

The Effect of Inquiry-Based Learning on Pre-Service Science Teachers Test Performance

Enrico D. Medina¹

¹University of Perpetual Help System DALTA, Las Piñas City, Philippines

¹Dr. Aurelio Mendoza Memorial Colleges, Ipil, Zamboanga Sibugay, Philippines

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ABSTRACT

Science education currently faces significant challenges with student disengagement and poor academic performance, largely exacerbated by a reliance on traditional, teacher-centered instruction. Inquiry-Based Learning (IBL) offers a proven, active-learning alternative to foster critical thinking. However, a critical gap persists its practical classroom execution, particularly among pre-service science teachers who often struggle with the content mastery necessary to facilitate inquiry phases effectively. This study aimed to determine the effectiveness of an IBL intervention on the academic test performance of pre-service science teachers. Utilizing a quantitative, one-group pretest-posttest research design, a sample of 20 pre-service science teachers completed the six-week IBL intervention progressing through its core phases: Orientation, Conceptualization, Investigation, Conclusion, and Discussion. Data were analyzed using descriptive statistics and a paired samples t-test. The results revealed a highly significant improvement in academic performance ($p < .001$, $d = 18.89$). Participants' baseline knowledge was categorized as "Good" ($M = 24.40$, 48.80%), which dramatically surged to "Very Good" level ($M = 39.80$, 79.60%) following the intervention. The findings confirm that structured IBL interventions proved to effective to overcome initial content knowledge deficits. This suggest that explicitly integrating IBL into teacher education programs is crucial for equipping future educators with the cognitive mastery and practical experience. The study was conducted with a small sample size, while the performance improvement is clear, future research should utilize quasi-experimental designs that include control groups for comparative effects of IBL against traditional instruction and subsequent studies should expand the application of IBL across different science domains.

Keywords: Inquiry-Based Learning, Pre-Service Science Teachers, Academic Test Performance, Science Education

INTRODUCTION

Science education is universally recognized as a vital pillar of 21st-century learning, equipping individuals with the knowledge and critical thinking skills required to address complex, real-world problems. However, global assessments such as the Program for International Student Assessment (PISA) consistently highlight a troubling incidence of poor academic performance and low scientific competence among learners. This underperformance often stems from a general lack of enthusiasm, with students finding science abstract and disconnected from their daily lives. Furthermore, research indicates that these difficulties are exacerbated by the prevalence of ineffective teaching practices dominated by traditional, lecture-based methods, which fail to develop essential science process skills (Arifin, Z., Sukarmin, Saputro, S., & Kamari, A., 2025).

In response to these challenges, contemporary educational frameworks have championed a transition from teacher-centered instruction to active, student-centered pedagogies such as Inquiry-Based Learning (IBL). IBL is a dynamic instructional approach where teachers act as facilitators, guiding students to explore concepts, ask questions, and solve problems through authentic scientific processes. A robust body of literature confirms that

IBL bridges theory and practice, significantly enhancing students' academic achievement, scientific literacy, and intrinsic interest in the subject compared to conventional methods. Additionally, systematic meta-analyses demonstrate that IBL yields a substantial positive effect on the cultivation of critical thinking skills, an essential objective of modern science education (Baraquia, L., 2019).

Despite the proven theoretical benefits of IBL, key issues persist regarding its practical implementation. While administrators frequently endorse innovative practices and provide professional learning communities, a noticeable gap remains between administrative intent and actual classroom execution. The effectiveness of Inquiry-Based Learning directly intersects with the preparation of future educators. Science Education students—pre-service teachers currently undergoing academic training—serve as the critical link to transforming the Philippine educational system. If these students experience and master IBL methodologies during their tertiary education, they are more likely to integrate these practices effectively into their future teaching careers.

The present study addresses this problem by implementing IBL intervention to directly measure its effect on academic test performance. Specifically, this research aims to determine the pretest and posttest performance levels of science learners, and to evaluate the significant difference between these scores to ascertain the intervention's effectiveness. This study endeavors to provide robust empirical evidence that can guide educators and policymakers in optimizing science instruction.

