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# Science Performance of Junior High School Using Trimodal Strategies: A Vital Factor in Shaping Science Education Among Students

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**Abstract**

Science education is vital in shaping students' critical thinking, problem-solving, and scientific literacy. At Alfredo D. Bersamina National High School, many students find science concepts challenging due to traditional, teacher-centered teaching methods that limit engagement and active learning. To address these gaps, student-centered approaches such as Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory-Based Learning (LBL) were examined.

The research investigates the effectiveness of Project-Based Learning, Inquiry-Based Learning, and Laboratory-Based Learning in enhancing the science performance of Junior High School students at Alfredo D. Bersamina National High School. Specifically, it looked into the level of science performance of Junior High School before and after the application of Project-Based Learning, Inquiry-Based Learning, Laboratory-Based Learning in teaching science; the significant difference between the level of science performance before and after the application of the most effective teaching strategies in teaching science and recommended a tool guide to improve performance.

The study used validated, teacher-made test instruments for data collection, which were statistically analyzed using weighted mean, t-Test, and ANOVA.

Results showed that the Post-test scores improved by an average of 10.5 points across all strategies. In addition, the data revealed that student-centered learning approaches significantly improved Junior High School students' science performance, with Inquiry-Based Learning and Laboratory-Based Learning proving to be the most effective.

Thus, in the end, it recommends integrating Inquiry-Based Learning and Laboratory-Based Learning with collaborative and interactive strategies, as well as using the 5E Model Frameworks and Laboratory Manual to support scientific inquiry. It is also suggested enhancing Project-Based Learning with inquiry-driven activities and encourages future research to explore additional factors for a more comprehensive understanding.

**Keywords:** *Inquiry-Based Learning, Laboratory-Based Learning, Project-based Learning, Science Education, Student-Centered Learning, weighted mean, t-Test, and ANOVA.*

# I. INTRODUCTION

Science education plays a crucial role in developing students' critical thinking, problem-solving, and scientific literacy. At Alfredo D. Bersamina National High School, students often struggle with science concepts due to traditional, teacher-centered methods that limit engagement. Student-centered strategies like Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory-Based Learning (LBL) encourage active participation, collaboration, and hands-on exploration, which have been shown to improve understanding and performance. This study aims to evaluate these strategies' effectiveness in enhancing science learning and to identify the most impactful approaches for Junior High School students.

**The Project-Based Learning (PBL)** strategy engages students in solving real-world problems, promoting collaboration, critical thinking, and practical application of knowledge. Meanwhile, **Inquiry-Based Learning (IBL)** focuses on students actively investigating questions and constructing understanding, improving curiosity, motivation, and scientific achievement. As for the **Laboratory-Based Learning (LBL)** uses hands-on experiments to reinforce theoretical concepts, enhancing problem-solving skills and comprehension.

Research shows that combining these student-centered strategies with interactive methods, such as the 5E Model Framework, supports scientific inquiry and deeper learning, leading to better academic performance. This study investigated the effectiveness of Project-Based Learning, Inquiry-Based Learning, and Laboratory-Based Learning in improving the science performance of Junior High School students at Alfredo D. Bersamina National High School. Specifically, it aimed to determine the level of students' science performance before and after the application of these teaching strategies, identify which approach was most effective, and examine whether there was a significant difference between pre-test and post-test scores. Furthermore, the study aimed to recommend tools and strategies that could support and enhance science learning based on the findings.

The study hypothesized that there was no significant change in the science performance of Junior High School students at Alfredo D. Bersamina National High School before and after the implementation of Project-Based Learning, Inquiry-Based Learning, and Laboratory-Based Learning. It also hypothesized that there were no significant differences in science performance as influenced by the three teaching strategies.

# II. MATERIALS and METHODS

## Research Design

The researcher employed an experimental pre-test and post-test design to examine the effects of Project-Based, Inquiry-Based, and Laboratory-Based Learning on students' science performance. A quasi-experimental design was not used, as the study involved a single group of respondents exposed to different instructional strategies.

## Participants

The chosen respondents were the 29 Grade 7 students and 33 Grade 8 students from Alfredo D. Bersamina National High School throughout the 2024–2025 academic year.

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**Instruments**

The researcher developed a 30-item pre-test and post-test to assess the impact of Project-Based, Inquiry-Based, and Laboratory-Based Learning on students' science performance. The pre-test measured baseline knowledge, while the post-test evaluated changes in understanding after the implementation of these strategies, showing their effect on improving student performance.

