



STUDENTS' ACADEMIC PERFORMANCE IN BIOLOGY THROUGH PROBLEM-BASED LEARNING INFOGRAPHIC ASSISTED INSTRUCTION

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ABSTRACT

Problem-Based Learning Infographic-Assisted Instruction (PBL-IAI) is an innovative pedagogical approach that combines the depth of inquiry-based learning with the visual clarity of infographics. This study examined the effect of PBL-IAI on the academic performance and scientific attitude of college students enrolled in the GEE1 — Math, Science, and Technology — course during the first semester of the 2025-2026 academic year. The study utilized a quasi-experimental pretest-posttest control group design, involving two sections of second-year BSED students of Roman C. Villalon Memorial Colleges Foundation Inc., who were assigned to the PBL-IAI group ($n = 43$) and the Non-PBL-IAI group ($n = 42$), with data gathered through a validated 75-item achievement test and an adapted and modified Scientific Attitude Scale (Khan & Siddiqui, 2020) that also underwent content validation. Students in the PBL-IAI group achieved a post-test Mean Percentage Score of 87.43%, significantly outperforming the Non-PBL-IAI group, which scored 72.16%. Likewise, the PBL-IAI group demonstrated a stronger scientific attitude ($M = 3.94$) across all four dimensions — rationality, open-mindedness, confidence in the scientific method, and curiosity — than the Non-PBL-IAI group ($M = 3.62$). The ANCOVA results affirm the synergistic power of combining problem-based learning with infographic-assisted instruction, revealing a significant difference in academic performance and scientific attitude between learners exposed to PBL-IAI and those not exposed to it.

Keywords: *Problem-Based Learning, Infographic Assisted Instruction, Scientific Attitude, Academic Performance*

INTRODUCTION

Science education plays a vital role in enhancing students' scientific literacy, enabling them to think rationally and apply their learning in real-life situations. In this regard, students' academic performance, particularly in science subjects such as biology, is a critical indicator of the effectiveness of science educational practices. However, the need to improve our science education is evident on the Philippines' performance during the PISA 2022 score, where Filipino students achieved an average score of 356 in science, which is lower in comparison with the overall average score of 449 for all participating countries in the Organization for Economic Co-operation and Development (PISA 2022 Results (Volume I and II) - Country Notes: Philippines, 2023), shows that the country faces challenges in improving in these areas and achieving competence in scientific literacy, problem-solving, communication, and critical thinking.

One reason for this performance may be the continued use of traditional teaching methods, which are common in biology subjects that rely heavily on lecture-based instruction and textbook-centered learning and may not effectively address the challenges faced by teachers and students in this subject. Studies have shown that traditional lecture-based instruction often fails to engage students and develop their critical thinking skills (Preeti et al., 2018). The method also fails to foster students' problem-solving skills, as they tend to focus on memorization rather than applying knowledge in real-world scenarios (Gupta & Pandey, 2016). As a result, academic performance remains low because students are not adequately engaged or encouraged to cultivate curiosity, inquiry, and critical thinking, which are key components of a scientific attitude.

A scientific attitude cultivates a mindset that embraces inquiry and evidence-based reasoning (Mr, R & Gangrade, 2024). Improving students' scientific attitude is not only about providing them with factual knowledge but also about equipping them with important 21st-century skills. Several studies have shown that students with a positive scientific attitude tend to perform well academically in science, as they are more likely to approach challenges systematically and participate actively in classroom activities (Mao et al., 2021; Manguil & De Leon, 2025).

In response to this issue, pedagogical strategies such as Problem-Based Learning (PBL) have gained attention for their potential to improve students' academic performance and scientific attitudes. The PBL engages learners in deep, meaningful learning through real-life, ill-structured problems (Pepper, 2015) and is grounded in constructivist principles. When integrated with multimedia tools like infographics, its effectiveness will be further enhanced (Kusumawati et al., 2025). The combination of PBL and audiovisual aids improves students' logical thinking and problem-solving skills (Proborini et al., 2024). On the other hand, infographics, which present information through a combination of text and visuals, support better comprehension and retention of complex science concepts (Medrano & Pacis, 2022).

In this context, problem-based learning (PBL) and infographics have emerged as promising approaches to enhance student learning and outcomes in biology. Their combination can create a synergistic effect, where the strengths of each approach complement and reinforce one another, leading to improved student outcomes in biology (Astuti et al., 2024; Kusumawati et al., 2025). Despite the potential benefits of this integrated approach, the existing literature on the combined use of problem-based learning and infographic-assisted instruction in Philippine education remains limited. The majority of studies have focused on the individual effects of PBL (Funa, 2023) or the use of infographics (Kilaton & Ranoa, 2023; Basco, 2020), without examining the potential synergistic benefits of integrating these two approaches. While Orozco and Yangco (2016) noted that PBL is not yet widely adopted in the Philippines at the secondary level, recent studies have explored problem-based approaches with visual materials. However, no studies have specifically examined the combined impact of PBL with infographic-assisted instruction on students' scientific attitudes in biology classrooms.

This study sought to investigate the effects of problem-based learning and infographic-assisted instruction on students' academic performance and scientific attitudes in biology. Specifically, it aimed to determine how the synergistic combination of these two approaches enhanced students' scientific attitudes and fostered their problem-solving abilities. By examining this combination, the research aimed to provide valuable insights into effective pedagogical strategies to improve biology education in the Philippine context and to contribute to the wider discussion about innovative teaching methodologies that addressed both content mastery and the development of essential scientific dispositions.

Research Questions

1. What is the student's academic performance level when exposed to problem-based learning using infographic-assisted instruction (PBL-IAI) and those exposed to the non-PBLIAI method?
2. What is the level of students' scientific attitude when exposed to problem-based learning using infographic-assisted instruction (PBL-IAI) compared to those exposed to a non-PBLIAI method in terms of: Rationality, Open-Mindedness, Confidence in Using Scientific Method, and Curiosity?
3. Is there a significant difference in students' academic performance level when exposed to problem-based learning using infographic-assisted instruction (PBL-IAI) and those who are exposed to a non-PBLIAI method?
4. Is there a significant difference in the level of students' scientific attitude when exposed to problem-based learning using infographic-assisted instruction (PBL-IAI) and those who are exposed to a non-PBLIAI method?

METHODOLOGY

This study employed a pretest–posttest control-group quasi-experimental design to examine the effects of problem-based learning using infographic-assisted instruction

(PBLIAI) compared with non-PBL infographic-assisted instruction on students' academic performance and scientific attitude. Two intact second-year classes enrolled in the Bachelor of Secondary Education major in English at Roman C. Villalon Memorial Colleges Foundation Inc. during the academic year 2025–2026 were selected, with 43 students assigned to the experimental group exposed to PBLIAI and 42 students to the control group exposed to non-PBL infographic-assisted instruction.

The experimental group engaged in a 7E-based PBL sequence incorporating animated infographics, real-life problem scenarios, guided group investigations, and student-created infographics, while the control group followed a 7E-structured non-PBL approach featuring teacher-guided discussion, reflective group reading of topic-aligned articles, and presentation of group interpretations without the problem-solving core.

Academic performance was measured using a researcher-constructed 75-item multiple-choice test, which was content-validated by experts and pilot-tested, yielding a Cronbach's alpha of .898; scores were interpreted using the institution's adopted grading scale. Scientific attitude was assessed using an adapted questionnaire based on Khan and Siddiqui (2020), content-validated and pilot-tested, with a Cronbach's alpha of .922, and interpreted on a 5-point Likert scale.

