educational levels due to its significant role in fostering national progress and socio-economic development. Within the Philippine Department of Education (DepEd) curriculum, the Grade 7 Science program places a strong emphasis on Earth Science, introducing learners to essential concepts such as the Earth's internal composition, atmospheric dynamics, geological processes, and astronomical movements. Structured according to the spiral progression approach, the curriculum enables students to gradually deepen their understanding by building on previously acquired knowledge (Department of Education, 2013). In the succeeding year, the Grade 8 curriculum shifts focus toward Life Science, encompassing core topics such as cellular biology, genetics, biodiversity, and ecological systems. Instruction at this level seeks to enhance scientific inquiry and critical thinking skills through practical applications, hands-on experiments, and community engagement. Collectively, Earth Science in Grade 7 and Life Science in Grade 8 form a vital academic foundation for developing scientific literacy and analytical competence among junior high school learners (DepEd, 2015).

Conversely, despite curriculum improvements, significant challenges persist in the teaching and learning of these science subjects. One major issue perceived is the continued reliance on traditional, teacher-centered instructional methods. Furthermore, despite the growing body of literature on effective teaching strategies in science education, there remains a significant gap in research specifically examining the combined application of Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory teaching in enhancing student performance in understanding motion. While individual studies have highlighted the benefits of each approach in fostering engagement and conceptual understanding, there is still a scarcity of comprehensive investigations that integrate these methodologies within a cohesive framework. Furthermore, existing research often overlooks the specific challenges, and the opportunities presented in the context of motion, an essential concept in physics that underpins various scientific principles.

Bases on the classroom experience of the teacher-researcher, students exhibited notable difficulties in learning the key concepts in both Earth Science and Life Science. In their subject Earth Science, Grade 7 students struggled to visualize and comprehend abstract topics such as plate tectonics, atmospheric phenomena, and astronomical patterns. Similarly, in Life Science, Grade 8 students found it challenging to grasp cellular structures, genetic processes, and ecological relationships. Through daily observations, quizzes, and classroom interactions, the teacher-researcher noticed that many learners showed signs of disengagement, confusion, and shallow understanding. These challenges were often linked to the traditional lecture-based instruction commonly used, which did not fully address the students' varied learning preferences.

To address the identified gaps in student engagement and performance, the teacher-researcher implemented a trimodal instructional approach, integrating inquiry-based, project-based, and laboratory-based teaching strategies into science instruction. The primary objective of this study is to align pedagogical methods with the varied learning styles of students in order to enhance conceptual comprehension, encourage active classroom participation, and ultimately improve academic outcomes in science. By employing these complementary modalities, the teacher-researcher seeks to establish a more inclusive and responsive learning environment in which learners are better equipped to understand and retain core principles in both Earth Science and Life Science.

Theoretical Framework

First, the Constructivist Learning Theory by Piaget (1976), which revealed that learners actively construct their own knowledge and understanding based on experiences and interactions with the world. Instead of passively receiving information, students engage with material, reflect on it, and build knowledge through exploration. Such theory supports student-centered learning environments, such as project-based learning and inquiry-based learning. In project-based and inquiry-based learning environments, students are encouraged to ask questions, investigate, and solve problems. These hands-on approaches align well with Constructivist principles, allowing students to make connections to the scientific conception of motion through practical applications.

Second, the Social Learning theory by Bandura (1977), highlight the benfit of observing and modeling behaviors, emotional reactions, and attitudes of others. It merely suggests that learning occurs in a social context and is influenced by others. This is applicable in the study as

Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
Volume 2 Issue 5 (2026)

collaborative learning in project-based activities enables students to observe their peers and learn from each other's experiences. By working together on experiments or projects related to motion, students can enhance their understanding through discussion and shared insights.

These theories collectively provide a comprehensive framework for understanding how, inquiry-based learning, project-based learning and laboratory teaching can enhance students' science performance. By integrating these approaches, the teacher-researcher can effectively create more engaging and learning experiences that can lead to a deeper understanding of complex scientific concepts.

Conceptual Framework

This study was guided by the research paradigm illustrated below.

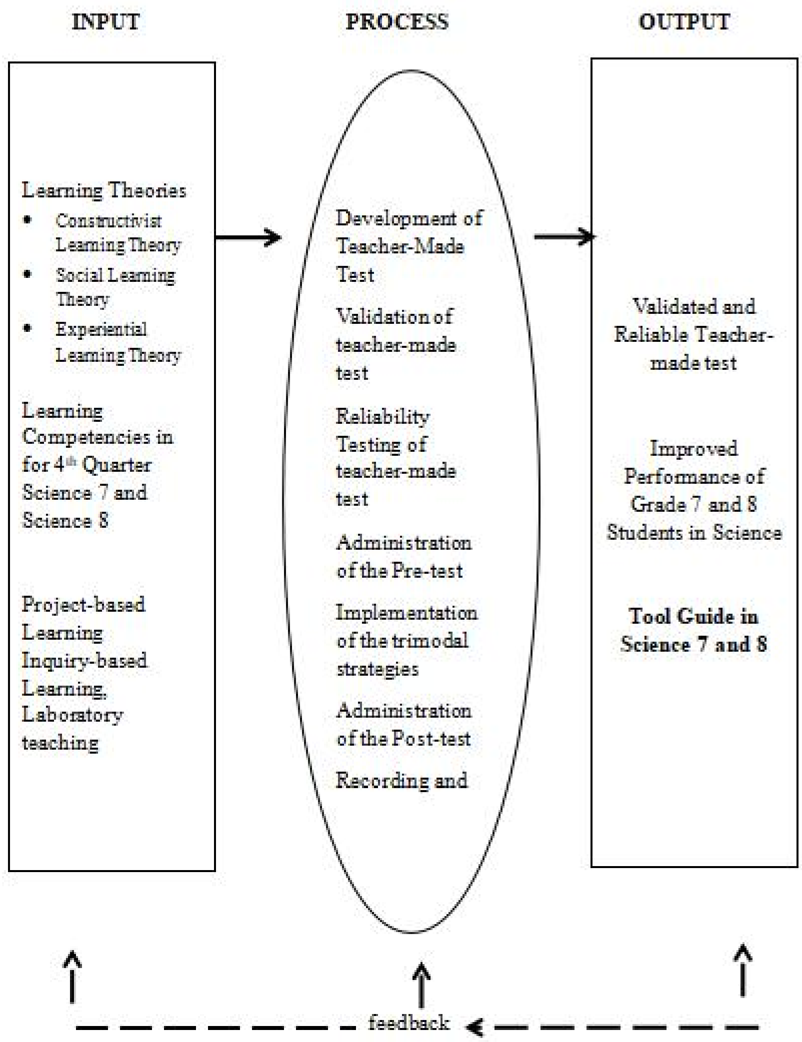

Figure 1.

Research Paradigm

The paradigm of the study focused on the inputs which included relevant learning theories such as Constructivism, Social Learning, and the Experiential; the specific Science 7 and 8 competencies for the fourth quarter; and the teaching strategies such as Inquiry-Based Learning, Project-Based Learning, and Laboratory-based Learning. The process includes the development, validation, and testing of the teacher-made pre-test and post-test. The implementation of the three learning strategies also took place as it became the basis for the data to be gathered and analyzed. As for the output, the validated and reliable teacher-made tests, improved student performance in Grade 7 and Grade 8 Science, and the tool guide for Grade 7 and Grade 8 Science were included.

