



ENHANCING GRADE 9 STUDENTS' ANALYTICAL THINKING SKILLS THROUGH INQUIRY-BASED SCIENCE INSTRUCTION (IBSI)

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ABSTRACT

Analytical thinking is essential in science education because it enables students to examine information, interpret evidence, identify relationships, and formulate logical conclusions. However, teaching practices that emphasize factual recall may provide limited opportunities for students to develop these higher-order thinking skills. This study examined the effectiveness of Inquiry-Based Science Instruction (IBSI) in enhancing the analytical thinking skills of Grade 9 students. The study was completed in December 2025 during the School Year 2025-2026 at a private school in Labason, Zamboanga del Norte, Philippines. A one-group pretest–posttest quasi-experimental design was employed with 33 Grade 9 students who demonstrated Moderate, Low, or Very Low analytical thinking skills during the screening assessment. The intervention was implemented over four weeks through eight sessions structured using the 5E instructional model. A validated multiple-choice test was administered before and after the intervention, and the data were analyzed using descriptive statistics and a paired-samples t-test. Results showed an upward movement in the participants' analytical thinking performance following the intervention, with several students progressing to the High level and a substantial decrease in the number of students classified at the Low level. The paired-samples t-test further revealed a statistically significant improvement in analytical thinking skills after the intervention. These findings suggested that IBSI provided meaningful opportunities for students to investigate scientific questions, analyze information, evaluate evidence, and formulate reasoned conclusions. The study recommended strengthening and sustaining learner-centered and inquiry-oriented approaches to promote higher-order thinking skills in science education.

Keywords: *Analytical thinking skills, Grade 9 students, Inquiry-based science instruction, 5Es instructional model, Science education*

INTRODUCTION

Analytical thinking skills are essential for students to effectively solve scientific problems and grasp complex scientific concepts. Inquiry-Based Science Instruction (IBSI), which actively engages students through questioning, investigation, and evidence-based reasoning, has emerged as a promising pedagogical approach for developing these higher-order cognitive skills (Lin et al., 2020). Research by Saritepeci (2020) and Lin et al. (2020) highlights that both inquiry-based and design-based learning approaches significantly improve students' problem-solving and reasoning capabilities. Additionally, Thawatchoti et al. (2023) found that applying problem-based learning strategies can enhance the analytical thinking abilities of Grade 9 students in science. Recent evidence further supports the value of inquiry-oriented approaches in developing higher-order thinking. Alanazi et al. (2024) reported that scaffolding strategies combined with guided discovery significantly improved students' higher-order thinking skills compared with conventional instruction. Similarly, Antonio and Prudente (2023), in their meta-analysis, found that inquiry-based approaches had positive effects on students' higher-order thinking skills in science. Arifin et al. (2025) likewise reported a substantial positive effect of inquiry-based learning on students' critical thinking skills, highlighting its potential for cultivating higher-order cognitive processes in science education. The 5E inquiry-based learning model has also been shown to improve students' analytical thinking, demonstrating the potential of structured inquiry activities to support the development of these skills (Namonsai et al., 2023). Together, these findings suggest that inquiry-oriented and appropriately supported learning environments can provide students with meaningful opportunities to analyze information, evaluate evidence, and develop reasoned conclusions.

Further support for inquiry-oriented instruction is provided by Kabatas Memis and Ergun (2023), who found that an argumentation-based inquiry approach positively affected students' academic achievement and analytical thinking skills. Kwinram et al. (2022) likewise reported improvements in science learning achievement and analytical thinking among Grade 7 students through 5E inquiry-based learning combined with graphic organizers. In addition, Hariyono et al. (2021) examined analytical thinking skills through inquiry-based learning in science, further emphasizing the relevance of inquiry-oriented instruction in developing students' higher-order thinking skills.

Despite its potential, many Grade 9 students continue to struggle with analytical thinking, largely due to traditional teaching practices that prioritize rote memorization over critical inquiry. Although previous studies have shown the benefits of inquiry-based instruction for younger learners, such as preschoolers and elementary students (Lin et al., 2020; Schlatter et al., 2020), empirical research on its effectiveness in secondary school science—particularly concerning analytical thinking—is still limited. Moreover, how IBSI

specifically fosters the development of analytical thinking in science problem-solving remains underexplored, signaling a need for more targeted investigation.

This study aimed to address these gaps by examining the effects of Inquiry-Based Science Instruction on the analytical thinking skills of Grade 9 students in the context of science problem solving.