Following the securing of institutional permission and ethics clearance, participants were oriented, administered the pretest and scientific attitude survey, exposed to their respective instructional treatments over the final term of GEE1- Math, Science, and Technology (People and Earth's Ecosystem), and then retested with the posttest and scientific attitude survey; the resulting data were scored, tallied, and analyzed using descriptive statistics and analysis of covariance (ANCOVA) to determine significant differences between the PBLIAI and non-PBLIAI groups. The study was limited to second-year college students and specific to GEE1 topics for the final term.

RESULTS

Table 1. Comparison of the Students' Level of Academic Performance

Raw Score	Percentage Equivalent	PRE-TEST				POST-TEST				Qualitative Interpretation
		PBL-IAI		NPBL-IAI		PBL-IAI		NPBL-IAI		
		<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	
73-75	98-100	0	0.00	0	0.00	3	6.98	0	0.00	E
72-73	95-97	0	0.00	0	0.00	3	6.98	0	0.00	S
69-71	92-94	0	0.00	0	0.00	13	30.23	4	9.52	VG
67-68	89-91	0	0.00	0	0.00	3	6.98	2	4.76	G
65-66	86-88	0	0.00	2	4.76	2	4.65	2	4.76	HS
63-64	83-85	1	2.33	0	0.00	5	11.63	2	4.76	S
60-62	80-82	3	6.98	1	2.38	5	11.63	3	7.14	BA
58-59	77-79	3	6.98	1	2.38	3	6.98	3	7.14	A
56-57	75-76	5	11.63	3	7.14	0	0.00	5	11.90	P

0-55	74-below	31	72.09	35	83.33	6	13.95	21	50.00	F
TOTAL		43	100	42	100	43	100	42	100	
Mean Score		45.40		43.43		65.57		54.12		
MPS		60.53 (F)		57.90 (F)		87.43(HS)		72.16 (F)		

Legend:

Percentage Equivalent	Qualitative Interpretation
98-100	Excellent (E)
95-97	Superior (S)
92-94	Very Good (VG)
89-91	Good (G)
86-88	Highly Satisfactory (HS)
83-85	Satisfactory (S)
80-82	Better than Average (BA)
77-79	Average (A)
75-76	Passing (P)
74-below	Failed (F)

Table 2. Students' rationality pre-test and post-test scores

Indicators	PRE-TEST				POST-TEST			
	PBL-IAI		NPBL-IAI		PBL-IAI		NPBL-IAI	
	Mean	QI	Mean	QI	Mean	QI	Mean	QI
I feel that studying science can contribute to the progress of society.	4.37	HAS	4.24	HSA	4.44	HSA	4.14	HSA
I believe that studying science is not easy for everyone.	3.90	HAS	3.80	HSA	4.02	HSA	4.10	HSA
I believe that traditional society can hold back the growth of science.	2.47	MSA	2.59	MSA	3.65	HSA	2.79	MSA
I accept traditional beliefs even when they go against scientific research.	2.60	MSA	2.62	MSA	3.14	MSA	2.79	MSA
I don't accept traditional beliefs when they go against scientific research.	2.69	MSA	2.61	MSA	3.12	MSA	2.98	MSA
Mean	3.21	MSA	3.17	MSA	3.67	HSA	3.36	MSA

Legend:

<u>Range</u>	<u>Interpretation</u>
4.51-5.00	Very High Scientific Attitude (VHSA)
3.51-4.50	High Scientific Attitude (HSA)
2.51-3.50	Moderate Scientific Attitude (MSA)
1.51-2.50	Low Scientific Attitude (LSA)
1.00 -1.50	Very Low Scientific Attitude (VLSA)

Table 3. Students' open-mindedness pre-test and post-test scores

Indicators	PRE-TEST				POST-TEST			
	PBL-IAI		NPBL-IAI		PBL-IAI		NPBL-IAI	
	Mean	QI	Mean	QI	Mean	QI	Mean	QI
I believe that studying science has helped me come up with new ideas	4.19	HSA	4.31	HSA	4.56	VHSA	4.50	HAS
I believe that sharing my knowledge with others is harmful	3.52	HSA	3.74	HSA	4.19	HSA	3.62	HAS
I find that positive criticism from others helps my knowledge to progress.	3.84	HSA	3.79	HSA	4.00	HSA	3.81	HSA
I feel offended by people who have a different opinion from mine	3.72	HSA	3.21	MSA	3.95	HSA	3.52	HSA
I think science makes people too dependent on technology	3.33	MSA	3.62	HSA	3.79	HSA	3.81	HSA
I tend to reject the opinions of inexperienced people, even when I am presented with evidence	3.30	MSA	3.33	MSA	3.53	HSA	3.26	MSA
I feel that it is acceptable to criticize new ideas when there is no factual information presented	2.81	MSA	2.95	MSA	3.30	MSA	2.98	MSA
Mean	3.53	HSA	3.62	HSA	3.90	HSA	3.64	HSA

Legend:

<u>Range</u>	<u>Interpretation</u>
4.50-5.00	Very High Scientific Attitude (VHSA)
3.50-4.49	High Scientific Attitude (HSA)
2.50-3.49	Moderate Scientific Attitude (MSA)
1.50-2.49	Low Scientific Attitude (LSA)
1.00 -1.49	Very Low Scientific Attitude (VLSA)

Table 4. Students' confidence in using scientific method pre-test and post-test scores

Indicators	PRE-TEST				POST-TEST			
	PBL-IAI		NPBL-IAI		PBL-IAI		NPBL-IAI	
	Mean	QI	Mean	QI	Mean	QI	Mean	QI
I ask questions to understand the problems better.	4.26	HSA	4.53	VHSA	4.63	VHSA	4.40	HSA
I think knowledge can change over time and is not always final.	3.70	HSA	3.52	HSA	4.21	HAS	3.86	HSA
I believe that I should collect enough evidence before accepting an idea.	3.67	HSA	3.93	HSA	4.07	HAS	3.71	HSA
I am honest and truthful in collecting and recording data.	3.79	HSA	3.55	HSA	4.07	HAS	3.57	HSA
I delay making decisions when I don't have enough data	3.30	MSA	3.38	MSA	3.70	HAS	3.43	MSA
I believe that data can be manipulated according to the needs of the student.	2.49	LSA	2.62	MSA	3.47	MSA	2.59	MSA
Mean	3.53	HSA	3.59	HSA	4.02	HAS	3.59	HSA

Legend:

<u>Range</u>	<u>Interpretation</u>
4.50-5.00	Very High Scientific Attitude (VHSA)
3.50-4.49	High Scientific Attitude (HSA)
2.50-3.49	Moderate Scientific Attitude (MSA)
1.50-2.49	Low Scientific Attitude (LSA)
1.00 -1.49	Very Low Scientific Attitude (VLSA)

Table 5. Students' curiosity pre-test and post-test scores

Indicators	PRE-TEST				POST-TEST			
	PBL-IAI		NPBL-IAI		PBL-IAI		NPBL-IAI	
	Mean	QI	Mean	QI	Mean	QI	Mean	QI
I like to explore things/concepts that are unfamiliar to me	4.09	HSA	4.21	HSA	4.44	HSA	4.29	HSA
I am interested in knowing why natural phenomena happen.	3.84	HSA	4.24	HSA	4.40	HSA	4.05	HSA