Statement of the Problem

The study aimed to investigate the science performance of Junior High school Grade 7 and 8 students in trimodal strategies.

Specifically, it sought to answer the following:

1. What is the difference in Science performance before and after implementing the trimodal strategies?
2. Is there a significant difference between the level of Science performance of Junior High school in Layugan Integrated School before and after the trimodal strategies?
3. Which among the trimodal strategies is found most effective in teaching the fourth quarter lessons in science?
4. What tool guide can be recommended based on the result of the study?

Hypotheses

1. There is no significant difference between the level of science performance of Junior High school in Layugan Integrated School before and after the application of trimodal strategies.
2. There is no significant difference between and among the level of science performance of the Junior High school students before and after the application of the trimodal strategies.

II. MATERIALS and METHODS

Research Design

This study employed a quantitative research approach, which focuses on the collection and analysis of numerical data to facilitate statistical interpretation and draw objective conclusions. Specifically, the study utilized experimental design, adopting a pre-test and post-test format to evaluate the effectiveness of three instructional strategies: Inquiry-Based Learning (IBL), Project-Based Learning (PBL), and Laboratory-based teaching. Two groups of junior high school students were involved in the analysis to compare their performance before and after the implementation of the trimodal strategies. By using this design, the study aimed to determine the impact of these approaches on students' academic achievement in selected fourth-quarter science topics. The quantitative nature of the research ensured a systematic and measurable assessment

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Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
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of how the applied teaching methods influenced learners' understanding and performance in science.

Population and Locale

The study took place in Layugan Integrated School located in Layugan, Bucay, Abra. The research had two groups of respondents. The experimental group were the (30) thirty Grade 7 students and the (30) thirty Grade 8 students at the said school who were enrolled for the School Year 2024-2025. This study utilized the total enumeration of the population. Thus, every member of the target population was included in the study, ensuring a comprehensive representation of the entire group. Table 1 presents the number and distribution of respondents for the two groups.

Table 1. Distribution of Respondents

Sex	Grade 7 Respondents	Grade 8 Respondents
Male	16	18
Female	14	12
Total	30	30

Table 1 shows the number of respondents for the study. Both Grade level (Grade 7 and 8) is composed of 30 students respectively. Specifically, for Grade 7, there are 16 male and 14 female students; while in Grade 8, there are 18 male and 12 female student-respondents.

Data Gathering Tool

The researcher utilized a 30-item, researcher-made test to assess the science performance of the respondents during the fourth quarter, employing parallel trimodal strategies. This instrument was administered as both the pre-test and post-test. To ensure the validity, replicability, and accuracy of the data, the research instrument underwent a rigorous process of validation and reliability testing. Content validity was established through the evaluation of two Science Master Teachers and the School Head, with the results analyzed using the weighted means to determine the appropriateness and clarity of the items. The computed content validity index was at 1.0 while the Fleiss Kappa was computed at 0.87 which is described as "almost perfect agreement".

Furthermore, to ensure the reliability of the instrument, pilot testing was done at Cristina B. Gonzales Memorial High School. The teacher-made tests for IBL (α=0.775), PBL (α=0.746) and Laboratory Teaching (α=0.737) all achieved an "acceptable" level Cronbach Alpha level which measured the internal consistency of the tests. This suggests that the items were highly related to each other and are likely measuring the same underlying construct. Establishing the validity and reliability of the instrument is a critical prerequisite for ensuring the integrity and quality of the measurement process (Kimberlin & Winterstein, 2008).

The following Likert-scale with corresponding descriptive equivalent was adapted from DepEd Order No.8, s 2015. It was used to describe the level of students'science performance before and after the application of the trimodal strategies.

Percentile Score	Descriptive Rating (DR)
90-100	Outstanding (O)
85-89	Very Satisfactory (VS)
80-84	Satisfactory (S)
75-79	Fairly Satisfactory (FS)
Below 75	Did Not Meet Expectation (DNME)

Data Gathering Procedure

The researcher first identified the competencies from the curriculum guides of Grade 7 and Grade 8. After which, the construction of teacher made test was done. The researcher then sought the permit for the validation of the said tool. After being validated, the researcher integrated the suggestions made by the validators.

In testing the reliability of the pre-test and post-test instruments, the researcher initially sought permission from the School Head of a nearby public school, Cristina B. Gonzales Memorial High School, to administer the tests. Upon approval, the instruments were administered, and the results were computed and analyzed. The reliability of the tests was measured using Cronbach’s Alpha, while the content validity was established through evaluation by two Science Master Teachers and the School Head, with the analysis conducted using the weighted mean.

As the instruments were confirmed to be valid and reliable, the researcher sought and obtained formal approval from the Schools Division Superintendent to conduct the study to the identified respondents.

Upon securing the necessary approval, the researcher distributed informed consent forms to the parents or guardians of the student-respondents. This step ensured that participation was voluntary and that ethical research standards, particularly those concerning minors, were strictly followed. Participants and their parents were briefed on the purpose of the study, the confidentiality of the data, and their right to withdraw from the study at any point.

Following the receipt of signed consent forms, the researcher administered the pre-test, focusing on the fourth quarter Grade 7 and 8 Science lessons, particularly the topic "Earth Science" and “Life Science”, respectively. After the pre-test was conducted, the data were retrieved, and the scores were analyzed by computing the frequency counts and the total weighted mean.

Subsequently, the teacher-researcher solely implemented each of the three teaching strategies, Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory Teaching for over a two-week period to ensure consistency in instruction and classroom management.

In the first week, Inquiry-Based learning was used, where the students were able to explore scientific questions through guided inquiry. The teacher-researcher facilitated the learning process by posing problems, encouraging student predictions, and guiding students in gathering and analyze concepts and data.

In the second week, Project-Based learning and Laboratory-Based learning were applied. The teacher-researcher served as a facilitator and provided resources, guided students’ collaboration, and conducted hands-on experiments. Classroom observations were conducted

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Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
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through the presence of a Master Teacher from the locale of the study to ensure that the intervention was applied with fidelity and consistency across sessions.

Immediately after the completion of the two-week instructional period, the post-test was administered to the same respondents. Upon retrieval, the post-test data were analyzed using the same methods as the pre-test, with frequency counts and total weighted means computed. The significant difference between the students' pre-test and post-test performances was then determined through appropriate statistical analysis.

Throughout the data collection, ethical considerations were strictly observed. All data collected were securely stored in password-protected electronic files accessible only to the researcher. Hard copies, if generated, were kept in a locked cabinet. The data were used exclusively for research purposes and will be securely destroyed after a designated retention period, in compliance with ethical research guidelines. Data recording, processing, analysis, and interpretation was also done.

Finally, the results of the study served as the foundation for developing a tool guide of best practices in the application of PBL, IBL, and Laboratory Teaching for fourth quarter Science topics. The final research paper was submitted for ethics review prior to dissemination.