Research Questions

This study aimed to determine the effectiveness of Inquiry-Based Science Instruction in enhancing the analytical thinking skills of Grade 9 students. Specifically, it sought to answer the following questions:

1. What is the level of the Grade 9 students' analytical thinking skills before the intervention?
2. What is the level of the Grade 9 students' analytical thinking skills after the intervention?
3. Is there a significant difference in the Grade 9 students' analytical thinking skills before and after the intervention?

METHODOLOGY

Locale of the Study

The study was conducted in a private school in Labason, Zamboanga del Norte, Philippines. The school served as the setting for the administration of the research instruments and the implementation of the Inquiry-Based Science Instruction intervention. The name of the institution was not disclosed because permission to identify the school had not been obtained.

Respondents and Sampling Method

The respondents of the study were Grade 9 students enrolled in the selected private school in Labason, Zamboanga del Norte. The participants were selected based on their availability, willingness to participate, and identified low analytical thinking skills, as determined through a screening assessment conducted before the intervention.

The study used purposive sampling, as the participants were intentionally selected based on predetermined criteria relevant to the purpose of the study. The respondents' demographic information, such as age and sex, was included in the Results section when available.

Research Instruments

The primary instrument of the study was a 50-item multiple-choice test designed to assess the analytical thinking skills of Grade 9 students in Science. The test covered core Science concepts from biology, chemistry, physics, and Earth science.

The items assessed inquiry-based analytical thinking processes, including analyzing data, evaluating evidence, identifying patterns, interpreting information, and forming evidence-based conclusions. The test was administered as a pretest before the intervention and as a posttest after the intervention to determine changes in the students' analytical thinking skills.

An observation tool was also used, as applicable, to monitor students' participation and engagement during the Inquiry-Based Science Instruction activities.

Validation of the Instruments

The research instruments underwent expert validation to establish their content and construct validity. A panel of experienced Science educators evaluated the test items and observation tool in terms of clarity, relevance, alignment with Grade 9 Science competencies, and appropriateness for assessing analytical thinking skills.

The comments and recommendations of the validators were considered in revising the instruments before their final administration. Where applicable, the instruments also underwent pilot testing before their actual use to identify unclear or inappropriate items and to ensure that the instruments were suitable for the intended respondents.

Data-Gathering Procedure

Before conducting the study, the researcher secured the necessary permission from the school administration and obtained the required consent from the participants and their parents or guardians, when applicable.

The data-gathering process began with a screening assessment to identify Grade 9 students who demonstrated low analytical thinking skills and met the criteria for participation. After the participants were identified, the 50-item pretest was administered to determine their baseline analytical thinking skills.

The participants then underwent the four-week Inquiry-Based Science Instruction intervention, which consisted of eight sessions conducted twice a week, with each session lasting 60 minutes. The activities involved hands-on and inquiry-based Science tasks that encouraged students to observe, ask questions, investigate, analyze data, evaluate evidence, and formulate conclusions.

During the first week, the students were introduced to Inquiry-Based Learning and participated in activities involving the formulation of questions and identification of variables. The second week focused on changes in states of matter and relationships within ecosystems. The third week involved investigations of chemical reactions and activities related to force and motion. The fourth week focused on Earth and space science simulations, followed by the administration of the posttest and student reflection through presentations of their inquiry projects.

The students' pretest and posttest scores were recorded and organized for statistical analysis.

Data Analysis and Statistical Treatment

The collected data were analyzed using descriptive and inferential statistical procedures. The mean and standard deviation were used to summarize the students' pretest and posttest scores.

A paired-samples t-test was used to determine whether there was a statistically significant difference between the students' pretest and posttest scores. This statistical treatment was appropriate because the same group of students was assessed before and after the intervention. The level of significance was set at 0.05.

The results of the statistical analysis were used to determine whether Inquiry-Based Science Instruction significantly improved the analytical thinking skills of the Grade 9 students.

Scope and Limitations

The study focused on the effectiveness of Inquiry-Based Science Instruction in improving the analytical thinking skills of selected Grade 9 students in a private school in Labason, Zamboanga del Norte. The intervention was limited to eight sessions conducted over four weeks, with each session lasting 60 minutes. The Science activities covered selected concepts from biology, chemistry, physics, and Earth science.

The study specifically measured analytical thinking skills through a 50-item multiple-choice test. Other outcomes, such as students' motivation, attitudes toward science, creativity, or long-term retention of learning, were not the primary focus of the study.