**Procedure**

The data collection was conducted in the fourth quarter of the 2024–2025 school year to assess the effects of Project-Based, Inquiry-Based, and Laboratory-Based Learning on Grade 7 and 8 students' science performance at Alfredo D. Bersamina National High School. A 30-item pre-test, validated for reliability, established baseline performance. The teacher-researcher then implemented the three instructional strategies, ensuring consistent instruction. After the intervention, a 30-item post-test measured students' progress and allowed comparison with pre-test results. Quantitative data were analyzed statistically to evaluate the effectiveness of the strategies, providing insights for developing a 5E Framework for Grade 7 and a Laboratory Manual for Grade 8.

**Data Analysis**

Frequency counts and weighted means assessed student performance, while t-tests determined significant differences before and after the intervention. ANOVA compared performances across Grades 7 and 8, with post hoc tests identifying specific group differences. The reliability of the test was confirmed using Cronbach's Alpha (95% CI), and the Content Validity Index (CVI) measured expert agreement on item relevance.

## III. RESULTS and DISCUSSION

**Table 1.1 Level of Science Performance of the Junior High School Grade 7 in ADBNHS**

| 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 | 80.31 | S | Inquiry-Based Learning | 92.03 | O |
| 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. | 78.55 | FS | Inquiry-Based Learning | 91.52 | O |
| LC3. Describe how the effects of | 78.55 | FS | Inquiry- | 90.90 | O |

| | | | | | |
|---|---|---|---|---|---|
| earthquakes on communities depend on their magnitude | | | Based Learning | | |
| 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 | 78.90 | FS | Inquiry-Based Learning | 89.76 | VS |
| 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 | 77.72 | FS | Project-Based Learning | 86.66 | VS |
| LC6. Refer to local disaster readiness plans to demonstrate what to do before during and after earthquake | 76.97 | FS | Project-Based Learning | 81.86 | S |
| LC7. Explain how earthquakes result in tsunamis that devastate shoreline communities | 77.79 | FS | Project-Based Learning | 83.69 | S |
| 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 | 80.90 | S | Project-Based Learning | 93.94 | O |
| LC9. Explain how energy from the Sun interacts with the atmosphere | 80.10 | S | Laboratory-Based Learning | 91.79 | O |
| 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. | 78.93 | FS | Laboratory-Based Learning | 86.62 | 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 | 78.34 | FS | Laboratory-Based Learning | 86.69 | VS |
| LC12. Explain how solar energy contributes to the occurrence of | 78.76 | FS | Laboratory-Based | 89.21 | VS |

| | | | | | |
|---|---|---|---|---|---|
| land and sea breezes, seasons, and the ITCZ. | | | Learning | | |
| Overall | 78.82 | FS | | 89.01 | VS |

| 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) |

The results showed that Grade 7 and 8 students at Alfredo D. Bersamina National High School significantly improved their science performance after the implementation of Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory-Based Learning (LBL). The mean pre-test score of Grade 7 students was 78.82 ("Fairly Satisfactory"), which increased to a post-test mean of 89.01 ("Very Satisfactory"), demonstrating an average gain of over 10 points. Competency-specific analysis revealed that IBL was highly effective for analytical and research-based skills, PBL excelled in contextual and problem-solving tasks, and LBL reinforced comprehension through hands-on experimentation. These results confirmed that integrating varied, student-centered strategies enhanced conceptual understanding, critical thinking, and engagement, supporting previous findings by Thomas (2020), Krajcik and Shin (2020), and Hofstein and Lunetta (2020).

These findings align with constructivist and experiential learning theories, which posit that knowledge is actively built through meaningful experiences and social interaction (Piaget, 1952; Vygotsky, 1978; Kolb, 1984). Prior studies also support the effectiveness of PBL, IBL, and LBL in improving scientific literacy, motivation, and collaborative skills (Bell et al., 2020; Furtak et al., 2019; Minner et al., 2021). While challenges such as limited resources and large class sizes may hinder implementation (Su & Zhang, 2021; Bennett & Lubben, 2022), professional development and adequate support can mitigate these barriers. Overall, this study provides evidence that combining active, learner-centered strategies improves science performance, offering practical implications for curriculum design, teaching practices, and educational policy in the Philippine context.