Statistical Treatment of the Data

The following statistical tools were used in the study:

1. Means was used to describe the level of students'science performance before and after the application of the trimodal strategies.
2. T-test for paired samples was used to determine significant difference between the pre-test and post-test results of the students' performance.
3. The Analysis of Variance (ANOVA) was used to identify the most effective strategy in teaching the fourth quarter lessons.
4. The Cronbach Alpha Coefficient (95 percent confidence interval) was used to determine the reliability of the researcher-made test while the Content Validity Index (CVI) was computed to quantify expert agreement on item relevance.

III. RESULTS

Problem 1. What is the level of Science performance of Junior High school in Layugan Integrated School before and after the application of Project-, Inquiry-, Laboratory- Based Learning in teaching the fourth quarter lessons in Science?

A, On the Level of Science Performance of the Junior High School Grade 7 in Layugan Integrated School

Table 2a shows the level of Science Performance of the Junior High School Grade 7 in Layugan Integrated School before and after the application of the Project-based learning, Inquiry-based, Laboratory in teaching the fourth quarter lessons in science.

It can be noted in the table that the overall pre-test mean is 68.00 which fell under the DNME (Did Not Meet Expectation) rating, however, after the application of the three various

Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
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strategies namely Inquiry-Based Learning, Project-Based Learning, and Laboratory-Based Learning, the result of the post-test mean increased to 77.13 which means "Fairly Satisfactory".

This implies that the use of Inquiry-Based Learning effectively enhanced students' understanding of geological faults and earthquake-related concepts. Clearly, IBL encouraged students to actively explore and question real- world processes specifically geological such as fault classification, how earthquakes are formed, and risk evaluations using tolls such as PHILVOCS fault finders. Rather than merely receiving information, the students were able to construct their understanding through collaborative discussions and data interpretation.

Table 2a Level of Science Performance of the Junior High School Grade 7 in Layugan Integrated School

Learning Competencies (LC)	Mean Pre-test Scores	DR	Strategy Applied	Mean Post-test Scores	DR
LC1. *Classify geological faults according to angle of the fault plane and direction of slip*	68.17	DNME	*IBL*	79.63	FS
LC2. *Use models or illustrations to explain how movements of faults are generate earthquakes and identify and explain which type of faults are most likely to occur in the Philippines and explain why.*	70.73	DNME	*IBL*	79.30	FS
LC3. *Describe how the effects of earthquakes on communities depend on their magnitude*	68.87	DNME	*IBL*	79.53	FS
LC4. *Use the PHIVOLCS fault finder or other reliable information source to identify where the nearest fault system is located from their community and assess the risk of earthquakes to their community*	71.13	DNME	*IBL*	81.30	S
LC5. *Make models of fault to illustrate a) the epicenter from its focus, b) the intensity of an earthquake from its magnitude, c) how underwater earthquakes may or may not generate tsunami*	71.00	DNME	*PBL*	80.30	S
LC6. *Refer to local disaster readiness plans to demonstrate what to do before during and after earthquake*	68.20	DNME	*PBL*	75.60	FS
LC7. *Explain how earthquakes result in tsunamis that devastate shoreline communities*	66.97	DNME	*PBL*	72.83	DNME
LC8. *Describe procedures that the authorities have in place to alert communities of pending tsunamis and what procedures can be implemented should a tsunami impact on a community*	69.23	DNME	*PBL*	76.27	FS
LC9. *Explain how energy from the Sun interacts with the atmosphere*	68.20	DNME	*LBL*	83.30	S
LC10. *Make a physical model or use drawings to demonstrate the tilt of the Earth relative to its orbits around the Sun affect the intensity of sunlight absorbed by different areas of Earth over a year.*	68.17	DNME	*LBL*	87.93	VS
LC11. *Explain using models how the tilt of the Earth affects the changes in the length of daytime at different times of the year*	65.80	DNME	*LBL*	77.63	FS
LC12. *Explain how solar energy contributes to the occurrence of land and sea breezes, seasons, and the ITCZ.*	66.70	DNME	*LBL*	78.23	FS
Overall	68.00	DNME		77.13	FS

Percentile Score	**Descriptive Rating (DR)**
90-100	Outstanding (O)

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Volume 2 Issue 5 (2026)

85-89	Very Satisfactory (VS)
80-84	Satisfactory (S)
75-79	Fairly Satisfactory (FS)
Below 75	Did Not Meet Expectation (DNME)

Such result for the application of Inquiry-Based Learning can be corroborated with the study by Capinig (2019), which statistically sowed that there was an improvement in the Earth Science performance of Grade 11 students as the intervention focused on learner-centered strategies that promoted the students to investigate concepts through guided activities and teacher facilitation. It also highlighted that IBL encourages better retention and comprehension of abstract scientific topics by allowing students to explore and experience concepts themselves rather than purely memorizing facts.

In addition, in the quasi-experimental study of Jacalan & Castillo (2023), they concluded that the interactive and exploratory nature of the IBL promotes students' better engagement with the lessons and deeper understanding of concepts. Similarly, the study by Aksa (2021) emphasized that through inquiry, students developed the ability to formulate questions, investigate, gather and analyze data, and make evidence-based conclusions.

Meanwhile, Project-Based Learning was used for Learning Competencies 5-8 (LC5. Make models of fault to illustrate a) the epicenter of the earthquake from its focus, b) the intensity from its magnitude, c) how underwater earthquakes may or may not generate tsunami; LC6. Refer to local disaster readiness plan to demonstrate what to do before, during and after earthquake; LC7. Explain how earthquakes result in tsunamis that devastate shoreline communities; and LC8. Describe procedures that the authorities have in place to alert communities of pending tsunamis and what procedures can be implemented should a tsunami impact on a community covered hands-on applications such as creating models of faults and exploring disaster preparedness. With these competencies, students got a pre-test score of 71.00 (DNEM), 68.20 (DNME), 66.97 (DNME), and 69.23 (DNME) before the application of the strategies; however, for the post-test mean which was done after the application of the strategy, there was an enhancement on the scores 80.30 (S), 75.60 (DNEM), and 76.27 (FS), respectively.

As for the Learning Competencies 9 to 12 (LC9. Explain how energy from the Sun interacts with the atmosphere; LC10. Make a physical model or use drawings to demonstrate the tilt of the Earth relative to its orbits around the Sun affect the intensity of sunlight absorbed by different areas of Earth over a year; LC11. Explain using models, how the tilt of the Earth affects the changes in the length of daytime at different times of the year; and LC12. Explain how solar energy contributes to the occurrence of land and sea breezes, seasons, and the ITCZ.) wherein the Laboratory-Based Learning was used to teach solar energy, Earth's tilt, and related atmospheric phenomena. Pre-test mean scores were 68.20 (DNME), 68.17 (DNME), 65.80 (DNME), and 66.70 (DNME). Post-test scores, however, significantly improved to 83.30 (S) , 87.93 (VS), 77.63 (FS) , and 78.23, respectively.

The prior results imply that the application of active learning strategies such as Inquiry-Based, Project-Based, and Laboratory-Based Learning resulted in notable improvements in student performance across all targeted Science competencies. The greatest gains were observed in the Laboratory-Based Learning, suggesting that hands-on experimentation may be the most effective approach for topic involving Earth and space science concepts.