LITERATURE REVIEW AND THEORETICAL FOUNDATION

Science education is currently undergoing a paradigm shift from traditional, teacher-centered instruction toward active, student-centered pedagogies. At the forefront of this shift is Inquiry-Based Learning (IBL), an educational strategy in which students follow methods and practices similar to those of professional scientists to construct knowledge. Rather than passively receiving information, learners in an IBL environment generate questions, formulate hypotheses, design experiments, and interpret data. Current literature is highly unified regarding the theoretical superiority of this approach; however, recent studies reveal a complex landscape regarding its practical outcomes and classroom implementation.

Current literature shows a strong consensus that IBL dramatically improves general academic achievement and deep conceptual understanding. In a recent meta-analysis by Mediana et al. (2025) synthesized 12 empirical studies and found a large positive effect size ($g = 0.913$) for IBL on improving students' conceptual understanding in science and mathematics. Their analysis revealed that open inquiry where students possess the highest degree of autonomy, yielded the most substantial effect ($g = 1.530$). These macro-level findings are heavily supported by localized empirical studies. For instance, Okpala et al. (2025) demonstrated through a quasi-experimental study of 240 students that guided inquiry significantly elevated chemistry achievement scores compared to conventional lecture methods. Similarly, Detalla et al. (2025) observed that integrating IBL with system models shifted a cohort of Earth Science students from a "Did Not Meet Expectations" baseline to an "Outstanding" post-intervention mastery level.

Beyond basic content retention, researchers agree that IBL is uniquely positioned to cultivate higher-order cognitive skills. A comprehensive second-order meta-analysis by Arifin et al. (2025) analyzed 36 study entries and confirmed a substantial standardized mean difference ($SMD = 1.27$) in critical thinking improvements among students exposed to IBL. Primary investigations corroborate this; Nurdianti and Setiawati (2025) utilized the Ennis-Weir Critical Thinking Essay Test to show that IBL students outperformed control groups specifically in the cognitive domains of analysis, evaluation, and inference.

In addition to cognitive gains, the literature highlights IBL's positive impact on the affective domains of learning. A systematic review by Gomez (2025) found that IBL positively influences behavioral, cognitive, and emotional engagement by fulfilling students' basic needs for competence and autonomy. When students learn through authentic, inquiry-based activities, their intrinsic motivation and interest in science subjects surge significantly.

Furthermore, collaborative inquiry environments have been shown to reduce science anxiety and foster resilience by shifting the focus from finding a single "correct" answer to exploring the scientific process.

Despite the overwhelming empirical evidence supporting IBL, a major conflict exists between administrative endorsement and actual classroom execution. Guerrero and Bautista (2023) found that while schools report high levels of administrative support and provide professional learning communities, teachers infrequently implement inquiry-based instruction in their daily routines. This implementation gap is attributed to several practical barriers. Nurdianti and Setiawati (2025) noted that both teachers and students face initial difficulties adjusting to the lack of traditional structure, often leading to time constraints and classroom management challenges. Furthermore, Gomez (2025) emphasizes that successful IBL requires teachers to possess high levels of content mastery and pedagogical confidence, which many currently lack.

Consequently, a significant gap exists in the literature regarding the practical integration of IBL within real-world classroom contexts. While previous studies focus heavily on establishing IBL's theoretical superiority or measuring isolated cognitive outcomes, there is a lack of actionable research that bridges the divide between administrative intent and successful teacher practice. The present study addresses this critical gap by explicitly examining the practical application of inquiry-based learning and measuring its direct impact on academic test performance from a structured classroom intervention. This research aims to offer educators actionable strategies to effectively integrate IBL, thereby fulfilling the promise of student-centered science education.

METHODOLOGY

This study employed a quantitative research approach utilizing a one-group pretest-posttest design to determine the effectiveness of the Inquiry-Based Learning (IBL) intervention. This quantitative design is highly appropriate for this educational research as it facilitates the direct measurement of students' academic performance before and after the implementation of IBL. Comparing the pretest and posttest scores, provides a clear, empirical basis for evaluating whether the student-centered teaching strategy IBL led to significant improvements in their test performance.

