WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Structured and Confirmation Inquiries in Designing Cross-Cutting Science Lessons in Reinforcing Scientific Thinking Skills

*Ivy C. De Villa-Alzaga[a], Elisa N. Chua PhD[b]**

[a]Secondary School Teacher I, Kapayapaan Integrated School, Calamba City, Laguna, 4027, Philippines
[b]Doctor of Philosophy, Laguna State Polytechnic University-San Pablo City Campus, San Pablo City, Laguna, 4000, Philippines

A B S T R A C T :

This study aimed to reinforce scientific thinking skills on students by designing cross-cutting lessons with the help of inquiry-based learning approach types which are the structured and confirmation inquiries. This descriptive experimental research which determined the effectiveness of the IBL and CCCs integration used a pre-performance and post-performance test regarding the students' scientific thinking skills. The test items are mostly adopted from PISA items which targets the student's critical, creative and problem-solving STS. The respondents were the one hundred fifty-two (152) Grade 9 students of Kapayapaan Integrated School at Canlubang Calamba City, Laguna comprising of four sections which are assigned as the Structured-Pattern group, Structured-Cause & Effect group, Confirmation-Pattern group and Confirmation-Cause & Effect group. The study was undertaken during the third quarter of the school year. Data were collected and analyzed using mean, standard deviation and two-way repeated measures ANOVA. Results showed that there is a significant difference between pre-performance level and post-performance levels of the students who were exposed to the teaching instruction which shows a p-value of <.001. These findings suggests that the use of cross-cutting concepts in IBL approach has been effective in reinforcing scientific thinking skills on students such as creative, critical and problem-solving.

Keywords: Inquiry-Based Learning, Cross-cutting Concepts, Scientific Thinking Skills

1. Introduction :

The Philippine school system still has to overcome a number of serious obstacles. These significant challenges have great impact to the quality of education in the country. Many schools, especially public ones, still use antiquated teaching techniques (McMurdock, 2023). Some key issues are poverty, overcrowded classrooms, insufficient learning resources, access to education in remote areas, early childhood education, and nutrition and health. Efforts are being made to address these challenges such as trainings and seminars of the teachers; however, it remains undeniable that after undergoing numerous trainings and seminars, teachers still lack effective teaching practices when it comes to instruction delivery in the classroom (Francisco & Celon, 2020). In addition, some students may find it difficult to adjust to new tactics employed in daily lessons, which can lead to a lack of efficacy. Educators and curriculum implementors must conduct additional study and develop new strategies in order to help students succeed in their classrooms in light of these difficulties (Ras, 2024).

Since the educational system in our country had been gone through a lot of changes. There are lot of expectations from the teachers as the curriculum implementers and from the students as the center of teaching and learning process. The education system needs to cope up with the 21st century. A classroom where teachers are the center of learning process shifted to student-centered classroom (Garcia et.al, 2020). Teachers became the facilitator of learning inside the classroom. A student-centered curriculum is designed for students, and it utilizes students' interests, experiences, and backgrounds.

Science curriculum for grades 3 through 10 aims to attain students' scientific, environmental, technological, and engineering literacy according to DEPED Matatag Curriculum. After meeting the curriculum's objectives, students will be prepared to actively engage in local, national, and international settings and meaningfully contribute to a world that is changing, varied, and rapidly increasing. Filipino students will exhibit the skills outlined in the Basic Education Development Plan (BEDP) 2030 by finishing their science curriculum. In order to achieve these objectives, the student must be able to acquire science literacy which is one of the aspects in education. Being science literate is about being capable of applying perceived ideas, not just knowing evidence. The most important goal in science education is that the students should be scientifically literate. Scientific literacy is the capacity to engage with issues relating to scientific knowledge and ideas, including the capacity to evaluate and design scientific discoveries as well as interpret and prove data scientifically (OECD, 2019; Ahmad, 2023). OECD/PISA defines scientific literacy as follows: "Scientific literacy is the capacity to use scientific knowledge, to identify questions, to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity." This statement suggests that it is not just the knowledge and processes that teachers must inculcate in students' minds, but how they understand these knowledge and processes and turn into meaningful learning.