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Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
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Such implication can be corroborated with the quasi-experimental study of Sy et al (2022), which found that students who engaged in activity-based learning not only acquired a deeper understanding of scientific concepts, such as plate tectonics, earthquakes, and climate systems, but also developed better critical thinking and application skills. Sy also concluded that the integration of active learning techniques in science instruction helps address different learning styles, promotes clarity of concepts, and improves both academic performance and classroom dynamics.

Furthermore, Kilag et al. (2024) conducted a study that explored the integration of technology-enhanced laboratory activities in science instruction. These activities enabled students to collect, analyze, and interpret data in real-time, thereby fostering a more dynamic and interactive learning environment. The approach sought to move beyond conventional laboratory exercises by incorporating technological tools such as digital sensors, data logging software, and interactive simulations. Findings from the study revealed that students who participated in these enhanced laboratory sessions exhibited notable improvements in critical thinking and problem-solving skills. The real-time engagement with data allowed learners to formulate hypotheses, perform varied experiments, and draw evidence-based conclusions with greater accuracy and depth. This study underscores the potential of technology-driven laboratory instruction in enhancing scientific inquiry and learner autonomy.

Moreover, according to the study by Kandamy (2019), on engineering students, laboratory practical in such field is an appropriate tool for teaching theories and demonstrate them for finding properties and selecting correct material or methods in such application. Thus, it was suggested that laboratory work is well articulated as it is a place to learn new and developing subject matter as well as insight and understanding of the real world.

B. On the Level of Science Performance of the Junior High School Grade 8 in Layugan Integrated School

Table 2b shows the level of Science Performance of the Junior High School Grade 8 in Layugan Integrated School before and after the application of the Project-based learning, Inquiry-based, Laboratory in teaching the fourth quarter lessons in science.

Table 2b Level of Science Performance of the Junior High School Grade 8 in Layugan Integrated School

Learning Competencies (LC)	Mean Pre-test Scores	DR	Strategy Applied	Mean Post-test Scores	DR
LC1. *Explain ingestion, absorption, assimilation, and excretion*	66.27	DNME	*Inquiry-Based Learning*	79.73	FS
LC2. *Compare mitosis and meiosis, and their role in the cell -division cycle*	70.33	DNME	*Inquiry-Based Learning*	81.90	S
LC3. *Predict phenotypic expressions of traits following simple patterns of inheritance*	67.37	DNME	*Inquiry-Based Learning*	75.83	FS
LC4. *Explain the concept of a species*	70.27	DNME	*Project-Based Learning*	85.33	VS
LC5. *Classify organisms using the hierarchical taxonomic system*	68.47	DNME	*Project-Based Learning*	80.80	S
LC6. *Explain the advantage of high biodiversity in maintaining the stability of an ecosystem*	75.10	FS	*Project-Based Learning*	84.33	S
LC7. *Analyze the roles of organisms in the*	71.93	DNME	*Laboratory-Based Learning*	83.93	S

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cycling of materials					
LC8. *Explain how materials cycle in an ecosystem*	68.73	DNME	*Laboratory-Based Learning*	80.53	S
LC9. *Suggest ways to minimize human impact on the environment*	72.57	DNME	*Laboratory-Based Learning*	91.20	O
Overall	69.40	DNME		81.47	S

Percentile Score	**Descriptive Rating (DR)**
90-100	Outstanding (O)
85-89	Very Satisfactory (VS)
80-84	Satisfactory (S)
75-79	Fairly Satisfactory (FS)
Below 75	Did Not Meet Expectation (DNME)

It can be seen that the pre-test average score was 69.40, which falls under the "Did Not Meet Expectations" (DNME) category, however, after the implementation of the learning strategies, the post-test average score rose to 81.47 which falls under the description "Satisfactory". This implies that the implemented learning strategies had a positive and meaningful impact on students' academic performance.

Categorically, for Learning Competencies 1 to 3 (LC1. Explain ingestion, absorption, assimilation, and excretion; LC2. Compare mitosis and meiosis, and their role in the cell - division cycle; and LC3. Predict phenotypic expressions of traits following simple patterns of inheritance) where Inquiry-Based Learning was applied, the pre-test score ranged from 66.27, 70.73, and 67.37, all fell under the DNME category respectively; however, with the application of the IBL, the post-test score of the respondents ranged from 79.73 (Fairly Satisfactory), 81.90 (Satisfactory), and 75.83 (Fairly Satisfactory). Meanwhile, the Learning Competencies 4-6 (LC4. Explain the concept of a species; LC5. Classify organisms using the hierarchical taxonomic system; and LC6. Explain the advantage of high biodiversity in maintaining the stability of an ecosystem) wherein Project-Based Learning was applied, the pre-test score ranged from 70.27 (DNME), 68.47 (DNME), and 75.10 (FS), however, after the application of the PBL, the post-test scores showed a difference in the mean score which is 85.33 (Very Satisfactory), 80.80 (S), and 84.33 (S), respectively.

As for Learning Competencies 7 to 9 (LC7. Analyze the roles of organisms in the cycling of materials; LC8. Explain how materials cycle in an ecosystem; and LC9. Suggest ways to minimize human impact on the environment) the pre-test scores ranged from 71.93 (DNME), 68.73 (DNME), and 72.57 (DNME) to the post-test scores of 83.93 (S), 80.53 (S), and 91.20 (Outstanding) after the application of Laboratory-Based Learning. The results imply that integrating IBL, PBL, and laboratory into science instruction significantly enhances student performance by promoting deeper understanding, engagement, and critical thinking across diverse learning competencies.

The implication of the study aligns closely with various research such as the stud by Artayasa et al (2017), which found that IBL significantly enhances students' understanding of scientific concepts by placing them at the center of the learning process. Unlike traditional, lecture-based instruction, IBL requires students to engage actively with content through observation, questioning, data collection, and analysis. This process fosters the development of scientific process skills**,** such as formulating hypotheses, designing and conducting experiments, analyzing data, and drawing evidence-based conclusions. These skills are essential not only for academic success in science but also for developing critical thinking abilities that students can apply in real-world situations. The study further revealed that students exposed to IBL exhibited greater retention of concepts and were more capable of applying their knowledge in unfamiliar contexts—an indication of deeper cognitive processing.

Similarly, Zion & Mendelovici (2021), emphasized that the exploratory nature of IBL cultivates a learning environment that encourages curiosity, autonomy, and sustained engagement. When students are given the opportunity to pose their own questions and pursue answers independently or collaboratively, their intrinsic motivation increases. This sense of ownership over learning motivates them to go beyond surface-level memorization and engage in meaningful inquiry. These findings support the assertion that IBL is particularly effective for topics that require abstract reasoning and active exploration, such as those found in life and environmental sciences.

Meanwhile, Krajcik et al (2021), conducted a study focused on the Multiple Literacy in Project-Based Learning (ML-PBL) program, which was designed to enhance student engagement and achievement through a hands-on, project-oriented approach to science education. The research involved elementary students and aimed to measure the impact of PBL on their science learning outcomes. One of the key findings from the study was that students who participated in the ML-PBL program showed significant gains in science achievement compared to their peers. On the science assessments, these students outperformed others by 8 percentage points, indicating that the project-based approach helped them better grasp and apply scientific concepts. The study also suggests that engaging students in real-world, inquiry-driven projects allows them to explore scientific content in a deeper and more meaningful way, thereby improving their understanding and retention of the material.