**Table 1.2 Level of Science Performance of the Junior High School Grade 8 in ADBNHS**

| Learning Competencies (LC) | Mean Pre-test Scores | DR | Strategy Applied | Mean Post-test Scores | DR |
|---|---|---|---|---|---|
| LC1. Explain ingestion, absorption, assimilation, and excretion | 78.42 | FS | Inquiry-Based Learning | 90.03 | O |
| LC2. Compare mitosis and meiosis, and their role in the | 79.15 | FS | Inquiry-Based | 87.06 | VS |

| | | | | | |
|---|---|---|---|---|---|
| cell -division cycle | | | Learning | | |
| LC3. Predict phenotype expressions of traits following simple patterns of inheritance | 76.36 | FS | Inquiry-Based Learning | 89.39 | VS |
| LC4. Explain the concept of a species | 76.48 | FS | Project-Based Learning | 84.94 | S |
| LC5. Classify organisms using the hierarchical taxonomic system | 76.12 | FS | Project-Based Learning | 81.21 | S |
| LC6. Explain the advantage of high biodiversity in maintaining the stability of an ecosystem | 76.91 | FS | Project-Based Learning | 88.09 | VS |
| LC7. Analyze the roles of organisms in the cycling of materials | 75.88 | FS | Laboratory-Based Learning | 89.73 | VS |
| LC8. Explain how materials cycle in an ecosystem | 77.12 | FS | Laboratory-Based Learning | 88.73 | VS |
| LC9. Suggest ways to minimize human impact on the environment | 80.03 | S | Laboratory-Based Learning | 92.52 | O |
| Overall | 77.39 | FS | | 87.97 | VS |

| **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) |

Table 1.2 shows a marked improvement in the science performance of Grade 8 students at Alfredo D. Bersamina National High School following the implementation of Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory-Based Learning (LBL). The pre-test mean of 77.39 ("Fairly Satisfactory") increased to a post-test mean of 87.97 ("Very Satisfactory"), reflecting a gain of 10.58 points. Competency-level analysis revealed that IBL was particularly effective in clarifying complex biological concepts such as ingestion, absorption, mitosis, and inheritance, while PBL enhanced collaborative learning, critical thinking, and interdisciplinary understanding in topics like taxonomy and ecosystem stability. LBL yielded the highest gains in practical, experiment-based competencies, with LC9 reaching a post-test mean of 92.52, illustrating that hands-on engagement strengthens both conceptual understanding and higher-order cognitive skills (Hofstein & Lunetta, 2020).

These results highlight the transformative impact of student-centered methodologies, shifting from passive instruction to active engagement, exploration, and application. Each strategy demonstrated domain-specific effectiveness: IBL for foundational biological processes, PBL for systemic and conceptual tasks, and LBL for experiential and environmental learning. The study underscores the need for professional development, adequate laboratory facilities, and technology integration to sustain these improvements (Duch et al., 2019; Li et al., 2023). Overall, the findings confirm that PBL, IBL, and LBL effectively enhance student performance, engagement, and long-term comprehension in science education.

**Figure 3.1 t-Test Result on the Significant Differences Between the Grade 7 Science Performance Pre-test Scores and the Post-Test Scores**