I tend to find the truth behind how things happen.	3.84	HSA	4.19	HSA	4.37	HSA	4.07	HSA
I believe that everything that happens in the world has a scientific explanation.	3.49	MSA	3.98	HSA	4.12	HSA	4.00	HSA
I believe that only scientists have the right to conduct scientific inquiries, not ordinary students.	3.14	MSA	3.02	MSA	3.42	MSA	3.07	MSA
Mean	3.68	HSA	3.93	HSA	4.15	HSA	3.90	HSA

Legend:

<u>Range</u>	<u>Interpretation</u>
4.50-5.00	Very High Scientific Attitude (VHSA)
3.50-4.49	High Scientific Attitude (HSA)
2.50-3.49	Moderate Scientific Attitude (MSA)
1.50-2.49	Low Scientific Attitude (LSA)
1.00 -1.49	Very Low Scientific Attitude (VLSA)

Table 6. Summary of the students' scientific attitude

Indicators	PRE-TEST				POST-TEST			
	PBL-IAI		NPBL-IAI		PBL-IAI		NPBL-IAI	
	Mean	QI	Mean	QI	Mean	QI	Mean	QI
Curiosity	3.68	HSA	3.93	HAS	4.15	HSA	3.90	HSA
Confidence	3.53	HSA	3.59	HAS	4.02	HSA	3.59	HSA
Open-Mindedness	3.53	HSA	3.62	HAS	3.90	HSA	3.64	HSA
Rationality	3.21	MSA	3.17	MSA	3.67	HSA	3.36	MSA
Weighted Mean	3.49	MSA	3.58	HAS	3.94	HSA	3.62	HSA

Legend:

<u>Range</u>	<u>Interpretation</u>
4.50-5.00	Very High Scientific Attitude (VHSA)
3.50-4.49	High Scientific Attitude (HSA)
2.50-3.49	Moderate Scientific Attitude (MSA)
1.50-2.49	Low Scientific Attitude (LSA)
1.00 -1.49	Very Low Scientific Attitude (VLSA)

Table 7. Analysis of Covariance (ANCOVA) of Students' Post-test Scores

Group	N	Mean	SD
Problem-based Learning Infographic Assisted Instruction	43	65.12	11.07
Non- Problem-based Learning Infographic Assisted Instruction	42	54.12	7.44
TOTAL	85	59.68	10.86

Source	SS	Df	MS	f-value	Sig.
Pre-test (covariate)	1610.29	1	1610.29	23.03	0.00
Group	4179.89	2	2089.94	29.89	0.00 ^s
Error	5734.54	82	69.93		
Total	312683.00	85			

Note: s- significant at 0.05 level

Table 8. Analysis of Covariance (ANCOVA) of Scientific Attitude in the Post-test

Group	N	Mean	SD
Problem-based Learning Infographic Assisted Instruction	43	3.94	.35
Non- Problem-based Learning Infographic Assisted Instruction	42	3.62	.24
TOTAL	85	3.78	.34

Source	SS	Df	MS	f-value	Sig.
Pre-test (covariate)	.040	1	0.40	4.53	0.04
Group	2.50	2	1.25	14.03	0.00 ^s
Error	7.32	82	0.89		
Total	1226.45	85			

Note: s- significant at 0.05 level

DISCUSSION

Students' Level of Academic Performance

Table 1 presents the students' pre-test and post-test scores for Problem-based Learning Infographic Assisted Instruction and Non-Problem-based Learning Infographic Assisted Instruction. As shown in the data below, the students' overall pre-test mean percentage scores (MPS) is 60.53% and 57.90%, respectively. These results indicate that both groups scored below the expected level, with scores below 75% or interpreted as "Failed."

The pre-test results indicated that both groups performed poorly, suggesting minimal prior knowledge of the lesson content. This result is similar to Clementir (2023), who found that pre-test scores below 75% indicated students had limited conceptual knowledge of the lesson before the discussion. Similarly, the research of Orozco and Yangco (2016) and Torres et al. (2026) found that students' low pre-test mean scores indicate limited prior understanding and the likely presence of misconceptions before instruction began.

After being exposed to the problem-based learning infographic-assisted instruction and the non-problem-based learning infographic-assisted instruction, the table shows that students' academic performance has improved. As shown in Table 1, students exposed to PBL-IAI achieved a mean percentage score of 87.43, indicating "Highly Satisfactory". In contrast, students exposed to NPBL-IAI achieved a mean percentage score of 72.16, indicating a "Failed" outcome. In contrast to students exposed to NPBL-IAI, students who participated in PBL-IAI showed a range of outcomes across all percentage categories. For the students who were exposed to PBL—IAI, out of the 43 students, thirteen (13) students (30.23%) had a "Very Good" performance, six (6) students (13.95%) had a "Failed" performance, five (5) students (11.63%) had a "Satisfactory" performance, five (5) students (11.63%) had a "Better than Average" performance, three (3) students (6.98%) had an "Excellent" performance, three (3) students (6.98%) had a "Superior" performance, three (3) students (6.98%) had a "Good" performance, three (3) students (6.98%) had an "Average" performance, and two (2) students (4.65%) had a "Highly Satisfactory" performance.

The results implied that integrating problem-based learning with infographic-assisted instruction is more effective at enhancing students' academic performance than using non-problem-based, infographic-assisted instruction. The higher mean percentage score and the wider spread of students from "Failed" to "Highly Satisfactory" performance levels in the PBL-IAI group suggest that engaging learners in authentic problem situations, supported by clear, visually organized infographics, promotes deeper conceptual understanding and helps address students' initial learning gaps. The findings also suggest that PBL-IAI has the potential to reduce students' misconceptions. Since low pre-test scores often signal incorrect prior conceptions, the substantial gain of many students into satisfactory and higher categories in the PBL-IAI group indicates that students were able to reconstruct their ideas during the problem-solving process. The structured stages of PBL, such as identifying the problem, clarifying terms or ideas, brainstorming possible explanations, and restructuring the problem, likely provided learners with opportunities to confront and refine their initial beliefs, while the infographics offered concise visual cues that supported accurate understanding.

The result aligns with research indicating that PBL and Infographics can reduce misconceptions and improve conceptual understanding when learners are guided to confront their prior ideas through inquiry and reflection. This finding supports the study of Valdez and Bungihan (2019), who reported that problem-based learning has a positive effect on students' problem-solving skills. It is also consistent with the findings of Caramay and Ortega-Dela Cruz (2023), who found that problem-based learning positively affected

students' academic achievement in science. In addition, Basco (2020) found that infographics can be an effective strategy for improving pupils' academic performance in science. Taken together, these studies suggest that integrating problem-based learning with infographic-assisted instruction can create an effective learning environment that strengthens students' understanding and test performance. This result is further supported by the studies of Aguilar and Panoy (2022), Chamsai et al. (2020), and Kusumawati et al. (2025), all of whom reported positive effects of problem-based learning combined with infographics on knowledge, achievement, and writing performance.

Students' Level of Scientific Attitude

Rationality

Table 2 presents students' scientific attitude regarding Rationality before and after the implementation of the two interventions. The results had shown that both groups had a moderate scientific attitude before the intervention. The mean scores for students under PBL-IAI and NPBL-IAI were 3.21 and 3.17, respectively, indicating a "Moderate Scientific Attitude." After the intervention, the PBL-IAI group showed significant improvement, with a mean score of 3.67, indicating a "High Scientific Attitude." In contrast, the students exposed to NPBL-IAI showed a modest gain, with a mean score of 3.36, indicating a "Moderate Scientific Attitude."

