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Flipped Inquiry- Based Learning in Science

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Abstract **Review Article**

This study examined the effectiveness of Flipped Inquiry-Based Learning (FIBL) in enhancing academic performance among Grade 12 Science students at Victoria High School during the 2025–2026 school year. Rooted in constructivist learning theory and the Community of Inquiry (CoI) model, FIBL integrates pre-class asynchronous activities with in-class inquiry-based tasks to foster active engagement, collaboration, and higher-order thinking. A quasi-experimental pretest-posttest control group design was used. Participants included 78 Grade 12 students randomly assigned to an experimental group (n = 39) receiving FIBL or a control group (n = 39) taught via traditional lecture methods. A validated teacher-made science test measured outcomes, with data analyzed using means, standard deviations, independent samples t-tests, and Cohen's d. Pretest scores confirmed baseline equivalence between groups. Posttest results showed the FIBL group significantly outperformed the control group ($M = 87.01$ vs. $M = 82.22$; $p < .001$), with greater mean gains and a large effect size (Cohen's $d = 2.539$). These findings affirm FIBL as a powerful strategy for boosting science achievement and promoting meaningful, student-centered learning.

Keywords: Flipped Inquiry-Based Learning (FIBL), Science Education, Academic Performance, Active Learning, Quasi-Experimental Design.

Introduction

Learning sciences is a cross-disciplinary area focused on understanding how individuals acquire knowledge and skills, bringing together insights from educational psychology, neuroscience, and data science to develop effective educational environments. Modern science education increasingly utilizes student-centered and active learning strategies to foster critical thinking and deeper comprehension. International assessments like PISA emphasize the value of inquiry and problem-solving, though they also warn against unstructured inquiry without teacher guidance. To maximize these advantages, according to Schallert et al. (2021), Flipped Inquiry-Based Learning (FIBL) blends the flipped classroom model—where students engage with content asynchronously before class—with in-class inquiry-based activities and collaborative problem-solving. Despite the promise of FIBL, there is a significant research gap regarding its efficacy in secondary science classrooms in developing nations like the Philippines, where resource limitations and large class sizes are common. Tan et al. Al (2024) evaluated systemic approaches, suggesting that inquiry-based flipped

learning must be supported by school-wide infrastructure to be sustainable, particularly in contexts where resources are limited and class sizes are large, such as in developing nations like the Philippines.

This research is anchored in the constructivist perspective, which suggests that learners do not merely absorb information but actively mold their understanding through personal experiences and social exchanges. By emphasizing the role of the learner as an active participant, this study aligns with the views of Piaget (1970) and Vygotsky (1978), who argued that knowledge is a product of cognitive construction within a social environment.

Furthermore, this study adopts the Community of Inquiry (CoI) as a lens to examine how students navigate the transition between independent home study and collaborative school activities. Traditionally, CoI is used to evaluate online environments, but here it is applied to bridge the gap between pre-class preparation and in-class scientific investigation. This model ensures that teaching, social, and cognitive presences are balanced, allowing students to feel supported by the instructor while they challenge one another's ideas during group experiments. Rather than just delivering facts, the educator's role shifts toward facilitating a space where students can refine their scientific reasoning through peer-to-peer dialogue. "Classroom time thus shifts toward advanced social interaction, collaborative problem-solving, and refinement of interpersonal competencies, transforming physical spaces into hubs for higher-order skill development" (Bergmann & Sams, 2012). "Empirical evidence consistently demonstrates that this approach enhances academic performance, scientific reasoning, motivation, and critical thinking" (Akçayır & Akçayır, 2018). "By relocating direct instruction to asynchronous home-based technology, instructors can dedicate class periods to project-based inquiry and group activities that promote active knowledge construction" (Bishop & Verleger, 2013). "The rapid evolution of educational technology from 2021–2025 has made its integration essential, enabling dynamic instruction that equips students with vital 21st-century digital competencies" (Selwyn, 2022).

Materials and Methods

This study used a quasi-experimental pretest-posttest design with experimental and control groups. Participants comprised 78 Grade 12 students from Victoria High School, evenly divided into an experimental group (n = 39) receiving Flipped Inquiry-Based Learning (FIBL) and a control group (n = 39) taught via traditional lecture methods. Both groups completed a pretest to establish baseline knowledge. During the intervention, the experimental group accessed pre-class video lectures and materials at home, followed by in-class inquiry-based activities. The control group received standard lecture instruction. Data were collected using a validated teacher-made science test, ensuring content validity and reliability. Analysis involved descriptive statistics (means and standard deviations) for performance trends, independent samples t-tests for between and within-group differences, and Cohen's d for effect size to assess the intervention's practical impact. Ethical protocols, including informed consent and data confidentiality, were strictly followed.