The study was limited by its use of purposive sampling, which restricted the generalizability of the findings to other Grade 9 students or schools. The one-group quasi-experimental design also did not include a separate control group, making it difficult to completely rule out other factors that may have influenced changes in students' scores. In addition, the relatively short four-week intervention limited conclusions regarding the long-term effects of Inquiry-Based Science Instruction.

RESULTS

Table 1

Descriptive Statistics of the Grade 9 Students' Analytical Thinking Skills in the Pretest

Score Range	Interpretation	Frequency	Percentage
41–50	Very High	0	0.00%
31–40	High	0	0.00%
21–30	Moderate	25	75.76%
11–20	Low	8	24.24%
0–10	Very Low	0	0.00%
	Total	33	100.00%
Mean		23.18	
Interpretation		Moderate	
Standard Deviation		4.15	

Table 2
Descriptive Statistics of the Grade 9 Students' Analytical Thinking Skills in the Posttest

Score Range	Interpretation	Frequency	Percentage
41–50	Very High	0	0.00%
31–40	High	7	21.21%
21–30	Moderate	24	72.73%
11–20	Low	2	6.06%
0–10	Very Low	0	0.00%
	Total	33	100.00%
Mean		27.67	
Interpretation		Moderate	
Standard Deviation		4.97	

Table 3
Paired-Samples *t*-Test of the Participants' Pretest and Posttest Scores

Assessment	Mean	SD	Mean Gain	<i>t</i>	df	<i>p</i>	Decision on H_0	Interpretation
Pretest	23.18	4.15	4.48	10.35	32	< .001	Reject H_0	Significant
Posttest	27.67	4.97						

DISCUSSION

The findings of the study indicated an overall improvement in the analytical thinking skills of the Grade 9 students following the implementation of Inquiry-Based Science Instruction (IBSI). The results from the three tables showed a consistent pattern of improvement, as reflected in the students' performance levels, mean scores, and inferential test results. These findings suggested that inquiry-based learning provided students with opportunities to engage in scientific processes that required analysis, interpretation, evaluation of evidence, and formulation of conclusions. However, because the study employed a one-group pretest–posttest design, the findings were interpreted as evidence of improvement associated with the intervention rather than as definitive proof that IBSI alone caused the improvement.

Analytical Thinking Skills Before the Intervention

The results in Table 1 showed that before the implementation of IBSI, most of the participants demonstrated a Moderate level of analytical thinking, while the remaining participants were classified at the Low level. The mean score of 23.18 also fell within the Moderate category. This finding indicated that although the students already possessed basic analytical abilities, these skills may not have been consistently developed enough to handle more complex scientific reasoning tasks.

The concentration of students in the Moderate and Low categories may have been related to the difficulty of applying analytical thinking processes in Science. Analytical thinking requires students not only to recall information but also to examine relationships, interpret evidence, identify patterns, compare possible explanations, and draw conclusions based on available information. The findings therefore suggested that the participants had room for further development, particularly in applying these skills to scientific problems.

This result was consistent with the concern identified in the Introduction that traditional teaching practices emphasizing factual recall may provide limited opportunities for the development of higher-order thinking skills. The literature cited in the study emphasized the importance of instructional approaches that actively engage students in inquiry, problem solving, and reasoning. Lin et al. (2020), for example, highlighted the potential of inquiry-based science instruction to support problem-solving and approaches to learning, while Thawatchoti et al. (2023) specifically reported that problem-based learning could enhance the analytical thinking skills of Grade 9 students in Science.

The pretest findings therefore provided an important baseline for understanding the participants' subsequent development. Since the students initially demonstrated mostly Moderate and Low levels, the implementation of an instructional approach that provided opportunities for investigation, evidence analysis, and scientific reasoning was appropriate for addressing their identified learning needs.

Analytical Thinking Skills After the Intervention

The results in Table 2 demonstrated a positive shift in the participants' analytical thinking performance after the implementation of IBSI. The mean score increased from 23.18 to 27.67, while the number of students classified at the High level increased from none to seven. At the same time, the number of students at the Low level decreased from eight to two. Although the overall mean interpretation remained at the Moderate level, the movement of students toward higher performance levels indicated improvement within the Moderate category as well as movement from the Moderate to High category.

This finding suggested that the inquiry-based activities may have helped students become more engaged in processes that required them to use information rather than simply recall it. The IBSI intervention involved activities in which students formulated questions, identified variables, investigated scientific phenomena, analyzed data, evaluated evidence, and developed conclusions. These processes corresponded closely with the analytical thinking skills assessed in the study.