Supporting this study is the meta-analysis by Balemen & Keskin (2018), which found out the large effect size associated with PBL, which was calculated to be 1.063 or 86 percent more effective than traditional methods in improving students' science learning outcomes. The analysis also highlighted that the effectiveness of PBL was observed across **various subjects and educational levels**, not just limited to science education. This suggests that the benefits of PBL extend beyond the science classroom and can be applied to a wide range of disciplines, making it a versatile teaching approach.

As for the affirmation of the significance of Laboratory-Based Learning, a 2023 study by Kolil et al, revealed that virtual laboratories, when designed with interactive elements, improved both intrinsic and extrinsic motivation among students. The study also indicated that performing virtual laboratory experiments for longer duration or multiple times positively influenced students' laboratory performance.

Furthermore, the study by Hofstein & Lunetta (2019), emphasized that LBL especially when it involves active student participation in manipulating variables and observing outcomes, plays a pivotal role in enhancing motivation and developing scientific reasoning skills.

Problem 2. Is there a significant difference between the level of science performance of Junior High school in Layugan Integrated School before and after the trimodal strategies?

A. On the Significant Differences between the Grade 7 Science Performance Pre-test Scores and the Post-Test Scores

Figure 3 explains the significant difference between the Science performance of the Grade 7 students in their pre-test and the post-test scores before and after the trimodal strategies.

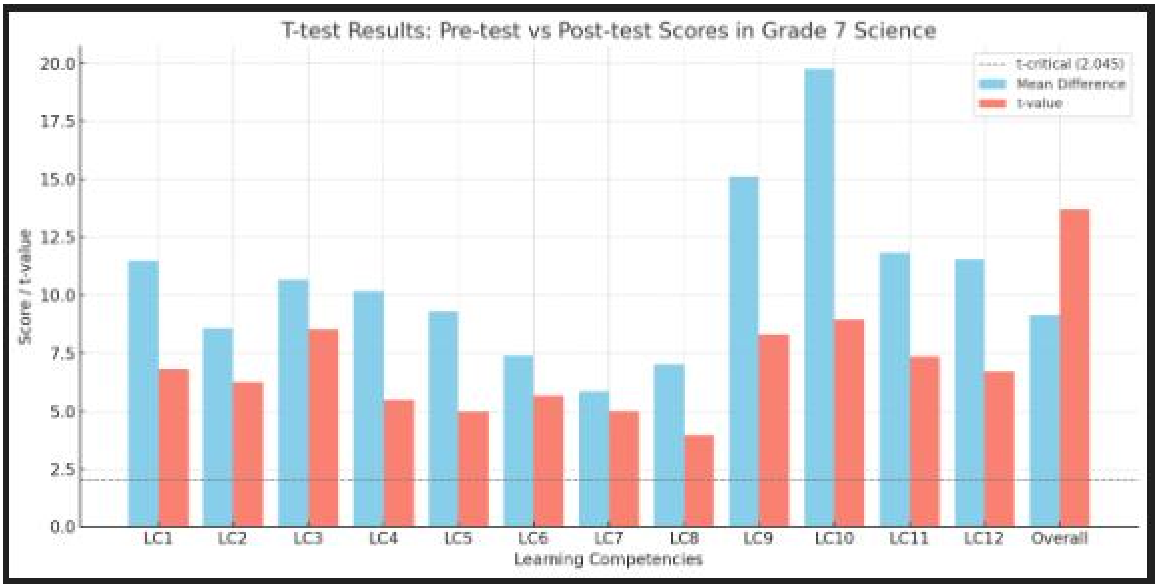

Figure 3. T-test Result on the Significant Differences between the Grade 7 Science Performance Pre-test Scores and the Post-Test Scores

It can be noted that the overall mean difference is 9.13 and a t-value of 13.686. In addition, all (12) twelve learning competencies exhibited substantial differences between the pre-test and post-test scores, with t-values greater than that of the critical value of 2.045 and p-value less than 0.01. Specifically, LC 9 and 10 show the highest mean differences of 15.15 and 19.77, respectively. Such statistical result revealed an immense improvement in student performance after the application of the trimodal strategies. Each strategies contributed uniquely as IBL fostered curiosity critical thinking, and exploration of real-world problems; PBL encouraged students to be creative, collaborate, and have deeper engagement with applied tasks; and LBL provided hands-on experiences with tangible experimentation. These strategies were particularly effective in higher-order thinking skills, as seen in LC9 and LC10, which likely involved assessing community earthquake risks and interpreting the implications of seismic activity.

This result is supported by Baltazar & Mendoza (2022) quasi-experimental study which also explored the effectiveness of trimodal learning strategies. Their study revealed that the students who are exposed to such approach demonstrated significant improvements in content mastery across several learning competencies especially those requiring critical thinking, practical application, and even scientific investigation.

In another study by Aljoani (2017), who emphasized the principles of Constructivist learning, stating that inquiry-based approaches enable students to construct their own understanding of scientific concepts through active exploration and questioning. This method not only enhances critical thinking but also promotes deeper retention of knowledge, which is essential in mastering science competencies.

Additionally, Thomas (2020), in his updated synthesis of research on project-based learning reaffirmed that students who learn through PBL perform better in science assessments compared to those taught using traditional methods. The study highlighted that combining PBL with inquiry and lab activities enhances students' problem-solving abilities and conceptual understanding.

However, LC 7 (*Explain how earthquakes result in tsunamis that devastate shoreline communities)* showed the lowest mean difference of 5.87 after the application of the trimodal strategies. This low mean result compared to the other learning competencies imply that even though trimodal strategies generally improve students performance, there are certain complex or abstract topics such as te mechanism of tsunami generation due to underwater earthquakes may require more specific instructional approaches. In addition, the student had problem simulating underwater processes, especially the activities used did not adequately demonstrate the underwater dynamics or the time was not enough to have in-depth exploration.

This result is supported by Evans et al (2019) which found that students taught with interactive simulations and videos of tsunami formation performed significantly better than those taught using traditional text or lecture-based methods. They also suggested that visual reinforcements is need for mastering complex geophysical phenomena.

Such implications are supported by Ortiz & Aliazas (2021), who conducted a study titled "Multi-modal Representations Strategies in Teaching Science towards Enhancing Scientific Inquiry Skills among Grade 4". In their study, it was concluded that multimodal strategies effectively enhance both engagement and comprehension, making science more accessible and meaningful, especially for young learners who benefit from concrete and sensory-rich learning experiences. These strategies are particularly effective at transitioning learners from basic to advanced levels of understanding.

Moreover, Kokotsaki et al (2016), conducted a comprehensive literary review on PBL and concluded that it contributes substantially to student engagement, motivation, and academic achievement, particularly in STEM-related subjects. The integration of real-world tasks and collaborative problem-solving in PBL equips learners with the skills needed for both academic success and lifelong learning.