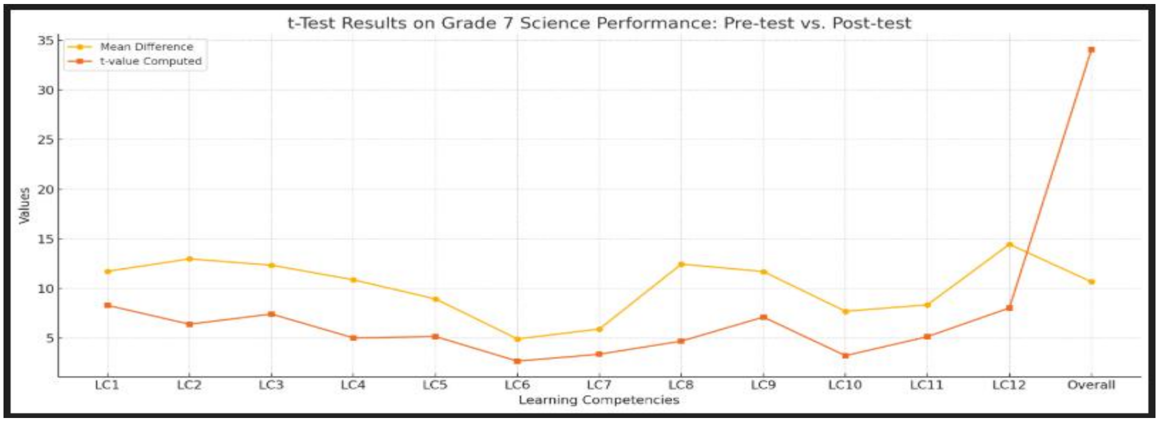


Figure 3.1 shows that the implementation of Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory-Based Learning (LBL) significantly improved Grade 8 students' science performance across all learning competencies. Mean differences between pre-test and post-test scores ranged from 4.90 to 14.45, with all t-values exceeding the critical threshold of 1.96, indicating statistical significance. Inquiry-Based Learning notably enhanced understanding of geological faults, earthquake effects, and community risk assessment, while PBL facilitated comprehension of seismic modeling, disaster preparedness, and collaborative problem-solving. Laboratory-Based Learning was particularly effective in competencies involving Earth's tilt, solar energy interactions, and weather systems, enabling students to engage directly with experiments and observations (Hofstein & Lunetta, 2020; Minner et al., 2021). Overall, the results demonstrate that these active learning strategies substantially improved comprehension, critical thinking, collaboration, and practical application of scientific concepts.

These findings align with constructivist and experiential learning theories, emphasizing that knowledge is actively built through meaningful experiences and inquiry (Piaget, 1952; Vygotsky, 1978; Kolb, 1984; Gijbels et al., 2005). Previous studies confirm that PBL, IBL, and LBL enhance engagement, conceptual understanding, and higher-order thinking (Thomas, 2020; Krajcik & Shin, 2020; Bell et al., 2020; Dori & Hameiri, 2018). The study also highlights the importance of professional development, sufficient resources, and effective implementation to maximize these methodologies' impact (Liu et al., 2020; Teng & Huang, 2022). These results

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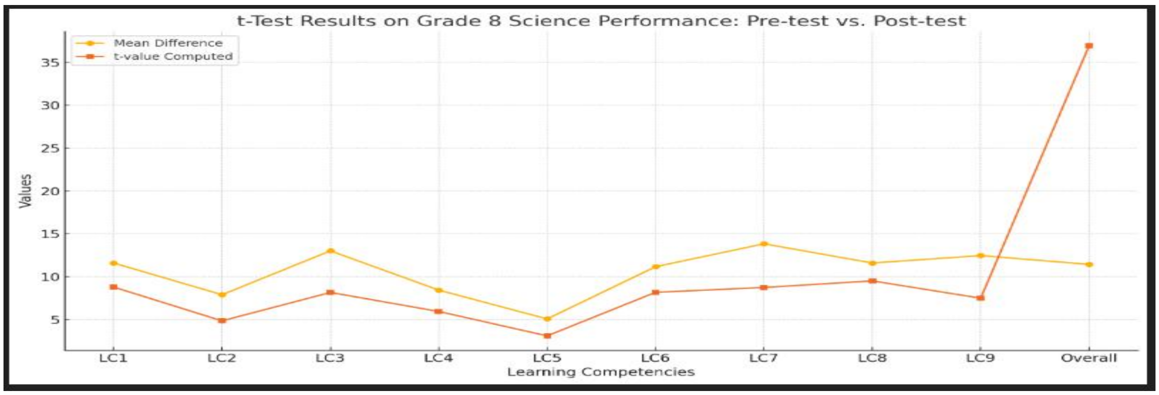
provide strong evidence for integrating active, student-centered learning approaches in science education, fostering deeper understanding, critical skills, and preparedness for real-world challenges.

**Figure 3.2 t-Test Result on the Significant Differences Between the Grade 8 Science Performance Pre-test Scores and the Post-Test Scores**




The t-Test results show that Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory-Based Learning (LBL) significantly improved the science performance of Grade 8 students at Alfredo D. Bersamina National High School, with all learning competencies showing statistically significant gains at the 0.01 level ($p < .01$). The greatest improvement was observed in Learning Competency 7 (Mean Difference = 13.85, t = 8.758), while the smallest, yet still significant, gain occurred in Competency 5 (Mean Difference = 5.09, t = 3.114), indicating varying effectiveness across topics.