Results and Discussions

Table 1. Pretest Mean Scores in the FIBL Method & Traditional Method of the Respondents

Group	N	Mean	SD	t	p-value	Decision
Flipped Inquiry- Based Learning Method Group (Experimental Group)	39	75.17	5.42	-1.265	0.210	Fail to

Traditional Method (Control Group)	39	76.71	5.33			reject Ho

p-value ≤ 0.05 *is significant*

The pre-test analysis confirms that both the Flipped Inquiry-Based Learning (FIBL) group (M=75.17, SD=5.42) and the Traditional Method group (M=76.71, SD=5.33) began the study with comparable levels of academic proficiency in Science. An independent samples t-test yielded a p-value of 0.210, which exceeds the 0.05 significance level, leading to a failure to reject the null hypothesis. This baseline homogeneity ensures that the two groups were statistically equivalent at the start, providing a robust foundation to attribute any future gains in post-test performance directly to the pedagogical intervention rather than pre-existing disparities.

Table 2. Posttest Mean Scores in the FIBL Method & Traditional Method of the Respondents

Group	*N*	*Mean*	*SD*	*t*	*p-value*	*Decision*
Flipped Inquiry- Based Learning	*39*	*87.01*	*6.93*	*3.519*	*< .001*	*Reject Ho*
Traditional	*39*	*82.22*	*4.92*			

p-value ≤ 0.05 *is significant*

Post-intervention results reveal that the Flipped Inquiry-Based Learning (FIBL) group achieved a significantly higher mean score (M=87.01, SD=6.93) compared to the Traditional Method group (M=82.22, SD=4.92). An independent samples t-test yielded a p-value of <.001, leading to the rejection of the null hypothesis and providing empirical evidence that the FIBL framework is a superior alternative for enhancing student understanding. These findings are consistent with recent research indicating that guided inquiry-based flipped classrooms are highly effective at improving student learning outcomes and achieving academic mastery Aidoo et al. (2022). Additionally, when well-designed flipped inquiry models are implemented, they support learners' cognitive growth and independence, fostering higher-order thinking skills that outperform traditional teacher-led instruction (Chen et al., 2025; Supornpanitkul et al., 2025).

Table 3. Comparison of the Mean Difference of the Posttest and Pretest of the Respondents

Group	N	Mean Gain	SD	t	p-value	Decision
Flipped Inquiry- Based Learning	39	11.84	3.31	11.210	< .001	Reject Ho

Traditional	39	5.51	1.22			

p-value ≤ 0.05 *is significant*

Analyzing the mean gain performance reveals that both groups experienced significant academic growth, though the Flipped Inquiry-Based Learning (FIBL) group achieved a substantially higher mean gain (M=11.84, SD=3.31) compared to the Traditional Method group (M=5.51, SD=1.22). A paired-samples t-test resulted in a p-value of <.001, leading to the rejection of the null hypothesis and confirming that while both groups improved, the FIBL approach facilitated much more pronounced progress. These results align with the findings of Olona et al. (2025); Conde-Izquierdo et al. (2025), who demonstrated that students in flipped inquiry settings consistently achieve higher scores on performance-based assessments than those receiving traditional instruction.

Table 4. Effect of FIBL in Science of the Respondents

Group		Mean Gain	Mean Difference		p-value	*Cohen's d*
Traditional Method (Control Group)	9	11.84	6.33	1.210	< .001	2.539
Flipped Inquiry-Based Learning Method (Experimental Group)	9	5.51				

p-value ≤ 0.05 *is significant*

The findings in Table 4 revealed a substantial advantage for the Flipped Inquiry-Based Learning (FIBL) group, which achieved a mean gain of 11.84 compared to 5.51 in the control group. With a t-value of 11.210 and a p-value of <.001, the performance gap is statistically significant and not due to chance. Furthermore, a Cohen's d of 2.539 represents a "large effect size," indicating that the FIBL method had a transformative and profound impact on student achievement. These results align with research by Borasheva (2025), which suggests that flipped environments drive improved performance by increasing student participation and providing more opportunities to actively apply knowledge (Soimaneewan et. al., 2024; Lubis et. al., 2024).

Based on the study's findings, the researcher concluded that while both instructional approaches—the Flipped Inquiry-Based Learning (FIBL) method and the traditional classroom setting—led to better student performance in science, they were not equally effective. Although both groups showed progress, the experimental group utilizing the FIBL method achieved a statistically significant advantage. Students in this group didn't just improve; they outperformed their peers in the control group, demonstrating a notably higher mean gain in their post-test scores. Ultimately, the data suggest that the integration of flipped inquiry-based learning serves as a more powerful catalyst for academic growth than conventional teaching

methods alone.

It is recommended that educators adopt the FIBL method to foster greater student engagement through both active and individualized learning. Research has demonstrated that purposeful scaffolding and structured inquiry activities within flipped classrooms significantly enhance student participation. This approach is particularly effective in diverse classrooms, as e-scaffolding helps students with varying levels of prior knowledge achieve higher cognitive development. Furthermore, in-class time can be more effectively utilized for collaborative, inquiry-oriented projects when core content is delivered asynchronously. For successful implementation, teachers require specific training to build the necessary techno-pedagogical competencies and confidence. To ensure successful implementation, school administrators should prioritize professional development programs that equip teachers with the essential skills to integrate the FIBL strategy into their pedagogical toolkit. As Aslan (2022) emphasized, for successful implementation, teachers require training to build the necessary techno-pedagogical competencies and confidence. Because this study focused on specific areas of science, future research is highly encouraged to test the effectiveness of FIBL across different subjects and topics to determine its broader potential for enhancing academic achievement.

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