In the same vein, Yilmaz and Baydas (2017), found that laboratory-based science instruction significantly improved students' scientific process skills and positive attitudes towards science. Their research supports the idea that hands-on experimentation fosters a deeper connection between theoretical knowledge and practical application, leading to better academic outcomes.

B. On the Significant Differences between the Grade8 Science Performance Pre-test Scores and the Post-Test Scores

Figure 4 explains the significant difference between the science performance of the Grade 8 students in their pre-test and the post-test scores before and after the trimodal strategies (Inquiry-Based Learning, Project-Based Learning, and Laboratory-Based Learning). It can be seen in the figure that the overall mean difference is 12.07, with a highly significant t-value of 14.508. It can also be noted that the computed t-values across all nine learning competencies were above the critical t-value of 2.045 at the 0.01 level of significance, indicating statistically significant improvements in the science performance of Grade 8 students after the

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implementation of the trimodal strategies (Inquiry-Based, Project-Based Learning, and Laboratory-Based Learning).

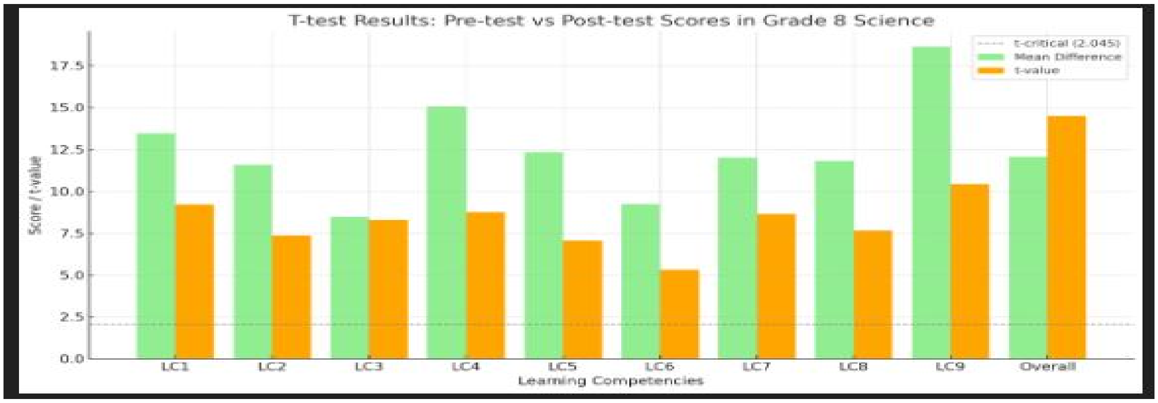

Figure 4 T-test Result on the Significant Differences between the Grade8 Science Performance Pre-test Scores and the Post-Test Score

Specifically, the mean difference ranges from 8.47 to 18.6, with Learning Competency 9 sowing the highest differences, while Learning Competency 3 got the lowest of 8.47. The following results imply that the combination of IBL, PBL, and LBI is effective in advancing students understanding and application of scientific concepts.

This implication is supported by the study of Gomez & Suarez (2020), which posits that Inquiry-Based Learning has a greater influence on students' perception and motivation, than in acquisition of scientific knowledge. Their study utilized PISA 2015 data which revealed that inquiry-based teaching methods significantly contribute to students' science achievement and the development of critical thinking abilities, even when accounting for socioeconomic factors.

In addition, the meta-analysis by Safitri (2024), found the Project-Based Learning had a substantial positive effect on students' achievements, with an average effect size of 1.12. The study even highlighted that PBL was particularly effective at elementary and high school levels, emphasizing its suitability for middle-grade learner.

Furthermore, a study by Karacalli & Korur (2019), provided evidence on the long-term academic benefits of Project-Based Learning (PBL). The hands-on experience, student-centered nature of PBL encourages active engagement and the application of concepts to real-life contexts, making the learning experience more memorable and personally relevant. The findings support the use of PBL as an effective strategy for fostering both academic achievement and lasting comprehension among junior high school learners.

Problem 3. Which among the trimodal strategies is found most effective in teaching the fourth quarter lessons in science?

Table 3 posits the significant differences of the effectivity of the tri-modal modal strategies (Inquiry-Based Learning, Project-Based Learning, and Laboratory-Based Learning) to know the most effective strategies among them.

Table 3 ANOVA Result on the Most Effective among the Trimodal Strategies (Inquiry Based, Project-Based Learning, and Laboratory-Based Learning) in Teaching the Fourth Quarter Lessons in Science

	Source of Variation	Sum of Squares	df	Mean Square	F_{Value}	Sig.
Grade 7	Strategies	560.00	2	280.000		
	Error	4919.60	87	56.547	4.952**	p<.01
	Total	5479.60	89			
Grade 8	Strategies	539.02	2	269.511		
	Error	3130.80	87	35.986	7.489**	p<.01
	Total	3669.82	89			

** significant at .01 level
* significant at .05 level

It can be noted that the ANOVA result in Table 4a shows significant difference in the effectiveness of Inquiry-Based Learning (IBL), Project-Based Learning (PBL), and Laboratory-Based Learning (LBL) in teaching the fourth-quarter science lessons in both Grade 7 ($F=4.952$, $p < .01$) and Grade 8 ($F = 7.489$, $p < .01$). This indicates that the trimodal strategies had a meaningful impact on student learning, with the effect being more pronounced in Grade 8 as shown by a higher F-value and a lower error variance. These findings imply that the integration of active, student-centered strategies fosters deeper understanding and improved academic outcomes in science education, particularly as learners advance in grade level.

Such implication is supported by Pundak & Rozner (2018), who highlighted that Inquiry-Based Learning promotes critical thinking and scientific reasoning, leading to improved student performance and motivation in science subjects. Similarly, Holbrook & Rannikmae (2020), emphasized the benefits of Project-Based Learning in enhancing students' ability to apply knowledge and collaborate effectively. They found that PBL boosts students' conceptual understanding, particularly when lessons are context-rich and aligned with real-world problems noted as a key characteristic also observed in this study's implementation of PBL in science lessons.

Meanwhile, Yusuf and Faize (2021), conducted an experimental study showing that students who engaged in hands-on laboratory work performed significantly better on science assessments than those who received traditional lecture-based instruction.