This research was conducted at a private higher education institution in the province of Zamboanga Sibugay, a setting that provides a diverse learning environment for students of varying backgrounds. The target population comprised second-year Bachelor of Secondary Education students majoring in science. A purposive sampling technique was utilized to select 20 participants from an organic chemistry class taught by the researcher. Inclusion criteria required that participants be officially enrolled for the 2024–2025 academic year, demonstrate a need for additional support in science learning, and provide voluntary informed consent.

The Inquiry-Based Learning (IBL) intervention was conducted over a six-week period, consisting of two 1.5-hour sessions per week. To provide a rigorous and structured pedagogical environment, the instructional treatment was anchored in the IBL framework proposed by Pedaste et al. (2015), progressing through its core phases: Orientation, Conceptualization, Investigation, Conclusion, and Discussion. Rather than relying on open, unstructured discovery, the instructor utilized a guided inquiry approach, acting as a facilitator who posed guiding questions and provided the procedural framework while students actively manipulated organic molecular model kits to construct spatial representations and collaboratively solve structural problems. The intervention was sequentially structured to cover specific midterm organic chemistry concepts: an introduction to isomerism in Week 1, structural isomers in Week 2, geometric isomerism in Week 3, optical isomerism in Week 4, chirality in Week 5, and conceptual integration alongside posttest administration in Week 6. To guarantee implementation fidelity and ensure the instructional treatment remained consistent across the entire six-week period, the researcher utilized Institutional Learning Plan mapping the specific IBL phases to each weekly objective. Furthermore, an observer checklist was employed during the sessions to systematically monitor the instructor's adherence to the planned IBL facilitation methods and ensure consistency in the collaborative activities. Following this structured 18-hour intervention, the identical 50-item test was administered as a posttest, with the items rearranged to minimize rote memorization or familiarity effect.

The primary data collection tool for this study was a researcher-developed 50-item test questionnaire designed specifically to measure participants' content mastery before and after the intervention. The test was strictly aligned with the course's midterm learning plan, covering specific organic chemistry concepts that included an introduction to isomerism, structural isomers, geometric isomerism, optical isomerism, and chirality. This instrument was administered in two distinct phases: first as a pre-test to establish the students' baseline knowledge, and later as a post-test following the six-week Inquiry-Based Learning (IBL) intervention. To mitigate the risk of testing effects or rote memorization, the identical 50 items on the post-test were systematically rearranged. The pedagogical rigor and structural integrity of the research instrument, the instrument underwent a strict validation and reliability testing process. Initially, the 50-item test was subjected to expert evaluation by a three-member panel of higher education professionals, comprising one college dean and two college science instructors. This expert panel evaluated and verified the instrument's content validity, ensuring that all questions were clearly articulated, properly aligned with the required curriculum, and strictly appropriate for college-level science learners. Following expert validation, a pilot test was conducted on a separate cohort of students who were not part of the main study sample. The pilot data were analyzed using the Kuder-Richardson Formula 20 (KR-20), which yielded a high reliability coefficient of 0.85, statistically confirming that the instrument possessed good internal consistency.

The quantitative data derived from the pretest and posttest were processed and analyzed using Microsoft excel. Student performance was interpreted using a grade equivalent scale ranging from "Poor" (0-21%) to "Excellent" (82-100%) as seen in Table 1. Statistical analysis was then applied to evaluate the significant difference between the pretest and posttest scores.

Table 1. Test Performance Scale

Raw Score	Percentage	Verbal Interpretation
41-50	82-100%	Excellent
31-40	62-81%	Very Good
21-30	42-61%	Good
11-20	22-41%	Fair
0-10	0-21%	Poor

Ethically, the study prioritized participant autonomy, ensuring that voluntary consent was explicitly obtained from all students prior to their inclusion in the intervention. The study protocol received prior approval from the institution's Research Ethics Committee. Given the dual role of the researcher as the students' instructor, specific safeguards were implemented to mitigate any potential pressure or coercion to participate. Students were explicitly assured, both verbally and in writing, that their involvement was entirely voluntary and that their decision to participate or decline would have absolutely no impact on their course grades or academic standing. Furthermore, strict confidentiality procedures were maintained throughout the study; all test scores and personal data were immediately anonymized, stored in secure, password-protected files, and utilized exclusively for the purposes of this research.