In the pre-test scores of the PBL-IAI group, the highest mean scores were observed for the statements: I feel that studying science can contribute to the progress of society (4.37) and I believe that studying science is not easy for everyone (3.90). The results suggest that before the intervention, the students already exhibited awareness of science's progressive role and acknowledged individual differences in aptitude. This claim is supported by the studies of Sabanal et al. (2023) and Sulthon (2018), which report that students, even prior to formal instructional intervention, possess an inherent recognition of science's societal significance. Similarly, according to Akinoğlu and Tandoğan (2007), as cited by Sabitu et al. (2025), students already value the relevance of science before formal instruction begins.

On the other hand, the lower pre-test scores were observed for the items: I accept traditional beliefs when they go against scientific research (2.60), and I believe that traditional society can hold back the growth of science (2.47). These results suggest that, before the intervention, students prioritize traditional beliefs over scientific evidence. This also reflects a low scientific attitude, as they are unwilling to question their societal beliefs, which can constrain them. This parallels the claims of Ravish (2025), who stated that misconceptions often originate from cultural and traditional beliefs and that such culturally embedded beliefs can be resistant to correction, even when exposed to quality instruction.

The post-test scores of students exposed to PBL-IAI have shown improvement across all indicators. The highest post-test scores were observed in I feel that studying science can contribute to the progress of society (4.44), I believe that studying science is

not easy for everyone (4.02), and I believe that traditional society can hold back the growth of science (3.65). This result suggests that Problem-based learning-Infographic Assisted Instruction effectively strengthened students' belief in the cause-and-effect relationship between science and society, as well as in objectivity. Additionally, indicators with lower mean scores on the post-test but still improved compared to the pre-test include: I don't accept traditional beliefs when they go against scientific research (3.12), and I accept traditional beliefs when they go against scientific research (3.14). This pattern suggests that their scientific attitudes have improved. The PBL-IAI intervention appears to have helped the students to become more reflective and more willing to prioritize scientific reasoning. These findings are consistent with the study by Sholikhah et al. (2023), which demonstrated that STEM-based PBL was significantly more effective than conventional learning in enhancing students' rational thinking ability. Syahidi and Fartina (2019) further confirmed that PBL effectively improved students' rational thinking skills and received positive responses from students.

The observed improvement in rationality among students exposed to PBL-IAI implies that integrating problem-based learning with infographic-assisted instruction can effectively cultivate higher-order thinking skills, particularly in evaluating evidence and questioning non-scientific beliefs. This suggests that when students are actively engaged in solving real-world problems and are supported with visual representations of information, they are more inclined to apply their scientific reasoning rather than rely on traditional assumptions. Hence, the PBL-IAI approach may serve as a powerful pedagogical strategy to promote a more critical, reflective, and evidence-based mindset among learners, which is essential for developing scientifically literate individuals.

For the Non-PBLL-AIA, the highest post-test mean scores are I feel that science can contribute to the progress of society (4.14) and " I believe that studying science is not easy for everyone (4.10), both of which denote a high scientific attitude, indicating that students recognize the value of science and acknowledge the individual differences in terms of scientific aptitude. The results indicated that even without Problem-based Learning Infographic Assisted Instruction, students still developed Rationality through structured instruction. These findings are consistent with the study of Bhan and Khanduri (2025), who measured scientific attitude across subscales, including Rationality, and found that even moderate instructional approaches yield measurable gains. Sombilon and Sariana (2025) supported these claims by demonstrating that structured instruction continues to contribute to the development of a high scientific attitude, even in the absence of a problem-based framework.

For the NPBL-IAI group, the improvement in rationality, though more modest, suggests that structured, guided instruction still plays a meaningful role in enhancing students' rational thinking. This indicates that even without the problem-based component, consistent exposure to organized scientific content can help students gradually shift toward more evidence-based thinking. However, the comparatively lower gain suggests that, while traditional approaches support rational development, they may not be as effective in deeply challenging students' pre-existing beliefs or fostering strong critical evaluation skills as more interactive and inquiry-driven methods such as PBL-IAI.

The results indicate that both PBL-IAI and Non-PBL-IAI contributed to enhancing students' scientific attitude toward Rationality; however, PBL-IAI demonstrated a stronger impact. This outcome is grounded in rationality itself, as Khan and Siddiqui (2020) note, drawing on Gauld and Hukins's (1980) idea that rationality involves evaluating ideas and information through logic and evidence. Immersing students in authentic problem scenarios that demand evidence-based judgment in PBL provides the cognitive conditions for deeper rational thinking. This result is consistent with the findings of Syahidi and Fartina (2019) and Sholikhah et al. (2023), both of whom affirmed that PBL's problem-solving structure yields more deliberate improvements in rational thinking, with PBL groups achieving significantly higher scores than conventional groups.

The infographic component also played a meaningful role. Basco (2020) found that science infographics improved learners' ability to organize information logically and to develop critical thinking skills, which are foundational to Rationality. Similarly, Elga et al. (2018) demonstrated that visualizing logical structures improved analytical reasoning by making logical relationships explicit and accessible. Together, these findings suggest that problem-based learning and infographic-assisted instruction challenge students to both visually process logical relationships and actively apply rational thinking in authentic, problem-centered contexts.

Open Mindedness

Table 3 presents the students' scientific attitude in terms of open-mindedness, comparing the effects of the Problem-based Learning Infographic Assisted Instruction (PBL-IAI) and Non-Problem-based Learning Infographic Assisted Instruction (NPBL-IAI) before and after the intervention. The mean scores for the PBLAIA and the Non-PBL-IAI on the pre-test were 3.53 and 3.62, respectively, indicating that both groups have a "High Scientific Attitude." On the other hand, the post-test mean scores of students under PBLAIA and Non-PBL-IAI were 3.90 and 3.64, respectively, indicating "High Scientific Attitude." The result implies that students' level of open-mindedness was similar across groups before and after the interventions.

In the pre-test, the PBL-IAI group scored high on I believe that studying science has helped me come up with new ideas (4.19), I find that positive criticism from others helps my knowledge to progress (3.84), I feel offended by people that has a different opinion from mine (3.72), and I believe that sharing my knowledge with others is harmful (3.52). These results suggest that even before the intervention, the students demonstrated a relatively high level of scientific attitude, characterized by intellectual openness, receptiveness to feedback, tolerance for differing opinions, and a low inclination to view knowledge-sharing as detrimental.

The result is similar to that of Sakliressy et al. (2021), who found that students already possessed a moderate-to-high baseline scientific attitude, including an open-minded attitude before PBL implementation, with mean scores on scientific attitude questionnaires indicating that students start from an existing foundation of scientific openness.

On the other hand, lower pre-test scores were observed in the following indicators: I think science makes people too dependent on technology (3.33); I tend to reject the opinions of inexperienced people, even when I am presented with evidence (3.30). It is acceptable to criticize new ideas when no factual information is presented (2.81). These results show that, before the intervention, the students had not fully developed intellectual openness, particularly in the critical evaluation of evidence-based arguments, the willingness to consider perspectives regardless of the source's experience, and reflective thinking about the role of science and technology in society. This result aligns with the findings of Parno et al. (2020), who observed that students exposed to conventional settings tend to have lower scientific literacy competencies, particularly in the attitudinal domain, suggesting that critical scientific dispositions such as evidence-based reasoning and open-mindedness require deliberate instructional intervention to be fully developed.

After the intervention, the students exposed to the PBL-IAI showed improvements in their mean scores across all indicators. The highest mean score was recorded for "I believe that studying science has helped me come up with new ideas" (4.63), which indicates that the group has a "Very High Scientific Attitude". Followed by: I believe that sharing my knowledge with others is harmful (4.19), and I find that positive criticism from others helps my knowledge progress (4.0). Similarly, the remaining indicators have shown growth, with students demonstrating an improved scientific attitude.