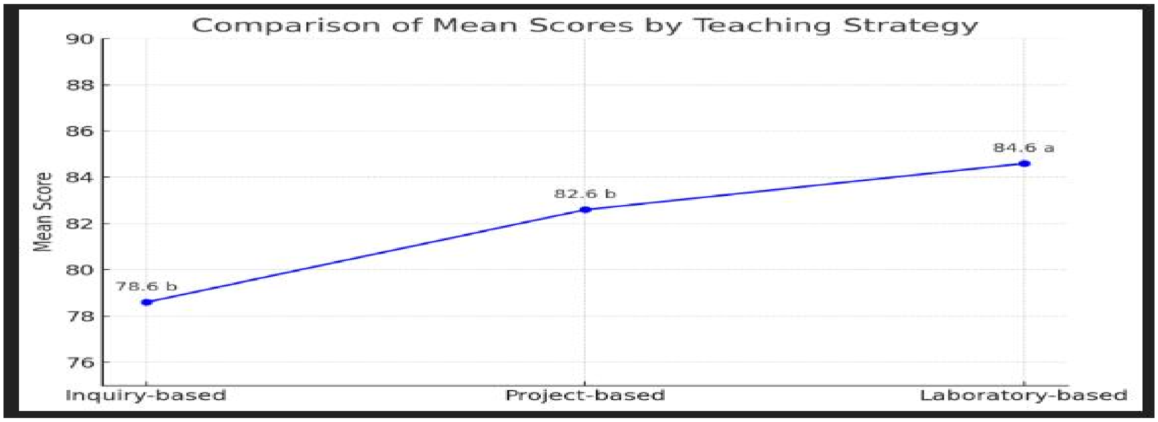

Figure 5 Post-Hoc Test Result on the Significant Differences between the Science Performance Score and the Strategies Applied (Grade 7)

It can be seen that students who experienced Laboratory-Based Learning achieved the highest mean score of 84.60, followed by those under Project-Based Learning with 82.60, and Inquiry-Based Learning with the lowest mean score of 78.60. The notation of letters indicates statistical significance; specifically, Laboratory-Based Learning (denoted with "a") was significantly more effective than Inquiry-Based Learning (denoted with "b"), while Project-Based Learning (with "ab") did not differ significantly from either, placing it in an intermediate position. These results imply that Laboratory-Based Learning is the most effective of the three strategies for improving science performance among Grade 7 learners. The hands-on and experiential nature of LBL may have contributed to students' better engagement, clearer conceptual understanding, and stronger retention of the fourth-quarter science topics.

Such result was reflected in the response of a student-respondent as he mentioned, "*Para sa akin, mas mahirap ang Project-Based learning kasi matagal gawin ang mga project at minsan nalilito kami kung ano talaga ang kailangan, Hindi rin lahat sa grupo ay tumutulong kaya mas mahirap matuto kumapara sa laboratory na malinaw ang gagawing hakbang at may nakagabay po, sir (*For me, Project-Based Learning is harder because the projects take a long time to finish, and sometimes we get confused about what's really required. Not everyone in the group helps out, so it's harder to learn compared to laboratory activities where the steps are clear and there's someone guiding us, sir.)"

According to Yusuf and Faize (2021), Laboratory-Based Learning allows students to interact directly with scientific materials and phenomena, thereby improving comprehension and performance. Their experimental study concluded that laboratory activities are particularly effective in teaching abstract and practical concepts, as students are able to see and manipulate the variables being studied. In contrast, Pundak and Rozner (2018) highlighted the strengths of Inquiry-Based Learning in fostering curiosity and scientific thinking; however, they noted that IBL may pose challenges for younger learners due to its demand for higher levels of independence and critical reasoning.

Supporting this further, Reyes & Dela Cruz (2023), conducted a comparative study in junior high science classrooms and found that Laboratory-Based Learning yielded the highest learning gains among lower secondary students, especially in content-heavy and concrete topics like those in Earth and Physical Science.

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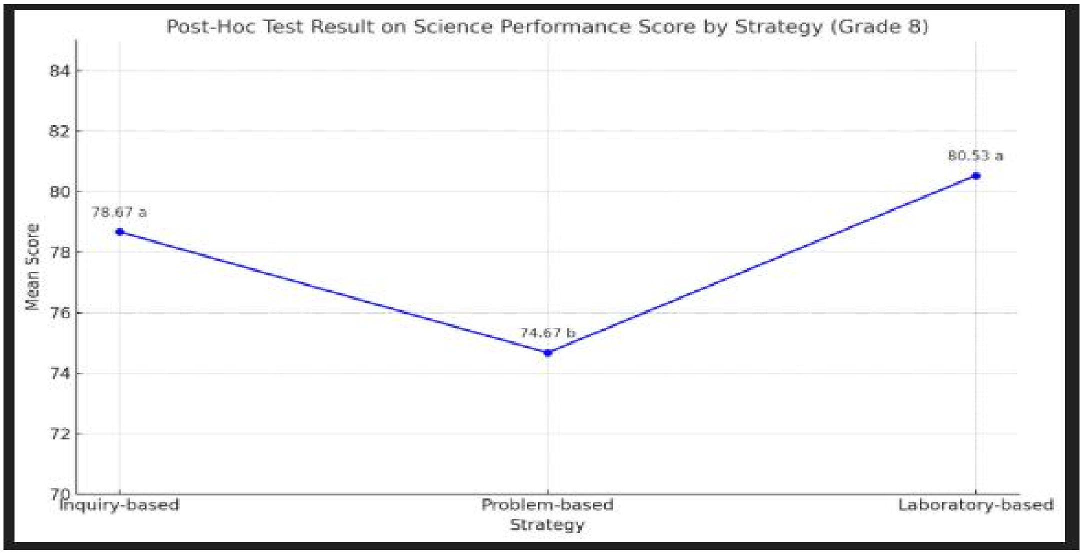

Figure 6. Post-Hoc Test Result on the Significant Differences between the Science Performance Score and the Strategies Applied (Grade 8)

It can be seen that Laboratory-based strategy yielded the highest mean score of 80.53, followed by Inquiry-based with 78.67, and lastly Project-based with 74.67. Based on the notation, Inquiry-based and Laboratory-based strategies do not significantly differ from each other, as they are both marked “a”, however, both are significantly better than the Project-based strategy which was marked “b”. The results imply that Laboratory-based and Inquiry-based strategies are more effective in enhancing Grade 8 students’ science performance compared to project-based learning.

This implication can be corroborated with the study conducted by Lee et al (2018), which found that students who engaged in both lectures and laboratory sessions achieved better academic results compared to those who only attended lectures. Specifically, laboratory participants excelled in skills such as classification, essay writing, and research proposal development. This suggests that Laboratory-Based Learning (LBL) provides students with opportunities to apply theoretical knowledge practically, thereby deepening their understanding and sharpening higher-order thinking skills. The laboratory setting allowed students to explore hands-on concepts, leading to improved cognitive and academic performance.

In the same vine, a research article published in Chemistry Education Research and Practic*e* (2016) also emphasized the importance of social interaction during laboratory activities. Drawing on social constructivist theory, it concluded that laboratories allow students to construct scientific knowledge collaboratively. Rather than passively receiving information, students actively engage in inquiry, discussion, and problem-solving with peers and instructors. These dynamic interactions evidently make learning more meaningful and lead to a deeper grasp of scientific concepts, which is more effective than passive learning modes like lectures.

Same idea was established by an article published in Web of Synergy (2023) which explained that modern laboratories now integrate innovative technologies, such as simulations and virtual labs, which not only engage students but also provide authentic scientific experiences. By manipulating real or simulated materials, students develop stronger analytical and evaluative skills, making them better prepared for complex scientific challenges. Laboratory experience fosters an active learning environment that improves both conceptual understanding and practical application.

Problem 4. What tool guide can be recommended based on the result of the study?

With the salient findings that the Laboratory-Based strategy was the most effective learning strategy in terms of Science teaching-learning, the tool guide that was recommended are the Grade 7 and Grade 8 Laboratory Manuals.