The use of the 5Es instructional model may also have supported this development. Through Engage, students were introduced to scientific problems or situations; Explore provided opportunities for investigation; Explain allowed them to communicate and justify their understanding; Elaborate encouraged them to apply concepts to other situations; and Evaluate provided opportunities to assess their learning. The repeated use of these stages may have encouraged students to gradually move from identifying information toward interpreting evidence and applying scientific reasoning.

The findings were generally consistent with previous studies cited in the Introduction. Lin et al. (2020) found positive effects of inquiry-based science and engineering activities on students' learning and problem-solving processes. Similarly, Ramadani et al. (2021)

reported that inquiry-based learning could improve students' critical thinking and problem-solving skills in science education. The present findings also agreed with Thawatchoti et al. (2023), whose study focused specifically on Grade 9 students and found that problem-based learning enhanced analytical thinking skills in Science.

The slightly higher standard deviation in the posttest also indicated that the students did not improve at exactly the same rate. Some students reached the High level, whereas others remained in the Moderate or Low categories. This variation may have reflected differences in students' initial abilities, participation, engagement, or responsiveness to inquiry-based activities. Thus, while the overall direction of the results was positive, the findings also suggested that inquiry-based instruction may benefit from appropriate scaffolding and differentiated support, particularly for students who continued to experience difficulty with analytical tasks.

Significant Difference Before and After the Intervention

The results in Table 3 provided further evidence of improvement in the participants' analytical thinking skills. The paired-samples t-test showed a statistically significant difference between the pretest and posttest scores, $t(32) = 10.35$, $p < .001$. The null hypothesis was therefore rejected, indicating that the participants performed significantly better after the intervention than before it.

The statistical finding was further supported by the pattern of individual score changes. Thirty of the 33 participants obtained higher posttest scores, one obtained the same score, and only two obtained lower scores. This indicated that improvement was observed among the large majority of participants rather than being produced only by a small number of students with substantial gains. The increase in the mean score and the movement of participants from lower to higher performance categories further supported the positive direction of the findings.

The significant improvement may have been explained by the nature of the IBSI activities implemented during the intervention. The activities required students to engage in questioning, investigation, observation, experimentation, data interpretation, evidence evaluation, and explanation. These processes directly involved the types of analytical thinking skills assessed in the study. In addition, the intervention was structured around the 5Es model, which provided students with repeated opportunities to encounter scientific problems, investigate them, explain their findings, apply their understanding, and evaluate their conclusions.

The findings were consistent with the related literature presented in the study. Ramadani et al. (2021) reported positive effects of inquiry-based learning on students' critical thinking and problem-solving skills in science education. Similarly, Thawatchoti et al. (2023) found that problem-based learning enhanced the analytical thinking skills of Grade 9 students. The findings also corresponded with Udonsathian and Worapun (2024), who reported positive effects of a 5E inquiry learning model combined with a 5W1H technique on Grade 8 students' analytical thinking skills in Science. These studies provided support for the present finding that inquiry-oriented learning environments could provide students with opportunities to develop higher-order thinking skills.

The results were also consistent with the broader argument presented in the Introduction that inquiry-based instruction promoted active learning through questioning, investigation, and evidence-based reasoning. Rather than limiting students to recalling scientific concepts, inquiry-oriented activities required them to work with information, examine evidence, identify relationships, and justify their explanations. These experiences may have helped students develop more systematic approaches to solving scientific problems.

However, the statistically significant improvement needed to be interpreted in consideration of the study's methodological limitation. The study used a one-group pretest–posttest quasi-experimental design and did not include a control group. Consequently, other factors, such as maturation, familiarity with the assessment, regular classroom instruction, or other learning experiences, may have contributed to the observed improvement. The significant difference therefore demonstrated that the students' analytical thinking skills improved during the period of the intervention, and this improvement was associated with their exposure to IBSI. However, the result could not establish with complete certainty that IBSI was the sole cause of the observed change.

Overall Interpretation of the Findings

Taken together, the results from Tables 1, 2, and 3 showed a consistent pattern of positive development in the analytical thinking skills of the Grade 9 participants. Before the intervention, the students were concentrated in the Moderate and Low categories. After the intervention, the mean score increased, seven students reached the High level, and the number of students in the Low category decreased substantially. The paired-samples t-test further confirmed that the difference between the pretest and posttest scores was statistically significant.