These results suggest that PBL-IAI effectively enhanced students' openness to new ideas, willingness to accept constructive feedback, and readiness to share and refine knowledge, thereby fostering a more developed scientific attitude. The observed improvement in open-mindedness among students exposed to PBL-IAI shows that engaging learners in collaborative, problem-centered activities supported by infographic-assisted instruction can effectively foster a more receptive and flexible mindset toward scientific ideas. This suggests that when students are given opportunities to exchange perspectives, evaluate alternative explanations, and refine their understanding through discussion, they become more willing to accept constructive criticism and consider different viewpoints.

These results suggest that PBL-IAI effectively enhanced students' openness to new ideas, willingness to accept constructive feedback, and readiness to share and refine knowledge, thereby fostering a more developed scientific attitude. This result is supported by Redjeki (2024), who found that PBL significantly increased students' open-minded attitudes compared to direct instruction and reported a strong association between PBL and open-mindedness. Furthermore, Redjeki (2024) added that collaborative discussion activities in PBL compel students to engage and consider their classmates' opinions, thereby cultivating their ability to accept viewpoints without imposing their own. Similarly, Bossér and Lindahl (2020) found that student-active science teaching, including group discussions and addressing existing scientific issues, encourages students to adopt open-minded attitudes and engage in elaborate talk.

The integration of Infographic-Assisted Instruction within the problem-based learning had further reinforced the development of open-mindedness among the

students. According to Dur (2014), as cited in Alrwele (2017), infographics develop students' life skills and attitudes, including their capacity to communicate ideas effectively. When students collaboratively create an infographic in a problem-based learning activity, they must combine information from multiple sources and share their individual ideas with the group for review and critique. This action reflects a component of being open-minded. This is further supported by Basco (2020), who states that infographic-based instruction improved learners' ability to communicate what they have learned to others, give and receive feedback, and develop self-confidence, all of which are attributed to open-mindedness.

For the Non-PBL-IAI, students' performance on the indicators has also improved over the post-test period. Similar to the PBL, IAI's highest post-test scores are: studying science has helped me come up with new ideas (4.50), and science makes people too dependent on technology (3.81). I find that positive criticism from others helps my knowledge to progress (3.81). The results suggest that even in a Non-Problem-Based Learning setting, Infographic-Assisted Instruction enabled students to develop an open-minded and reflective scientific attitude, indicating that structured instruction can support growth in openness to new ideas, critical reflection on science, and acceptance of constructive criticism. This finding aligns with the idea of Mulhall et al. (2016), who noted that open-mindedness can be fostered within educational settings rather than tied to specific instructional methods.

While both groups show an improvement, the PBL-IAI group demonstrated higher gains in open-mindedness, which can be attributed to the synergistic effect of both the Problem-based learning and Infographic Assisted Instruction, which both have a unique characteristic, such as students collaboratively solving problems using an infographic, and considering multiple perspectives in addressing structured problems. Furthermore, the effects of both PBL and infographics on open-mindedness are particularly evident through the lens of constructivist learning theory. Tatalović Vorkapić and Tomljenović (2020) presented evidence that, within constructivist pedagogy, the construction of visual representations serves as a mechanism for learners to externalize, refine, and communicate knowledge built through social interaction and experience. According to Taber (2024), constructivism allows learners to actively engage with problems and discuss them with others, leading them to become more open to new ideas rather than simply accepting what they are told.

Together, the two approaches address both the process and the product of open-minded learning. The PBL nurtures the disposition to seek and consider multiple perspectives, while infographic creation requires students to act on that disposition by communicating their idea through visual representation.

Confidence in Using the Scientific Method

Table 4 displays the mean scores for students' scientific attitude regarding Confidence in using the Scientific Method, comparing results before and after applying the Problem-based Learning Infographic Assisted Instruction (PBL-IAI) and the Non-

Problem-based Learning Infographic Assisted Instruction (NPBL-IAI). Based on the results, both groups exhibited a high level of scientific attitude before and after the intervention. The PBL-IAI had mean pre-test and post-test scores of 3.53 and 4.02, respectively, indicating a "High Scientific Attitude." The NPBL-IAI had similar mean scores on the pre-test and post-test (3.59), indicating a "High Scientific Attitude." This shows that both groups had the same level of scientific attitude before and after the intervention.

In the pre-test, the PBL-IAI received high scores on the following indicators: I ask questions to understand the problems better (4.26), I am honest and truthful in collecting and recording data (3.79), I think knowledge can change over time and is not always final (3.70), and I believe that I should collect enough evidence before accepting an idea (3.67). These scores suggest that the students were already inquisitive, truthful, evidence-oriented, and open to the tentative nature of knowledge. These findings imply that the group had strong confidence in its scientific orientation before the intervention. This finding is similar to those of Kanyesigye et al. (2022) and Wibawa et al. (2023), in which students showed positive attitudes and confidence even before being exposed to active instructional strategies.

After the intervention, students in the PBL-IAI group showed improvement across all indicators. The most significant improvement was observed in I ask questions to understand problems better, which recorded the highest mean score of 4.63, indicating a "Very High Scientific Attitude." This was followed by a "High Scientific Attitude" in the following indicators: I think knowledge can change over time and is not always final, with a mean score of 4.21, and I believe that I should collect enough evidence before accepting an idea, and I am honest and truthful in collecting and recording data, both with a mean score of 4.07.

These improvements suggest that students have deepened their confidence in the process, becoming more assured in their questioning behavior, more committed to evidence-based reasoning, and more accepting of knowledge as dynamic and changeable. This result is supported by the study of Sombilon and Sariana (2025), which states that interactive, curiosity-driven class activities, a characteristic of PBL-IAI, could further enhance students' enthusiasm and sustain their confidence in science. Similarly, Valdez and Bungihan (2019) found that students in PBL-trained classes developed a more confident scientific orientation, as they showed a greater willingness to investigate, question, and construct evidence-based arguments than those in non-PBL instruction. Additionally, Gebre (2018) demonstrated that when students create infographic-based reports, they develop stronger confidence, especially in finding, synthesizing, and analyzing credible scientific information, which directly correspond to the evidence-collection and data-honesty indicators that improved in the present study's PBL-IAI group.

For the Non-PBLIAI, the highest mean score before the intervention was I ask questions to understand problems better (4.53) which denotes a "Very High Scientific Attitude, followed by I believe that I should collect enough evidence before accepting an idea (3.93) and I am honest and truthful in collecting and recording data (3.55), and I think knowledge can change over time and is not always final (3.52), which all denotes as "

High Scientific Attitude." The result suggests that, similar to the PBL-IAI group, the non-PBL-IAI group also exhibits inquisitive thinking, an evidence-oriented approach, and openness to the tentative nature of knowledge. This is consistent with findings by Jeffery et al. (2016), who found that students in structured, non-inquiry-dominant science courses can also exhibit measurable confidence in questioning and evidence-seeking at the start of instruction, indicating that confidence in the scientific method is not exclusively the product of active learning but can emerge from any science learning context that consistently models and rewards scientific thinking.