Scientific literacy is essential to comprehend and interact with the world around us (Kelp et.al, 2023). It includes the ability to ask questions, find solutions, and apply scientific knowledge to daily situations; it goes beyond simply understanding scientific facts. Some key aspects of scientific literacy are understanding scientific concepts, scientific inquiry, critical thinking, and application to real-world issues. Understanding scientific concepts includes knowledge of fundamental scientific facts and principles, such as rules of physics, structure of DNA, or the principles of ecology. Scientific inquiry is the capacity to carry out experiments, record observations, and reach evidence-based conclusions. This procedure aids people in comprehending the creation and validation of scientific information. On the other hand, critical thinking is composed of making educated decisions based on data, separating reliable sources from false information, and critically assessing scientific claims. Students may also apply their scientific literacy to real-world problems by using scientific knowledge to confront and comprehend concerns like health care, technological breakthroughs, and climate change. Encouraging inquiry-based learning, incorporating these components into educational systems, and offering opportunity for practical experiences through science centers, museums, and other unofficial learning settings are all part of fostering scientific literacy (Lee et.al, 2023).

Additionally, one aspect of scientific literacy is scientific thinking which is defined as a cognitive process that solves a basic problem by identifying its underlying causes. It is the capacity to think like a scientist, or more accurately, the habit. It is what sets true experts in any subject apart from others who are just passingly familiar with it based on a few statistics and some jargon (Working Voices, 2024).
Using the above statement from OECD/PISA as evidence, inquiry-based learning is an approach that can help the students to be engaged by making real-world connections, of course, by means of exploration and high-level questioning which is parallel to the goal of inquiry-based learning approach. Students are allowed to follow their natural curiosity and are actively involved in the learning process in this kind of learning environment.

2. Methodology

2.1. Research Design

A descriptive experimental research design was used to determine the effectiveness of the type of inquiry-based approaches such as structured inquiry and confirmation inquiry in reinforcing scientific thinking skills among grade 9 students. Descriptive experimental research is a combination of depicting the participants or respondents in an accurate way, and a manipulation to determine their effect on the dependent variables while experimental research is commonly used in sciences, wherein one or more variables are manipulated to determine their effect in the dependent variables (Upen, 2021). The variables on this design are identified as the types of inquiry-based learning strategies which are structured and confirmation inquiry and the integration of the types of cross-cutting concepts which are the patterns and cause and effect as the independent variables and the students' scientific thinking skills such as critical scientific thinking, creative scientific thinking and problem-solving scientific thinking as the dependent variables. The independent and dependent variables are appropriate to be studied.

2.2. Respondents of the Study

This study was conducted during the third quarter of the school year 2024-2025. The researcher involved the participants of one hundred sixty-five (165) students from four different sections of Grade 9 students of Kapayapaan Integrated School in Brgy. Canlubang, Calamba City, Laguna consisting of forty-one (41), forty (40), forty-two (42) and forty-two (42) students per section, respectively. However, only one hundred fifty-two (152) students completed the data since some students were not able to take the pre-test or post-test. Specifically, these student-respondents are those who demonstrated lower Mean Percentage Scores (MPS) in the first to fourth quarterly examinations in science, as identified through the F-1 score distribution and supported by the statistical results gathered from the previous school year. This group was selected to provide focused insights on how the intervention could support learners who may be struggling academically in the subject.

The study was designed to involve four groups consisting of students from the first section were exposed to structured – pattern cross-cutting concept, the other section are the structured inquiry group using the cause and effect cross-cutting concept, another section as the confirmation – pattern cross-cutting concept group and the last other section was the confirmation – cause and effect cross-cutting concept group who undergone the intervention. The researcher selected the sections that are grouped heterogeneously according to their abilities, skills, and performances.

2.3. Research Instruments

Before conducting the study, all instruments utilized were first validated by a group of validators which include teacher III, head teachers, master teachers, and education program specialists from different schools and divisions. A pre- and post-performance test instrument was utilized by the researcher to determine the effectiveness of these inquiry-based learning approaches in designing cross-cutting science lessons in enhancing students' scientific thinking skills. The test items were adopted from the PISA items released by OECD. The pre-performance assessment was given before the execution of the inquiry-based learning approaches integrated with CCCs. This helped the researcher to determine if the respondents have the same abilities, skills, and performance or not. If they are not, then they are the appropriate respondents of the study since there is a need to utilize heterogenous groups for more credible results. After the implementation of the pre-performance test, the validated lesson exemplar was constructed by the teacher which was in line with the inquiry model of John Dewey. Lesson exemplars used include structured inquiry with pattern and cause and effect CCCs, and confirmation inquiry with patterns and cause and effect CCCs. The researcher also included the process of the integration of cross-cutting science lessons in making the lesson exemplars. In addition, in analyzing how students will engage in the specific components of the CCC that the teacher selected for the lesson, the researcher used the ASET CCC Grade-Band indicators. The researcher also designed activity sheets for all the groups that served as students' resources during the exposure of the inquiry-based learning approach types such as structured and confirmation inquiry which integrated cross-cutting concepts. After the implementation of the IBL approach types with CCCs, the post-performance assessment was administered to determine which of the strategies became effective and if these approaches were effective in improving students' scientific thinking skills.