RESULTS

Baseline Test Performance Prior to IBL To determine the baseline level of knowledge, descriptive statistics were calculated from the 50-item pre-test. Table 2 presents an item-level analysis which revealed that the mean correct response rate across all test items was 48.80%, which is interpreted as a "Good" performance level. The highest correct response rate for any single item on the pre-test did not exceed 50%.

Table 2. Pre-test Response Distribution (n = 20)

Item	A (n)	A (%)	B (n)	B (%)	C (n)	C (%)	D (n)	D (%)	Correct Answer	Correct Response (%)	Interpretation
1	4	20%	8	40%	4	20%	4	20%	B	40%	Fair
2	7	35%	5	25%	4	20%	4	20%	A	35%	Fair
3	4	20%	4	20%	9	45%	3	15%	C	45%	Good
4	5	25%	5	25%	4	20%	6	30%	D	30%	Fair
5	4	20%	8	40%	4	20%	4	20%	B	40%	Fair
6	7	35%	5	25%	4	20%	4	20%	A	35%	Fair
7	4	20%	3	15%	10	50%	3	15%	C	50%	Good
8	5	25%	6	30%	5	25%	4	20%	B	30%	Fair
9	5	25%	4	20%	4	20%	7	35%	D	35%	Fair
10	4	20%	4	20%	8	40%	4	20%	C	40%	Fair
11	4	20%	9	45%	4	20%	3	15%	B	45%	Good
12	7	35%	5	25%	4	20%	4	20%	A	35%	Fair
13	5	25%	5	25%	4	20%	6	30%	D	30%	Fair
14	4	20%	4	20%	8	40%	4	20%	C	40%	Fair
15	5	25%	7	35%	4	20%	4	20%	B	35%	Fair
16	5	25%	5	25%	4	20%	6	30%	D	30%	Fair
17	4	20%	4	20%	9	45%	3	15%	C	45%	Good
18	8	40%	4	20%	4	20%	4	20%	A	40%	Fair
19	5	25%	7	35%	4	20%	4	20%	B	35%	Fair
20	5	25%	5	25%	6	30%	4	20%	C	30%	Fair
21	10	50%	4	20%	3	15%	3	15%	A	50%	Good
22	4	20%	8	40%	4	20%	4	20%	B	40%	Fair
23	5	25%	4	20%	4	20%	7	35%	D	35%	Fair
24	4	20%	4	20%	9	45%	3	15%	C	45%	Good
25	8	40%	4	20%	4	20%	4	20%	A	40%	Fair
26	5	25%	7	35%	4	20%	4	20%	B	35%	Fair
27	5	25%	5	25%	6	30%	4	20%	C	30%	Fair
28	4	20%	8	40%	4	20%	4	20%	B	40%	Fair
29	5	25%	4	20%	4	20%	7	35%	D	35%	Fair
30	4	20%	9	45%	4	20%	3	15%	B	45%	Good
31	5	25%	5	25%	6	30%	4	20%	C	30%	Fair
32	7	35%	5	25%	4	20%	4	20%	A	35%	Fair
33	10	50%	4	20%	3	15%	3	15%	A	50%	Good
34	4	20%	8	40%	4	20%	4	20%	B	40%	Fair
35	7	35%	5	25%	4	20%	4	20%	A	35%	Fair
36	5	25%	5	25%	6	30%	4	20%	C	30%	Fair
37	8	40%	4	20%	4	20%	4	20%	A	40%	Fair
38	7	35%	5	25%	4	20%	4	20%	A	35%	Fair
39	4	20%	9	45%	4	20%	3	15%	B	45%	Good
40	4	20%	4	20%	8	40%	4	20%	C	40%	Fair
41	5	25%	7	35%	4	20%	4	20%	B	35%	Fair
42	9	45%	4	20%	4	20%	3	15%	A	45%	Good
43	5	25%	5	25%	6	30%	4	20%	C	30%	Fair
44	4	20%	8	40%	4	20%	4	20%	B	40%	Fair
45	5	25%	7	35%	4	20%	4	20%	B	35%	Fair