After the post-test, the non-PBL-IAI group showed no overall improvement; although half of the indicators improved, the other half had lower mean scores than on the pre-test. The mean score for 'I ask questions to understand problems better' decreased from 4.53 (indicating a Very High Scientific Attitude) to 4.40 (indicating a High Scientific Attitude). Likewise, 'I should collect enough evidence before accepting an idea,' which decreased from 3.93 to 3.71, although both scores remained within the High Scientific Attitude range. These results imply that the students continued to demonstrate scientific confidence, but the post-test findings suggest no improvement in their curiosity or evidence-seeking disposition. This result may be attributed to the fact that non-PBL-IAI instruction is not inquiry-driven, leading to a slight decline in some of the indicators in students' confidence in the scientific method. This result aligns with Kanyesigye et al. (2022), who found that students under non-PBL instruction showed smaller and less consistent gains in science-related confidence because traditional instructional formats offer fewer opportunities for students to exercise and reinforce confidence through self-directed questioning and independent evaluation of evidence. The lack of improvement may further reflect what Turcotte et al. (2022) described as the absence of a student-voice structure, in which classroom conditions that validate students as active knowledge-builders, more prevalent in PBL environments, had affected students' growing confidence in using the scientific method.

Overall, the results reveal that both instructional approaches maintained a high level of scientific attitude in terms of confidence; however, the PBL-IAI group demonstrated more consistent and meaningful growth across all confidence indicators, whereas the NPBL-IAI group exhibited a slight decline in some areas, despite retaining a high overall level. These differences underscore the unique contribution of PBL-IAI in building students' confidence, specifically in questioning, demanding sufficient evidence, recording data with integrity, and accepting that scientific knowledge is never final. Together, the two approaches had helped develop students' confidence, both as a cognitive disposition and as an enacted practice. These findings are similar to the educational context, as Caramay and Ortega-Dela Cruz (2023) and Valdez and Bungihan (2019) collectively affirm that Problem-based Learning is particularly effective for students in cultivating the scientific confidence necessary to sustain inquiry-based learning, and as Basco (2020) and Dogomeo and Aliazas (2022) confirm that infographics independently contribute to Filipino students' self-confidence in learning.

Curiosity

Table 5 presents the pre-test and post-test mean scores of both the PBL-IAI and NPBL-IAI groups on the Curiosity subscale of scientific attitude. Prior to the intervention, both groups already demonstrated a “High Scientific Attitude (HSA)” level of curiosity, with the PBL-IAI group obtaining an overall pre-test mean of 3.68 and the NPBL-IAI group obtaining a mean of 3.93. After the interventions, both groups retained their High Scientific Attitude classification; however, the PBL-IAI group recorded a higher post-test mean of 4.15, compared with the NPBL-IAI group's post-test mean of 3.90. This pattern suggests that while both interventions can be associated with high levels of curiosity among students, the Problem-Based Learning Infographic-Assisted Instruction yielded greater improvement in students' curiosity about science.

In the post-test, the PBL-IAI group shows an improvement across all the indicators. The highest post-test score was observed for the indicator I like to explore things/concepts that are unfamiliar to me (4.44), followed by I am interested in knowing why natural phenomena happen (4.40) and I tend to find the truth behind how things happen (4.37). The result denotes a “High Scientific Attitude.” This result suggests that the intervention helped develop students' willingness to explore unfamiliar ideas, seek explanations for natural phenomena, and pursue an evidence-based understanding of how things occur.

The observed improvement in students' curiosity after exposure to PBL-IAI suggests that integrating problem-based learning with infographic-assisted instruction can effectively stimulate students' intrinsic motivation to explore and inquire about scientific concepts. The increased willingness of students to engage with unfamiliar ideas, investigate natural phenomena, and seek underlying explanations suggests that the intervention promotes active learning and deeper cognitive engagement. This indicates that when students are placed in problem-solving contexts and supported with visual tools that simplify complex information, they become more inclined to ask questions, investigate, and construct their own understanding. Consequently, the PBL-IAI approach may serve as an effective strategy in fostering a sustained sense of curiosity, which is essential for developing lifelong learners and promoting continuous engagement in scientific inquiry.

This finding is consistent with Kanyesigye et al. (2022) and Putri and Aznam (2024), who demonstrated that active problem engagement in a Problem-Based Learning context significantly stimulates students' interest and curiosity in science. Similarly, Jirout (2020) underscored that engaging in inquiry generates uncertainty that, in turn, drives students to curiosity. Simultaneously, the PBL-IAI approach's infographic-assisted component offered visual representations that made difficult scientific ideas more approachable and cognitively comprehensible. Laela and Dixit (2025) affirm that infographics increase students' interest in and engagement with learning, and that their combination with problem-based approaches is particularly effective in fostering curiosity and creativity.

The indicator with the lowest mean score was I believe that only scientists have the right to conduct scientific inquiries, not ordinary students, with a mean score of 3.42, which was interpreted as "Moderate Scientific Attitude". This result suggests that students have rejected the idea that scientific inquiry is restricted to a scientist, indicating that there is a growing sense of scientific curiosity and self-efficacy in terms of inquiry; however, the moderate interpretation also implies that students still hold beliefs about the exclusivity of scientific work, suggesting that there is still a need for further reinforcement. Ligutom and Ocdenaria (2025) found that a learning environment significantly predicts students' scientific attitudes, and they also emphasized that critical thinking plays a particularly important role in shaping how students perceive themselves as capable inquirers.

The NPBL-IAI group also showed significant improvement across the indicators, except for "I am interested in knowing why natural phenomena happen," where the mean score decreased from 4.24 in the pre-test to 4.05 in the post-test, although both values can still be interpreted as "High Scientific Attitude." This result suggests that, while the Non-PBL-IAI strengthened students' curiosity, their motivation to seek explanations for natural phenomena decreased slightly, indicating that the intervention may not have fully deepened this particular aspect of scientific curiosity. This result aligns with the findings of Steidtmann et al. (2022), who reported that interest and motivation in science tend to decline over time, and that teaching quality and instructional methods significantly influence the trajectory of students' scientific interest. Tirta et al. (2025) similarly find that lecture-based instruction reduces curiosity and scientific attitudes, even when supplementary materials are employed, and that active inquiry methods are necessary to produce meaningful and durable improvements.

The findings highlight the differential instructional value of combining problem-based learning with infographic-assisted instruction versus non-problem-based learning with infographic-assisted instruction. The PBL-IAI group's higher post-test performance relative to the NPBL-IAI group can be attributed to the complementary, mutually reinforcing mechanisms of the two components. PBL engaged students in authentic problem-solving, activating curiosity as a functional drive to explain and explore. At the same time, infographic-assisted instruction provided the visual scaffolding that made unfamiliar concepts cognitively accessible and visually compelling, thereby lowering the affective threshold for inquiry (Kanyesigye et al., 2022; Liu et al., 2024; Laela & Dixit, 2025).

A scientific attitude guides how students think, feel, and act when engaging with scientific ideas and investigations. It includes being rational, open-minded, confident in using scientific methods, and curious about understanding how and why phenomena occur. Developing these attitudes is essential because they support critical thinking, evidence-based decision-making, and sustained interest in science learning.

Table 6 summarizes the students' levels of scientific attitude across rationality, open-mindedness, confidence, and curiosity in both the Problem-based learning infographic-assisted instruction (PBL-IAI) and Non-Problem-based learning infographic-assisted instruction (NPBL-IAI). The pre-test results showed that students in the NPBL-

IAI had an overall weighted mean score of 3.58, indicating a High Scientific Attitude; by contrast, students in the PBL-IAI had an overall mean score of 3.49, indicating a Moderate Scientific Attitude. After the intervention, both groups have shown positive improvements, with the NPBL-IAI overall post-test mean score of 3.94 and the PBL-IAI mean score of 3.94, indicating that both groups have a High Scientific Attitude. The results showed that both instructional methods improved students' scientific attitudes, but PBL-IAI produced a greater improvement.