2.4. Research Procedure

This study utilized two inquiry-based approaches—structured inquiry and confirmation inquiry—in designing cross-cutting science lessons aimed at improving the scientific thinking skills of Grade 9 students. These skills include critical scientific thinking, creative scientific thinking, and problem-solving scientific thinking. Structured inquiry provided guided learning experiences where students followed provided procedures to arrive at expected outcomes, while confirmation inquiry allowed students to verify known concepts through experimentation and reflection. These approaches were integrated into various science topics to encourage deeper cognitive engagement and enhance students' analytical and reasoning abilities.

The first phase of the study involved administering a pre-performance test to assess the baseline scientific thinking skills of the participants. This diagnostic phase was essential in identifying specific areas of weakness among the students, enabling the researchers to tailor their instructional interventions accordingly. The analysis of the pre-test results guided the development of lesson plans that strategically embedded inquiry-based tasks to target the learners' gaps. By aligning the instructional design with the identified needs, the researchers ensured that the program was both relevant and responsive to the students' academic context.

The second phase involved planning research instruments such as lesson exemplars anchored in the John Dewey's inquiry cycle and ASET cross-cutting concepts grade-band descriptors, performance assessments which have test items adopted from the PISA items, and activity sheets that are utilized during the implementation of the treatments on the groups of students. Prior to their use in the intervention, all research instruments underwent a rigorous validation process. Subject matter experts, including science educators and curriculum specialists, reviewed the instruments to ensure their content validity, appropriateness for the Grade 9 level, and alignment with the intended learning outcomes. Feedback from the validation process was used to refine and finalize the materials, ensuring that they were pedagogically sound and effective in achieving the study's objectives.

The third phase involved the actual implementation of the intervention among the respondents, who were Grade 9 students. During this phase, the designed lessons and instructional materials—based on structured and confirmation inquiry approaches—were delivered over a specified period. The implementation aimed to provide students with hands-on, inquiry-driven learning experiences that would enhance their critical, creative, and problem-solving scientific thinking skills. Following the completion of the intervention, a post-performance test was administered to assess the extent of student improvement. The test was designed to mirror the pre-performance assessment, allowing for a direct comparison of results. The data gathered from the post-test were systematically tabulated, analyzed using appropriate statistical methods, and interpreted to determine the effectiveness of the inquiry-based teaching strategies.

2.5. Data Analysis

After the study was implemented, the pre-assessment and post-assessment scores were promptly gathered and recorded. These results were then submitted to a statistician for analysis. The data underwent statistical computation, followed by interpretation and a corresponding narrative analysis.

2.6. Ethical Considerations

The confidentiality of the respondents' information and results was strictly maintained, ensuring that access was limited solely to the researcher and the research adviser.

2.7. Statistical Treatment of Data

The pre-performance and post-performance scores of the respondents were collected and undergone tabulation and analysis with the utilization of simple descriptive statistics such as mean and standard deviation.

To test the difference in the pre-performance and post-performance levels of all groups (structured – patterns CCC, structured – cause and effect CCC, confirmation – patterns CCC and confirmation – cause and effect CCC) as well as its mean gain score, a statistician used two-way repeated measures ANOVA since this study comprised more than two groups.

3. Results and Discussion

Table 1. Pre-Performance Level of the Students on their Scientific Thinking Skills as to Critical Thinking Skills

Inquiry-based Learning Group	Cross-cutting Integration Group	Mean	Std. Deviation	f	Verbal Interpretation
Structured Inquiry	Pattern	76.79	4.108	38	FS
	Cause and Effect	79.13	5.014	38	FS
	Ave. Mean	**77.96**	**4.703**	**76**	**FS**
Confirmation Inquiry	Pattern	79.13	7.238	38	FS
	Cause and Effect	77.34	4.593	38	FS
	Ave. Mean	**78.24**	**6.088**	**76**	**FS**
Total	Pattern	77.96	5.963	76	FS
	Cause and Effect	78.24	4.860	76	FS
	Overall Mean	**78.10**	**5.423**	**152**	**FS**