According to Kumar (2025), a tool guide in research refers to a document, resources, or manual that explains how to effectively use a particular research tool or instrument. It often includes step-by-step instructions, descriptions of components, guidelines for implementation, and sometimes validation data or usage scenarios.

Meanwhile, based on Yildiz & Ergin (2017) tool guides aimed to fill the gap in available resources for science teachers to facilitate such activities. It focuses on materials aligned with learning outcomes of specific grade levels.

IV. DISCUSSIONS

1. For the level of Science performance of the Junior High School Grade 7 in Layugan Integrated School, the overall pre-test mean is 68.00 which fell under the DNME rating, however, after the application of the three various strategies namely Inquiry-Based Learning, Project-Based Learning, and Laboratory-Based Learning, the result of the post-test mean went high to 77.13 which means "Fairly Satisfactory". Specifically, Learning Competencies 1 to 4, which focus on understanding geological faults and earthquake-related phenomena and was taught using the Inquiry-Based Learning. In the pre-test, the students scored 68.17 (DNME), 70.73 (DNME), and 68.87 (DNME); however, after the implementation of the IBL, scores improved to 79.30 (FS), 80.30 (S), and 75.60 (FS), respectively. Meanwhile, Project-Based Learning was used for Learning Competencies 5-8, covered hands-on applications such as creating models of faults and exploring disaster preparedness. With these competencies, students got a pre-test score of 71.00 (DNME), 68.20 (DNME), and 66.97 (DNME) before the application of the strategies; however, for the post-test mean which was done after the application of the strategy, there was an enhancement on the scores 80.30 (S), 75.60 (FS), 72.83 (DNME), and 76.27 (FS), respectively. As for the Learning Competencies 9 to 12, wherein the Laboratory-Based Learning was used to teach solar energy, Earth's tilt, and related atmospheric phenomena. Pre-test mean scores were 68.20 (DNME), 68.17 (DNME), 65.80 (DNME), and 66.70 (DNME). Post-test scores, however, significantly improved to 83.30 (S), 87.93 (VS), 77.63 (FS) and 78.23, respectively

2. For the level of science performance of the Junior High School Grade 8 in Layugan Integrated School, the pre-test average score was 69.40, which falls under the "Did Not Meet Expectations" (DNME) category, however, after the implementation of the learning strategies, the post-test average score rose to 81.47 which falls under the description of "Satisfactory". Categorically, for Learning Competencies 1 to 3 where Inquiry-Based Learning was applied, the pre-test score ranged from 66.27, 70.73, and 67.37, all fell under the DNME category respectively; however, with the application of the IBL, the post-test score of the respondents ranged from 79.73 (Fairly Satisfactory), 81.90 (Satisfactory), and 75.83 (Fairly Satisfactory). Meanwhile, the Learning Competencies 4-6 wherein Project-Based Learning was applied, the

pre-test score ranged from 70.27 (DNME), 68.47 (DNME), and 75.10 (FS), however, after the application of the PBL, the post-test scores showed a difference in the mean score which is 85.33 (Very Satisfactory), 80.80 (S), and 84.33 (S), respectively. As for Learning Competencies 7 to 9, the pre-test scores ranged from 71.93 (DNME), 68.73 (DNME), and 72.57 (DNME) to the post-test scores of 83.93 (S), 80.53 (S), and 91.20 (Outstanding) after the application of the Laboratory-Based Learning.

3. The result for the significant difference between the Science performance of the Grade 7 students in their pre-test and the post-test scores before and after the trimodal strategies showed that the overall mean difference is 9.13 and a t-value of 13.686. In addition, all (12) twelve learning competencies exhibit substantial differences between the pre-test and post-test scores, with t-values greater than that of the critical value of 2.045 and p-value less than 0.01. Specifically, LC 9 and 10 show the highest mean differences of 15.15 and 19.77, respectively.

4. The overall mean difference for the level of science performance of the Grade 8 students before and after the application of the trimodal strategies is 12.07, with a highly significant t-value of 14.508. It can also be noted that the computed t-values across all nine learning competencies are above the critical t-value of 2.045 at the 0.01 level of significance, indicating statistically significant improvements in the science performance of Grade 8 students after the implementation of the trimodal strategies (Inquiry-Based, Project-Based Learning, and Laboratory-Based Learning). Specifically, the mean difference ranged from 8.47 to 18.6, with Learning Competency 9 sowing the highest differences.

5. As for the most effective strategy, the Laboratory-Based Learning yielded the highest mean performance score (84.60) in both grade levels. Inquiry-Based Learning recorded the lowest mean score (78.60), while Project-Based Learning (82.60) performed in between the two but was not significantly different from either.

6. Students who experienced Laboratory-Based Learning achieved the highest mean score of 84.60, followed by those under Project-Based Learning with 82.60, and Inquiry-Based Learning with the lowest mean score of 78.60. The notation of letters indicates statistical significance; specifically, Laboratory-Based Learning (denoted with "a") was significantly more effective than Inquiry-Based Learning (denoted with "b"), while Project-Based Learning (with "ab") did not differ significantly from either, placing it in an intermediate position.

7. Finally, the post-hoc test results further showed that Laboratory-Based Learning yielded the highest mean performance score (84.60) in both grade levels, indicating it as the most effective strategy. Inquiry-Based Learning recorded the lowest mean score (78.60), while Project-Based Learning (82.60) performed in between the two but was not significantly different from either.

Conclusion

Based on the comprehensive findings of the study, the following conclusions were drawn:

1. The application of active learning strategies such as Inquiry-Based, Project-Based, and Laboratory-Based Learning resulted in notable improvements in Grade 7 students' performance across all targeted Science competencies. The greatest gains were observed in Laboratory-Based Learning, suggesting that hands-on experimentation may be the most effective approach for topics involving Earth and space science concepts.

2. Integrating PBL, IBL, and into science instruction significantly enhances student performance by promoting deeper understanding, engagement, and critical thinking across diverse learning competencies of the Grade 8 students.

3. There is a significant difference between the Science performance of the Grade 7 students after the application of the trimodal strategies (Inquiry-based learning, Project-based learning, and Laboratory-based learning).

4. There is a significant difference between the Science performance of the Grade 8 students after the application of the trimodal strategies (Inquiry-based learning, Project-based learning, and Laboratory-based learning).

5. Laboratory-Based Learning is the most effective of the three strategies for improving Science performance of the respondents. The hands-on and experiential nature of LBL may have contributed to students' better engagement, clearer conceptual understanding, and stronger retention of the fourth-quarter science topics.

Recommendations:

Based on the salient findings and conclusions, the following recommendations were drawn:

1. Given the notable improvements in student performance through Inquiry-Based Learning (IBL), Project-Based Learning (PBL), and especially Laboratory-Based Learning (LBL), teachers may continuously integrate these strategies across the Science curriculum.

2. With the effectiveness of the Laboratory-based learning strategy, there is now a need for proper planning and support to solve problems such as lack of laboratory equipment and safety concerns.

3. The output of the study which is the Laboratory Manuals for Grade 7 and 8 Fourth Quarter Science may be adopted and utilized as supplementary instructional materials in science classes.

4. Inputs and other laboratory-based activities for the first to the third quarter of the Grade 7 and 8 curriculums can be added in the manual.

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