The findings supported the potential of Inquiry-Based Science Instruction as an approach for developing analytical thinking in Grade 9 Science. The results were generally consistent with the studies cited in the Introduction, particularly those emphasizing inquiry-based, problem-based, and 5E instructional approaches for developing higher-order thinking, problem-solving, and reasoning skills.

Nevertheless, the continued concentration of students in the Moderate category and the presence of two students at the Low level indicated that the development of analytical thinking required sustained instructional support. The four-week intervention provided meaningful improvement; however, continued exposure to inquiry-based activities, progressively complex scientific problems, scaffolding, and differentiated instruction may have been necessary for students to achieve higher levels of analytical thinking.

Future studies could use larger samples, longer intervention periods, comparison groups, and delayed posttests to provide stronger evidence regarding the effectiveness and long-term impact of IBSI. Such approaches could also help determine whether the observed improvements were sustained over time and were attributable more specifically to the intervention.

Conclusions

The study concluded that the selected Grade 9 students needed further development in analytical thinking before the intervention. While most of the participants demonstrated a

Moderate level, a considerable group performed at the Low level, and none reached the High or Very High categories. These findings showed that the participants needed structured learning experiences that could strengthen their ability to examine scientific information, identify relationships, evaluate evidence, and formulate logical conclusions.

Following the implementation of Inquiry-Based Science Instruction, the participants demonstrated meaningful and statistically significant improvement in their analytical thinking skills. Several students progressed to the High level, while the number of students classified at the Low level decreased substantially. Although the overall mean level remained Moderate, the upward movement in scores and the significant difference between the pretest and posttest results indicated that the participants' analytical thinking skills improved during the intervention period. Given the one-group pretest–posttest design, this improvement was associated with the implementation of IBSI but could not be attributed exclusively to the intervention.

Continued and longer implementation of inquiry-based activities, together with appropriate scaffolding and differentiated support, may be necessary to help more students attain the High and Very High levels of analytical thinking.

Recommendations

Inquiry-Based Science Instruction may be continuously incorporated into Grade 9 Science lessons, particularly in competencies that require experimentation, data interpretation, problem-solving, and evidence-based reasoning. Teachers may provide regular opportunities for students to formulate questions, investigate scientific phenomena, analyze results, compare explanations, and justify conclusions. Students who remain at the Low level may be provided with additional scaffolding, guided inquiry activities, and targeted remediation to address specific analytical thinking difficulties.

The intervention may also be extended beyond four weeks to allow students to engage in more frequent and progressively challenging inquiry experiences. Regular formative assessments may be administered to monitor students' development and identify analytical skills that require further attention. Teachers may also use the results of these assessments to adjust instructional strategies and provide differentiated support based on students' learning needs.

Future action research may involve a larger number of participants, a longer intervention period, a comparison group, and a delayed posttest to provide stronger evidence of the effectiveness of IBSI. These methodological improvements may also help determine whether the observed gains in analytical thinking are sustained over time and can be more confidently associated with Inquiry-Based Science Instruction.

Compliance with Ethical Standards

The researchers ensured that all ethical standards were observed throughout the conduct of the study. Before the data-gathering process, informed consent was obtained from the respondents and, when applicable, from their parents or guardians. The respondents were properly informed about the purpose, procedures, and nature of the study and were made aware that their participation was voluntary. They were given the freedom to refuse

participation or withdraw from the study at any time without penalty or negative consequences.

The anonymity and confidentiality of the respondents were maintained by not disclosing their names or other personally identifiable information in the research report. All information and data collected were handled in accordance with applicable data privacy principles and were used only for legitimate research purposes. The researchers also safeguarded the physical, emotional, and academic well-being of the respondents throughout the study and ensured that participation in the research did not cause unnecessary harm, discomfort, or disadvantage.

The researchers declared that there was no conflict of interest that could influence the conduct or findings of the study. Plagiarism, fabrication, falsification, and other forms of academic dishonesty were strictly avoided, and all sources used in the study were properly acknowledged and cited. The researchers maintained objectivity and took measures to minimize bias in the collection, analysis, interpretation, and presentation of the findings. The data and results obtained from the study were used solely for academic and research purposes and were not used for purposes unrelated to the study.

Furthermore, the researchers disclosed that artificial intelligence (AI) tools were used only as aids in drafting, organizing, and improving the language of portions of the research manuscript. The researchers remained responsible for verifying the accuracy, originality, interpretation, and final content of the study. AI tools were not used to fabricate, manipulate, or falsify research data, results, or findings.

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