Legend: *75.00 and below = Did Not Meet Expectation; 75.01 – 81.49 = Fairly Satisfactory; 81.50 – 88.49 = Satisfactory; 88.50 – 94.49 = Very Satisfactory; 94.50 – 100.00 = Outstanding*

Table 1 reveals that all four groups are on fairly satisfactory ratings, with a mean of 76.79, 79.13, 79.13 and 77.34, respectively. This indicates that, the four groups prior to the implementation of the experiment have limitations on their critical scientific thinking skills. It suggests that students were likely struggling with essential critical thinking processes, such as analyzing arguments, evaluating evidence, and interpreting information in meaningful ways. It is observed in their pre-performance that they have little knowledge about the concepts of El Niño and La Niña. Some of them answered the question directly, some even did it in bullet form, and other students did not able to answer the question about difference of the two climatic phenomena. This reflected basic attempts to distinguish the two but lacks depth, clarity, and accuracy, indicating that student has some exposure to the topic but needs further guidance to understand the scientific concepts clearly and make meaningful comparisons.

On the other hand, on numbers 33-50 in the pre-performance, the questions are all about characteristics of stars and its uses in early civilizations, and how and why do stars appear to move on the sky. The students' answers present general ideas but lack detail or scientific accuracy. They also used words such as "navigations", "telling time", "farming season" but they did not able to explain how and why. Some of them described stars incorrectly. In addition, students answered that stars are indeed moving in the night sky but struggles to explain the cause. Some mentioned Earth's rotation but stated it incorrectly. The students' responses demonstrate a basic awareness of the topics being discussed; however, their explanations are generally underdeveloped and reveal several misconceptions. In many instances, scientific terms are used inaccurately or out of context, indicating a lack of deep understanding. Furthermore, the connections between key concepts and ideas are limited or unclear, suggesting that students are struggling to integrate and apply their knowledge effectively. These issues highlight the need for targeted guidance, instructional support, and clarification in order to help students construct a more accurate and comprehensive understanding of the subject matter.

Table 2. Pre-Performance Level of the Students on their Scientific Thinking Skills as to Creative Thinking Skills

Inquiry-based Learning Group	Cross-cutting Integration Group	Mean	Std. Deviation	f	Verbal Interpretation
Structured Inquiry	Pattern	85.53	6.880	38	S
	Cause and Effect	84.50	6.805	38	S
	Ave. Mean	**85.01**	**6.817**	**76**	**S**
Confirmation Inquiry	Pattern	83.08	6.478	38	S
	Cause and Effect	81.39	6.193	38	S
	Ave. Mean	**82.24**	**6.352**	**76**	**S**
Total	Pattern	84.30	6.751	76	S
	Cause and Effect	82.95	6.649	76	S
	Overall Mean	**83.63**	**6.712**	**152**	**S**

Legend: *75.00 and below = Did Not Meet Expectation; 75.01 – 81.49 = Fairly Satisfactory; 81.50 – 88.49 = Satisfactory; 88.50 – 94.49 = Very Satisfactory; 94.50 – 100.00 = Outstanding*

For Table 2, it was observed that the pre-performance levels of creative thinking among the four experimental setups were remarkably similar, making the comparisons fair for later. All groups were rated at a satisfactory level, indicating that their creative thinking skills were moderately developed. At this level, students can generate ideas and approaching tasks with some originality. However, they may lack depth, flexibility, or fluency in their creative output—meaning their ideas might be conventional or lack refinement. They can engage in creative tasks but may require prompts, structure, or support to fully explore novel approaches or think "outside the box." In the pre-performance, it was observed that the students illustrated greenhouse effect but some of them failed to use the correct labels. Some students also failed to follow the instructions and just copied the reference illustration above without using the provided patterns by the teacher. Arrows are used but not clearly labelled as incoming or outgoing radiation. There is a minimal creativity or visual clarity, where diagram is understandable but not polished. Some also showed minor errors in label placement. Based on the observations discussed above, it is evident that the students met the basic expectations of the task. Their responses demonstrate a general understanding of the greenhouse effect, indicating that they have grasped the fundamental concepts, even if not in full depth. Additionally, they were able to use the provided patterns and labels with a fair degree of accuracy, though occasional errors suggest the need for further clarification and reinforcement to solidify their comprehension.