Furthermore, Table 6 shows that the PBL-IAI group showed clear gains in rationality, moving from a moderate scientific attitude (3.21) to a high scientific attitude (3.67), while the NPBL-IAI group remained at a moderate scientific attitude (pre-test: 3.17; post-test: 3.36), even though their scores increased. This indicates that problem-based activities, supported by infographics, may be especially helpful in training students to think more logically and base their ideas on evidence. Open-mindedness remained high in both groups from pre-test (PBL-IAI - 3.53; NPBL-IAI – 3.62) to post-test (PBL-IAI - 3.90; NPBL-IAI – 3.64), indicating that students in both conditions were willing to consider new ideas and to continue improving in this area.

The results for confidence and curiosity also give important insights. Confidence began at a high level in both groups (PBL-IAI - 3.53; NPBL-IAI – 3.59), but only the PBL-IAI group showed a notable increase after the intervention, with a mean score of 4.02, while the NPBL-IAI group did not show the same pattern and remained at a mean score of 3.59. This suggests that solving problems and working with visual materials may help students feel more confident in their science work. Curiosity remained at a high level in both groups (pre-test PBL-IAI - 3.68; pre-test NPBL-IAI – 3.93), with a slightly larger increase in the PBL-IAI group (mean score 4.15), indicating that both approaches can keep students interested in science. However, the problem-based infographic approach may spark greater interest.

The overall improvement in students' scientific attitude across all subscales indicates that both instructional methods are effective in cultivating positive scientific dispositions; however, the superior gains observed in the PBL-IAI group demonstrate the enhanced benefits of combining problem-based learning with infographic-assisted instruction. The significant rise in rationality and confidence indicates that involving students in problem-solving activities, augmented by visual aids, improves their capacity to think logically, assess evidence, and cultivate self-assurance in comprehending scientific topics. Additionally, the results show that students exposed to PBL-IAI activities demonstrated clear improvement as they collaborated to evaluate evidence, develop a mitigation plan, and present it as an infographic, which helped them think more like scientists and feel more confident putting ideas together. On the other hand, the non-PBL-IAI group showed only a small gain in rationality and no change in confidence, suggesting that the teacher-centered lessons with reflective reading tasks were not as effective at developing a reflective, evidence-based mindset as the problem-based, infographic activities.

Both groups remained very open-minded and curious, but the PBL-IAI group improved these skills more quickly. This shows that interactive, student-centered learning environments can further develop these attributes. Based on classroom observations during the study, the students exposed to PBL-IAI would initiate questions, pursue follow-up inquiries, and explore alternative explanations during their group work. They openly challenged their individual assumptions, sought input from their groupmates, and revised their infographics based on the new ideas they derived. Their behavior showed growing comfort with uncertainty and a willingness to test and revise hypotheses, indicating greater development of an open-minded, active curiosity.

In contrast, students in the non-PBL-IAI group tended to wait for teacher guidance before asking questions; they also tended to accept initial explanations without exploring other possible ideas, and completed their group reflective readings with very limited discussion, since they were only focused on getting the main ideas of the article provided. Opportunities to express or expand curiosity and open-mindedness occurred less often. These patterns suggest that teacher-centered instruction and reflection did not encourage proactive questioning and exploratory behavior, as observed with PBL-IAI.

These results suggest that PBL-IAI not only cultivates fundamental scientific attitudes but also enhances advanced dispositions critical to scientific inquiry. Consequently, integrating problem-based and visually supported instructional strategies in science classrooms may be more efficacious in cultivating learners who are rational, confident, curious, and open-minded. The result is supported by Yasmin et al. (2025), which confirms that PBL significantly improves students' scientific attitudes by engaging them in authentic, inquiry-driven problem-solving that demands analytical reasoning and intellectual openness. Similarly, Handayani and Suyanta (2024) found that PBL promotes the development of a scientific attitude by encouraging students to actively build their own understanding rather than simply receiving information in conventional instruction.

On the other hand, Hope and Cheta (2018) also reported that students exposed to infographic-based instruction demonstrated more favorable academic attitudes than those in conventional classroom settings.

Based on the results, the combination of Problem-Based Learning and infographic-assisted instruction appears to have produced a synergistic effect on students' scientific attitudes. This result is confirmed by Agustira et al. (2025), who demonstrated that PBL models supported by structured visual tools can engage learners cognitively and affectively at multiple levels simultaneously, thereby deepening the attitudinal impact of the learning experience. Similarly, the study of Budakoğlu et al. (2023) shows that Infographics, when embedded within a problem-solving framework, signal the relevance and accessibility of science, which are preconditions for attitudinal development. Taken together, the results suggest that problem-based learning, when supported by infographics, has meaningful potential to elevate students' scientific attitudes.

Analysis of Covariance (ANCOVA) of Students' Academic Performance

Table 7 shows the students' academic performance exposed to Problem-based Learning Infographic Assisted Instruction. The students who were exposed to Problem-based Learning Infographic Assisted Instruction obtained a mean score of 65.12 (SD = 11.07). In contrast, those exposed to non-problem-based Learning Infographic Assisted Instruction obtained a mean score of 54.12 (SD = 7.44). The study's results indicated a significant difference at the 0.05 level, with an F-value of 29.89. The results clearly show that students exposed to PBL-IAI scored significantly higher than those in the Non-PBL-IAI group. Therefore, this rejects the stated null hypothesis that there is no significant difference in the academic performance of students engaged in Problem-Based Learning (PBL) infographic-assisted instruction compared to those taught through non-PBL Method infographic-assisted instruction.

The current study reveals that students' exposure to PBL-IAI resulted in a significant difference compared to the non-PBL-IAI group, as they were actively engaged in collaborative inquiry, research, and the development of solutions to authentic problems, and in communicating their findings through self-created infographics. Students became co-constructors of knowledge rather than passive recipients of instruction. In doing so, students become co-constructors of knowledge, develop their problem-solving and critical thinking skills, and improve their academic performance. Additionally, the findings indicate that PBL-IAI produced meaningful learning gains, likely because students were engaged in inquiry, authentic problem-solving, and collaborative creation of infographic-based outputs. These activities support deeper thinking, peer help, and reflection, which explain the improvement in content understanding and problem-solving skills. The larger variability in the PBL-IAI group (SD = 11.07) than in the non-PBL-IAI group (SD = 7.44) suggests that students responded differently to the approach, highlighting the need for scaffolds and differentiated support to ensure equitable benefit. Overall, these results suggest that integrating PBL with infographic creation in science instruction can improve academic outcomes.

Meta-analyses have consistently demonstrated that problem-based learning (PBL) yields significant gains in academic achievement across science disciplines (Uluçınar, 2023; Zhang & Ma, 2023). The results are similar to those of Nicholus et al. (2023), which found that PBL markedly improved physics achievement and motivation among secondary learners, and to Valdez and Bungihan (2019), who reported that PBL significantly enhanced students' problem-solving skills. The infographic component of the instructional approach further amplifies these outcomes, as Basco (2020) documented meaningful improvements in science academic performance among sixth-grade pupils who received infographic-assisted lessons. Similarly, Alrwele (2017) found that the use of infographics led to higher academic achievement and more favorable student perceptions.