These findings align with studies by Fathima and Ponnusamy (2022), who emphasized that competency-based instructional strategies enhance student outcomes, and Kim and Lim (2021), who highlighted the benefits of differentiated instruction and formative assessment. Additionally, Johnson et al. (2023) note that ongoing formative evaluation and reflective teaching practices provide real-time insights into learner progress, allowing teachers to identify misconceptions early and adjust instruction effectively.

**Table 2.1 ANOVA Result on the Differences Between the Science Performance Scores and the Strategies Applied**

| | Source of Variation | Sum of Squares | df | Mean Square | $F_{Value}$ | Sig. |
|---|---|---|---|---|---|---|
| Grade 7 | Strategies | 560.644 | 2 | 280.322 | | |
| | Error | 571.034 | 84 | 6.798 | 41.236** | p<.01 |
| | Total | 1131.678 | 86 | | | |
| Grade 8 | Strategies | 609.051 | 2 | 304.525 | 38.454** | p<.01 |
| | Error | 760.242 | 96 | 7.919 | | |

| | | |
|---|---|---|
| Total | 1369.293 | 98 |

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

The ANOVA results in Table 2.1 indicate that differences in science performance among Grade 7 and 8 students were statistically significant based on the instructional strategies applied, with F-values of 41.236 and 38.454, respectively ($p < .01$). This demonstrates that teaching methodology had a substantial impact on student learning outcomes.

These findings are supported by Nguyen and Walker (2021), who found that students exposed to inquiry-based, hands-on, and collaborative strategies outperformed those in traditional classrooms. Similarly, Lopez and Sharma (2023) reported that aligning instructional strategies with students' developmental readiness significantly improved science achievement, while Park and Liu (2020) showed that active learning approaches, including group experiments and guided inquiry, enhanced engagement and conceptual understanding. Together, these studies reinforce that student-centered, interactive teaching strategies strongly influence academic performance in science.

**Table 2.2 Post-Hoc Test Result on the Significant Differences Between the Science Performance Score and the Strategies Applied (Grade 7)**

| Strategy | Mean Score |
|---|---|
| Inquiry-Based Learning | 90.72 [a] |
| Project- Based Learning | 84.72 [b] |
| Laboratory- Based Learning | 89.14 [a] |

*means with the same letters are not significant

The post-hoc test results showed that Inquiry-Based Learning (IBL) achieved the highest mean score of 90.72, closely followed by Laboratory-Based Learning (LBL) at 89.14, both substantially outperforming Project-Based Learning (PBL) with a mean of 84.72. This indicates that IBL and LBL are more effective for enhancing Grade 7 students' science performance. IBL's strength lies in fostering student inquiry, hypothesis testing, and guided experimentation, which develop higher-order thinking and deep conceptual understanding (Bell et al., 2020; Furtak et al., 2019). LBL complements this by providing concrete, hands-on experiences that transform abstract concepts into observable phenomena, consistent with Kolb's Experiential Learning Theory (1984) and supported by Hofstein & Lunetta (2020) and Minner et al. (2021).

While PBL promotes problem-solving and teamwork, its open-ended format may challenge younger learners who lack sufficient foundational knowledge or scaffolding, limiting its effectiveness (Thomas, 2020; Krajcik & Shin, 2020; Gordon & Jang, 2022). These findings emphasize the importance of selecting instructional strategies aligned with students' developmental readiness and learning objectives. The study underscores the need for ongoing teacher training, adequate classroom resources, and active, inquiry-based, and experiential approaches to improve comprehension, engagement, and motivation in science education (Dori & Hameiri, 2018; Li et al., 2023).

**Table 2.3 Post-Hoc Test Result on the Significant Differences Between the Science Performance Score and the Strategies Applied (Grade 8)**

| Strategy | Mean Score |
|---|---|
| Inquiry-Based Learning | 88.70 [a] |
| Problem-Based Learning | 84.27 [b] |
| Laboratory-Based Learning | 90.09 [a] |

*means with the same letters are not significant

The post-hoc results for Grade 8 students revealed that Laboratory-Based Learning (LBL) achieved the highest mean score of 90.09, followed closely by Inquiry-Based Learning (IBL) at 88.70, both significantly outperforming Project-Based Learning (PBL), which scored 84.27. LBL's strength lies in providing hands-on, experiential learning where students directly manipulate scientific materials and observe outcomes, reinforcing theoretical knowledge (Hofstein & Lunetta, 2020; Germann et al., 2019; Bodner & Weiland, 2021). IBL promotes active inquiry, hypothesis testing, and problem-solving, enabling deeper conceptual understanding and critical thinking (Bell et al., 2020; Furtak et al., 2019). Student interviews supported these findings, with respondents noting that laboratory activities were more engaging and easier to follow due to structured, hands-on instructions.