These findings emphasize the critical importance of nurturing and enhancing creative thinking skills through the use of Inquiry-Based Learning (IBL) integrated with Crosscutting Concepts (CCCs). This instructional approach fosters an environment that encourages divergent thinking, intellectual risk-taking, and the exploration of novel and original ideas. By allowing students to engage in inquiry-driven activities, they are better equipped to think independently, challenge assumptions, and develop innovative solutions to complex problems. Furthermore, the pre-performance results serve as a valuable benchmark for assessing student progress, providing a clear reference point for evaluating the growth and development of creativity throughout the course of the intervention. This highlights the effectiveness of structured yet flexible learning experiences in cultivating creativity, which is essential for both academic success and real-world application.

Table 3. Pre-Performance Level of the Students on their Scientific Thinking Skills as to Problem-Solving Thinking Skills

Inquiry-based Learning Group	Cross-cutting Integration Group	Mean	Std. Deviation	f	Verbal Interpretation
Structured Inquiry	Pattern	81.61	8.049	38	S
	Cause and Effect	85.26	8.636	38	S
	Ave. Mean	**83.43**	**8.494**	**76**	**S**
Confirmation Inquiry	Pattern	85.45	8.349	38	S
	Cause and Effect	83.87	7.349	38	S
	Ave. Mean	**84.66**	**7.853**	**76**	**S**
Total	Pattern	83.53	8.372	76	S
	Cause and Effect	84.57	7.996	76	S
	Overall Mean	**84.05**	**8.176**	**152**	**S**

Legend: *75.00 and below = Did Not Meet Expectation; 75.01 – 81.49 = Fairly Satisfactory; 81.50 – 88.49 = Satisfactory; 88.50 – 94.49 = Very Satisfactory; 94.50 – 100.00 = Outstanding*

Table 3 shows that all setup groups had a Satisfactory level in problem-solving scientific thinking skills during the pre-assessment. This indicates that students had a basic grasp of scientific inquiry and could handle routine problems using familiar strategies. However, they struggled with complex or unfamiliar tasks requiring deeper reasoning and concept integration. Their responses often lacked depth, included misconceptions, and misused scientific terms, revealing limited understanding. These findings highlight the need for targeted instruction to develop higher-order thinking and strengthen conceptual clarity.

It was observed in the students' pre-performance where they were asked to choose an image to reflect and how does this happened and what can day do as a student to prevent this from happening. Some of the students clearly selected one image and gave a basic explanation of what is happening and described the situation with enough accuracy to show they understand the issue, but with limited depth. They provided a reasonable explanation of how the problem happened, though it may be general or surface-level and they missed deeper causes. Some offered a solution and preventive actions that are typical and student-centered but lack creativity or depth. Some answered correctly but did not clearly show analysis of the problem, evaluation of alternatives, or justification for chosen actions and offered first solution that comes to mind, without weighing other options.

Table 4. Post- Performance Level of the Students on their Scientific Thinking Skills as to Critical Thinking Skills After the Exposure to Inquiry-based Learning and Cross-Cutting Concepts

Inquiry-based Learning Group	Cross-cutting Integration Group	Mean	Mean Diff.	Std. Deviation	f	Verbal Interpretation
Structured Inquiry	Pattern	85.79	9	6.952	38	S
	Cause and Effect	89.92	10.79	8.335	38	VS
	Ave. Mean	**87.86**	**9.9**	**7.902**	**76**	**S**
Confirmation Inquiry	Pattern	90.21	11.08	7.056	38	VS
	Cause and Effect	88.16	10.82	6.025	38	S
	Ave. Mean	**89.18**	**10.94**	**6.598**	**76**	**VS**
Total	Pattern	88.00	10.04	7.305	76	S
	Cause and Effect	89.04	10.8	7.278	76	VS
	Overall Mean	**88.52**	**10.42**	**7.286**	**152**	**VS**

Legend: *75.00 and below = Did Not Meet Expectation; 75.01 – 81.49 = Fairly Satisfactory; 81.50 – 88.49 = Satisfactory; 88.50 – 94.49 = Very Satisfactory; 94.50 – 100.00 = Outstanding*

Table 4 reveals an increase in the critical thinking levels of learner-respondents across all four learning setups following the treatment. The overall mean of 88.52 with a mean difference of 10.42, implied that the learners improved their critical scientific thinking skills after the exposure to the experiment. This improvement marks a transition in performance from a fairly satisfactory to a very satisfactory level for most groups, indicating a substantial enhancement in their critical thinking abilities.