The result of the study supports the claims of Kusumawati et al. (2025), who found that PBL paired with digital infographics significantly improved the performance of the experimental group while enhancing engagement and visual comprehension, and

Pathana et al. (2024), who reported that PBL integrated with infographic media significantly raised the scores of the students. Furthermore, Astuti et al. (2024) observed that PBL with infographic support improved cognitive learning outcomes across instructional cycles in science, demonstrating the transformative potential of this instructional combination, even among learners who initially underperform.

However, this result contradicts the research of Brown (2021), which found that in the fifth-grade students, there is no statistically significant difference in their academic performance between the students exposed to PBL and those under traditional instruction, and the study of Omoniwa (2022) claims that there is no significant difference in the academic performance of junior secondary school students through infographics versus conventional lecture methods. These contrasting results suggest that PBL and infographic-assisted instruction may not work equally well in all situations; their effectiveness may depend on the subject, grade level, implementation, and the length of the intervention.

Analysis of Covariance (ANCOVA) of Students' Scientific Attitude

Table 8 presents the students' scientific attitudes exposed to Problem-based Learning Infographic-Assisted Instruction. The students who were exposed to Problem-based Learning Infographic Assisted Instruction obtained a mean score of 3.94 (SD = .35). In contrast, those students exposed to non-problem-based Learning Infographic Assisted Instruction obtained a mean score of 3.62 (SD .24). The study's results indicated a significant difference at 0.5. The result clearly shows that students exposed to PBL-IAI had developed a more positive scientific attitude than those in the Non-PBL-IAI group. Therefore, this rejects the stated null hypothesis that there is no significant difference in the scientific attitude of students engaged in Problem-Based Learning (PBL) infographic-assisted instruction compared to those taught through a non-PBLIAI Method.

The statistically significantly higher mean in the PBL-IAI group compared to the non-PBL-IAI group not only confirms a reliable effect but also shows how the instructional combination of problem-based learning and infographic-assisted instruction affects students' scientific attitudes. The results show that PBL-IAI influences multiple scientific attitudinal components by providing learners with authentic problem contexts in which infographics serve as cognitive organizers. While the problem-based format gets students actively working on real scientific questions through group discussion and practice, the infographics likely reduce extra mental effort, allowing students to focus on evaluating evidence and testing hypotheses. When combined, PBL-IAI helps students become more reflective, more inclined to seek evidence to support their claims, and more at ease with the tolerant nature of uncertainty in scientific work. Overall, the findings indicate that instructional designs that jointly target cognitive processing through visual-organizational supports through an infographic and epistemic practice through problem-centered tasks can improve students' scientific attitudes. In other words, changes in the structure of classroom activities and in representational support also reshape students' enduring mindset and values toward science.

The improvement observed in the PBL-IAI group aligns with the findings of Handayani and Suyanta (2024), who demonstrated that when learners are required to investigate real problems, they develop ownership of the learning process, fostering attitudinal growth beyond what conventional instruction typically achieves. Consistent with these findings, Yasmin et al. (2025) also found that PBL-based environments significantly elevate students' scientific attitudes compared with traditional pedagogical approaches. Furthermore, Sakliressy et al. (2021) confirmed that the PBL model led to a significant difference in students' scientific attitudes.

The more pronounced attitudinal improvement in the PBL-IAI group can also be attributed, in part, to the integration of infographic-assisted instruction. Basco (2020) claimed that a favorable attitude towards a subject can be developed when students encounter content that is both intellectually accessible and visually compelling, thereby reinforcing their motivation to explore scientific ideas. The result is also similar to the study of Dogomeo and Aliazas (2022), which found that the use of instructional infographics is associated with heightened student interest and improved affective responses to science learning.

The combination of Problem-Based Learning and infographic-assisted instruction has produced a synergistic effect on students' scientific attitudes. This claim is similar to the findings of Aguilar and Panoy (2022), which demonstrated that infographic-based instructional materials integrated with PBL stages produced highly integrated learning outcomes that significantly advanced students' scientific knowledge and affective engagement. In addition, both Agustira et al. (2025) and Budakoğlu et al. (2023) reported that when visually rich instructional materials, such as infographics, are embedded within a problem-solving framework, learners are engaged cognitively and affectively at multiple levels simultaneously.

Conclusions

The academic performance of students who were exposed to problem-based learning combined with infographic-assisted instruction (PBL-IAI) was generally higher than that of students who received non-problem-based learning with infographic-assisted instruction (NPBL-IAI). While both groups showed improvement on the post-test, the PBL-IAI group's gains were greater on average, suggesting that PBL-IAI is more effective at enhancing learning outcomes.

At the level of students' scientific attitude, the study assessed four subscales: Rationality, Open-mindedness, Confidence in the Scientific Method, and Curiosity. Before the intervention, both groups showed different levels of scientific attitude, with the PBL-IAI group classified as "Moderate Scientific Attitude" and the NPBL-IAI group as "High Scientific Attitude". After the intervention, the PBL-IAI group improved in all four areas, reaching an overall "High Scientific Attitude" level. The greatest improvement was observed in Rationality, with the PBL-IAI group moving from Moderate to High Scientific Attitude, while the NPBL-IAI group remained at the Moderate level. Both groups maintained a High Scientific Attitude, characterized by open-mindedness and curiosity,

but the PBL-IAI group showed greater gains. Regarding confidence in the scientific method, only the PBL-IAI group showed noticeable improvement, whereas the NPBL-IAI group even declined slightly in some areas. Overall, the findings suggest that PBL-IAI was more effective in fostering positive scientific attitudes among students, particularly in areas that require active thinking and deeper engagement with science.

Exposure to PBL-IAI significantly increased students' academic performance and scientific attitude. The results indicated a significant difference between the two interventions, leading to the rejection of the null hypotheses. Still, these conclusions are contingent on the study's sample size, effect sizes, and other potential factors such as prior knowledge, teacher effects, and student motivation. Overall, the evidence supports the conclusion that PBL-IAI has improved academic performance and fostered positive scientific attitudes.

Recommendations

Students may continue to use problem-based learning with an infographic-assisted instruction strategy, actively participate in class discussions, and apply what they learn to real-life situations to deepen understanding and maintain good performance, thereby helping sustain and further improve academic performance and scientific attitude.

Teachers are encouraged to adopt Problem-Based Learning Infographic-Assisted Instruction in teaching science, as it significantly improves students' academic performance and scientific attitudes. They should design authentic problem scenarios that challenge students to think critically, evaluate evidence, and communicate their findings through infographics.

School administrators are encouraged to support the implementation of PBL-IAI by providing adequate resources, seminars, training, workshops, and other opportunities to help teachers develop professionally.

Future researchers may conduct further studies across different grade levels, subject areas, and school settings to further validate and explore the effectiveness of PBL-IAI. Furthermore, studies that separate the individual effects of problem-based learning and infographic-assisted instruction may provide deeper insights into which component contributes more significantly to student outcomes.

Compliance with Ethical Standards

Appropriate steps were taken to ensure participants were fully aware of their involvement in the study. The participants were given a consent form signed by their respective parents or guardians and the students themselves. In accordance with the Republic of the Philippines' Republic Act No. 10173, also known as the Data Privacy Act of 2012, all information obtained from participants was kept strictly confidential and disclosed only when necessary and with their consent. Participants were informed of what was expected of them, including the study's content and objectives. They were given

enough information to decide whether to participate in the study and may withdraw at any time without consequences.

An Institutional Ethics Review Committee (IERC) Permit was also obtained to ensure that the researcher adhered to the University Code of Research Ethics of Central Mindanao University. The researcher ensured an unbiased interpretation of the findings, and the results were used only for research purposes. The researcher used AI solely to check for grammatical errors and to improve the paper's readability.

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