46	4	20%	10	50%	3	15%	3	15%	B	50%	Good
47	4	20%	4	20%	8	40%	4	20%	C	40%	Fair
48	5	25%	4	20%	7	35%	4	20%	C	35%	Fair
49	9	45%	4	20%	4	20%	3	15%	A	45%	Good
50	5	25%	5	25%	4	20%	6	30%	D	30%	Fair
Mean										48.80%	Good

Test Performance After IBL Intervention To assess performance following the intervention, the same 50-item test was administered as a post-test. As seen on Table 3, the mean correct response rate across the instrument increased to 79.60%, elevating the cohort's performance interpretation to "Very Good". Every item on the test recorded an increase in the correct response percentage, with several items achieving a 90% correct response rate.

Table 3. Post-test Response Distribution (n = 20)

Item	A (n)	A (%)	B (n)	B (%)	C (n)	C (%)	D (n)	D (%)	Correct Answer	Correct Response (%)	Interpretation
1	17	85%	1	5%	1	5%	1	5%	A	85%	Excellent
2	18	90%	1	5%	1	5%	0	0%	A	90%	Excellent
3	1	5%	17	85%	1	5%	1	5%	B	85%	Excellent
4	1	5%	17	85%	1	5%	1	5%	B	85%	Excellent
5	2	10%	16	80%	1	5%	1	5%	B	80%	Very Good
6	16	80%	2	10%	1	5%	1	5%	A	80%	Very Good
7	1	5%	1	5%	18	90%	0	0%	C	90%	Excellent
8	1	5%	1	5%	18	90%	0	0%	C	90%	Excellent
9	1	5%	1	5%	18	90%	0	0%	C	90%	Excellent
10	2	10%	16	80%	1	5%	1	5%	B	80%	Very Good
11	1	5%	17	85%	1	5%	1	5%	B	85%	Excellent
12	1	5%	1	5%	18	90%	0	0%	C	90%	Excellent
13	16	80%	2	10%	1	5%	1	5%	A	80%	Very Good
14	1	5%	1	5%	0	0%	18	90%	D	90%	Excellent
15	1	5%	18	90%	1	5%	0	0%	B	90%	Excellent
16	1	5%	1	5%	1	5%	17	85%	D	85%	Excellent
17	17	85%	1	5%	1	5%	1	5%	A	85%	Excellent
18	1	5%	17	85%	1	5%	1	5%	B	85%	Excellent
19	1	5%	17	85%	1	5%	1	5%	B	85%	Excellent
20	17	85%	1	5%	1	5%	1	5%	A	85%	Excellent
21	2	10%	1	5%	1	5%	16	80%	D	80%	Very Good
22	2	10%	1	5%	16	80%	1	5%	C	80%	Very Good
23	1	5%	1	5%	17	85%	1	5%	C	85%	Excellent
24	2	10%	1	5%	16	80%	1	5%	C	80%	Very Good
25	2	10%	1	5%	1	5%	16	80%	D	80%	Very Good
26	2	10%	16	80%	1	5%	1	5%	B	80%	Very Good
27	2	10%	2	10%	1	5%	15	75%	D	75%	Very Good
28	1	5%	1	5%	17	85%	1	5%	C	85%	Excellent
29	1	5%	18	90%	1	5%	0	0%	B	90%	Excellent
30	2	10%	15	75%	2	10%	1	5%	B	75%	Very Good
31	17	85%	1	5%	1	5%	1	5%	A	85%	Excellent
32	17	85%	1	5%	1	5%	1	5%	A	85%	Excellent
33	1	5%	17	85%	1	5%	1	5%	B	85%	Excellent