Conversely, PBL, while fostering collaboration and real-world problem-solving, was less effective at the Grade 8 level, likely due to its open-ended nature and limited direct experimentation. These results highlight the importance of selecting instructional strategies aligned with students' developmental readiness and content complexity. Effective science instruction requires combining inquiry and experiential methods to promote active learning, engagement, and comprehension. The study underscores the need for professional development and well-equipped learning environments to maximize the benefits of IBL and LBL, ensuring students gain both immediate academic achievement and long-term STEM skills (Dori & Hameiri, 2018; Teng & Huang, 2022; Thomas, 2020; Miller, 2023).

**Recommended Tool Guide based on the Result of the Study**

The study revealed that Inquiry-Based Learning (IBL) and Laboratory-Based Learning (LBL) were the most effective strategies for Grade 7 and 8 Science classes. Consequently, the recommended tools are the Grade 7 5E Model Framework and the Grade 8 Laboratory Manual. Research by Piper et al. (2018) emphasizes that teacher guides significantly enhance learning outcomes, potentially yielding gains equivalent to an additional half-year of learning. Such guides provide clear instructional pathways, especially for teachers with limited training, enabling effective content delivery and classroom management. Similarly, the International

Journal of Innovative Research in Multidisciplinary Field (2017) reported that learner manuals improve student participation and assessment performance, supporting concept retention and independent learning.

The Grade 7 5E Model Framework assists Earth Science educators in implementing IBL through engaging classroom experiences aligned with the K to 12 curriculum. It integrates the five phases: Engage, Explore, Explain, Elaborate, and Evaluate to promote active learning, critical thinking, and scientific curiosity. The Grade 8 Laboratory Manual provides hands-on activities aligned with life science competencies, allowing students to explore biological processes, model cellular divisions, predict genetic outcomes, classify organisms, and understand ecosystem dynamics. These exercises cultivate observation, critical thinking, and problem-solving skills essential for science and everyday life. Both tools begin with a preface outlining their purpose, guiding students and teachers toward meaningful, structured, and experiential learning.

## IV. CONCLUSION

With the following results, the conclusions were drawn:

1. The improvement in science performance from "Fairly Satisfactory" to "Very Satisfactory" among Grade 7 and 8 students at Alfredo D. Bersamina National High School indicates that the implemented learning strategies effectively enhanced students' comprehension and academic achievement.
2. Significant differences between pre-test and post-test scores confirm that Project-Based Learning (PBL), Inquiry-Based Learning (IBL), and Laboratory-Based Learning (LBL) were instrumental in improving science performance and fostering 21st-century skills, including critical thinking, collaboration, and problem-solving.
3. Active, hands-on strategies like IBL and LBL proved more effective than traditional teaching methods in boosting student achievement.
4. The 5E Model Framework and Laboratory Manual effectively supported instruction by providing structure, promoting exploration, and ensuring safe, consistent practices during experiments.

## V. RECOMMENDATION

Based on the conclusions drawn from the study, the following recommendations aer given:

1. Educators should consistently implement PBL, IBL, and LBL throughout the Science curriculum to sustain and enhance student learning outcomes.
2. Teachers should receive regular training on these strategies, while school administrators support the development of interdisciplinary projects and activities emphasizing critical thinking, collaboration, and problem-solving.
3. Science educators should adopt student-centered, experiential approaches by incorporating regular lab activities and inquiry-based tasks, with the Grade 7 5E Model Framework and Grade 8 Laboratory Manual serving as formal supplementary resources.

4. To further enrich these tools, additional content and activities aligned with the first to third quarter competencies of the Grade 7 and 8 Science curriculum may be integrated.

5. Future researchers should explore the scalability of these instructional strategies and examine additional factors not included in this study to provide a more comprehensive understanding of their impact.

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