34	2	10%	1	5%	16	80%	1	5%	C	80%	Very Good
35	16	80%	2	10%	1	5%	1	5%	A	80%	Very Good
36	1	5%	17	85%	1	5%	1	5%	B	85%	Excellent
37	1	5%	18	90%	1	5%	0	0%	B	90%	Excellent
38	17	85%	1	5%	1	5%	1	5%	A	85%	Excellent
39	2	10%	1	5%	1	5%	16	80%	D	80%	Very Good
40	2	10%	1	5%	16	80%	1	5%	C	80%	Very Good
41	1	5%	1	5%	18	90%	0	0%	C	90%	Excellent
42	1	5%	18	90%	1	5%	0	0%	B	90%	Excellent
43	18	90%	1	5%	1	5%	0	0%	A	90%	Excellent
44	2	10%	1	5%	1	5%	16	80%	D	80%	Very Good
45	17	85%	1	5%	1	5%	1	5%	A	85%	Excellent
46	1	5%	1	5%	18	90%	0	0%	C	90%	Excellent
47	1	5%	1	5%	18	90%	0	0%	C	90%	Excellent
48	1	5%	18	90%	1	5%	0	0%	B	90%	Excellent
49	18	90%	1	5%	1	5%	0	0%	A	90%	Excellent
50	1	5%	1	5%	18	90%	0	0%	C	90%	Excellent
Mean										79.60%	Very Good

Effectiveness of the IBL Intervention

To determine the baseline level of knowledge before and after the intervention, descriptive statistics were calculated from the 50-item pre-test as presented in Table 4. The pre-test results yielded a mean score of 24.40 (SD = 3.78), with individual scores ranging from a minimum of 18 to a maximum of 31. The post-test results indicated a substantial improvement, with the overall mean score rising to 39.80 (SD = 3.13) and scores ranging from 34 to 45.

Table 4. Descriptive Statistics of Pre-test and Post-test Scores (n = 20)

Assessment	N	Mean	Standard Deviation	Minimum	Maximum	Percentage (%)	Interpretation
Pre-test	20	24.40	3.78	18	31	48.80	Good
Post-test	20	39.80	3.13	34	45	79.60	Very Good

Prior to conducting the inferential analysis, the distribution of the difference scores was evaluated and confirmed to satisfy the normality assumption required for a paired samples t-test using jamovi software. The analysis revealed a mean score increase of 15.30 points (SD= 0.81) between the pre-test and post-test, with a 95% confidence interval. The paired t-test demonstrated that this improvement was highly significant, $t(19) = 84.47$, $p < .001$.

The effect size was calculated using Cohen's d_z (the mean difference divided by the standard deviation of the difference scores), yielding an exceptionally large value of $d_z = 18.89$. To ensure full transparency regarding the unusual magnitude of this effect size, the individual pretest and posttest scores for all 20 participants have been made available in the supplementary materials. Furthermore, while these results confirm the practical significance of the IBL intervention on participants' cognitive achievement, it must be acknowledged that administering the identical 50-item instrument at both pretest and posttest intervals with the items rearranged may have introduced a practice or familiarity effect that partially inflated the observed performance gains.

Table 5. Paired Samples t-test Result

Comparison	Mean Difference	SD Difference	t-value	df	p-value	Interpretation	Cohen's d
Post-test - Pre-test	15.30	0.182	84.47	19	< .001	Highly Significant	18.89

Overall, the quantitative evidence firmly establishes that the integration of Inquiry-Based Learning confirmed to be highly effective in improving the test performance of pre-service science teachers, shifting their collective understanding from a baseline of 'Good' to an outcome of 'Very Good'.

DISCUSSION

The primary objective of this exploratory study was to determine the effectiveness of Inquiry-Based Learning (IBL) on the test performance of pre-service science teachers. Baseline findings revealed that prior to the intervention, the 20 participants demonstrated a "Good" level of test performance, with a mean score of 24.40 and an accuracy rate of 48.80%. This indicates an initial deficit in content mastery among these pre-service teachers. Following the short six-week IBL intervention, test performance improved to a "Very Good" level, with a post-test mean score of 39.80 and a 79.60% accuracy rate. The paired samples t-test indicated that this improvement was statistically significant ($p < .001$) with a large practical effect size (Cohen's $d = 18.89$). While the achievement test used in this study primarily measures content retention rather than specific cognitive mechanisms, these findings suggest that the structured IBL intervention effectively confirmed the pre-service teachers in mastering organic isomer concepts they initially struggled to comprehend.

Although the one-group research design precludes definitive causal claims regarding the absolute superiority of IBL over traditional teaching methods, these results align with existing literature advocating for active learning. The improvements in test scores corroborate the findings of Detalla et al. (2025), who noted that IBL and system model integration can elevate students' academic standing. Furthermore, while this study did not directly measure higher-order critical thinking or broad scientific literacy, the observed academic gains are consistent with the systematic meta-analysis by Arifin et al. (2025), which associated IBL with positive learning outcomes. Demonstrating these outcomes in a small group of pre-service teachers, this study addresses the implementation barriers noted by Guerrero and Bautista (2023), indicating that structured IBL frameworks may help pre-service teachers overcome foundational content knowledge deficits.

These findings can be interpreted through the IBL framework proposed by Pedaste et al. (2015), progressing through its core phases: Orientation, Conceptualization, Investigation, Conclusion, and Discussion. The systematic instructional dynamic toward facilitation during the six-week period, the IBL intervention encouraged students to take an active role in discovering concepts, manipulating models, and solving problems. The data suggest that immersing learners in these scientific processes may have helped them connect theoretical knowledge with practical application. While the absence of a control group limits the ability to isolate exact mediating variables, the data suggest this hands-on exploration was a primary factor in the academic improvements observed in the post-test.

This study contributes to the literature by moving beyond theoretical affirmations to measure direct pre-test and post-test outcomes in a classroom setting. It offers preliminary evidence that pre-service science teachers who often face challenges with content knowledge and pedagogical execution—can achieve significant academic gains when exposed to targeted IBL interventions (Siew, N. M., & Chai, P. M., 2024). However, because the study was conducted with a small sample ($n = 20$) over a brief six-week period, these findings should be viewed as an initial step rather than conclusive proof of a generalized pedagogical shift.

Practically, the findings suggest that teacher education programs could benefit from integrating IBL more explicitly into their curricula. Experiencing IBL firsthand, pre-service teachers may build the necessary content

knowledge and confidence to facilitate these methods in their future classrooms. From a policy perspective, administrators should consider providing robust professional learning communities, peer mentoring, and adequate resources (e.g., laboratory equipment, preparation time) to support this instructional strategy (Wale, B. D., & Bishaw, K. S., 2020).

Despite the significant improvements observed, the methodological limitations namely, the lack of a control group, the small sample size, and the short intervention period, restrict the generalizability of the results and the ability to isolate IBL's comparative effects against conventional lecture methods. Future research should address these limitations by utilizing quasi-experimental designs with control groups, expanding across different science domains, and employing extended implementation periods alongside qualitative measures to assess both higher-order cognitive engagement and long-term knowledge retention.

CONCLUSION

The purpose of this study was to determine the practical effectiveness of Inquiry-Based Learning intervention on the academic test performance of pre-service science teachers. The findings indicate that the intervention was associated with a substantial improvement in short-term achievement, transitioning the cohort's baseline knowledge from a "Good" level (48.80%) to a "Very Good" level (79.60%) post-intervention. While this statistically significant transformation ($p < .001$, $d = 18.89$) suggests that IBL is a viable strategy for enhancing targeted content mastery, the small sample size and lack of a control group preclude definitive causal claims regarding its absolute superiority over conventional instruction. Ultimately, this research contributes preliminary empirical evidence to the field of science education, indicating that integrating practical, student-centered applications into teacher preparation programs may help overcome initial content knowledge deficits, though future controlled studies are required to confirm these effects and evaluate broader impacts on scientific literacy.

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APPENDICES

Table 6. Individual Scores

Participant	Pre-test	Post-test
P1	21	37
P2	25	41
P3	18	34
P4	27	42
P5	23	39
P6	29	44
P7	20	36
P8	26	40
P9	22	38
P10	31	45
P11	24	40
P12	19	35
P13	28	43
P14	23	39
P15	30	44
P16	21	37
P17	26	41
P18	24	39
P19	29	43
P20	22	38