During the experiment, the students were able to hone their critical scientific thinking skills by doing their group activities such as Analyzing Historical Climatic Data (Patterns of Droughts, Floods and Extreme weather) where students provided the information they have searched on the internet and interpreted those data; Global Temperature Pattern Over Time where students interpreted them by creating graphs; and last Topics with Causes and Effects where students from the structured group formulated effects and students from confirmation group made a link between its causes and effect. In addition, they were able to investigate the patterns of constellations using a phone application named Stellarium where students draw some constellations, identify their cardinal positions, search the time or season of their appearance by making outline and explain how and why these constellations move in the night sky. This upward shift implies that students have become more adept at recognizing biases, evaluating evidence, constructing well-reasoned arguments, and thinking independently. They are more reflective, analytical, and systematic in their thought processes. Notably, the only exception was the Structured-Pattern Group, which, while still showing progress, remained at the satisfactory level, suggesting a more modest improvement compared to the others. The differentiated outcomes among the groups may reflect the varying degrees of cognitive stimulation and learner autonomy embedded in each learning setup. Groups that reached the very satisfactory level likely benefited from the intervention they have undergone that fostered their critical thinking skills. Meanwhile, the relatively lower gains in the Structured-Pattern Group may suggest a need to re-examine the instructional design to better support the development of critical thinking skills among students.

Overall, the findings affirm the positive impact of the intervention on students' critical thinking skills. These findings are also parallel to the study of Kotsis (2024) which states that integrating inquiry-based learning into the teaching and learning process or to the curriculum enhances educational outcomes where students' scientific literacy and critical thinking skills can be fostered.

Table 5. Post- Performance Level of the Students on their Scientific Thinking Skills as to Creative Thinking Skills After the Exposure to Inquiry-based Learning and Cross-Cutting Concepts

Inquiry-based Learning Group	Cross-cutting Integration Group	Mean	Mean Diff	Std. Deviation	f	Verbal Interpretation
Structured Inquiry	Pattern	89.13	3.6	8.464	38	VS
	Cause and Effect	90.26	5.76	7.172	38	VS
	Ave. Mean	**89.70**	**4.69**	**7.813**	**76**	**VS**
Confirmation Inquiry	Pattern	88.79	5.71	6.905	38	VS
	Cause and Effect	88.92	7.53	6.820	38	VS
	Ave. Mean	**88.86**	**6.62**	**6.817**	**76**	**VS**
Total	Pattern	88.96	4.66	7.674	76	VS
	Cause and Effect	89.59	6.64	6.984	76	VS
	Overall Mean	**89.28**	**5.65**	**7.320**	**152**	**VS**

Legend: *75.00 and below = Did Not Meet Expectation; 75.01 – 81.49 = Fairly Satisfactory; 81.50 – 88.49 = Satisfactory; 88.50 – 94.49 = Very Satisfactory; 94.50 – 100.00 = Outstanding*

Table 5 shows a marked increase in the creative thinking levels of learner-respondents across all four different learning setups following the treatment. This upward shift in performance—from satisfactory to very satisfactory—indicates that students have developed a stronger ability to think outside the box, generate original and flexible ideas, and approach problems with greater creativity and innovation. During the experiment, the students were able to enhance their creative scientific thinking skills by doing concept map, flow charts, and illustrations/diagrams about the climatic phenomena. After every activity, the students were given an opportunity to present their works on the board and shared their learnings to the class. In addition, each group were asked to make constellation models of their chosen constellations from different cardinal positions. And as usual, they will present their works to the class.

Students have grown more confident in trying new ideas, taking intellectual risks, and exploring different perspectives. This progress suggests that the learning environments effectively fostered their creativity by encouraging exploration, open-ended thinking, and self-expression.

As presented in the table, the highest mean score was observed in the Structured-Cause-and-Effect Group, suggesting that this particular setup was especially effective in fostering creative thinking. The structure may have provided enough guidance while still allowing students to explore cause-and-effect relationships in inventive ways such as the cause-and-effect flow chart and the constellation shadow box that they made. In contrast, the lowest mean score was recorded in the Confirmation-Pattern Group, which may indicate that this setup, while still beneficial, provided fewer opportunities for divergent thinking or creative exploration compared to the others.

Overall, the results highlight the positive impact of the intervention in enhancing students' creative thinking, with an overall mean of 89.28 and a mean difference of 5.65. The findings suggest that Inquiry-Based Learning (IBL), integrated with Crosscutting Concepts (CCCs), effectively promotes scientific thinking by encouraging exploration, creativity, and innovation. This aligns with the study by Krit et al. (2024), which found that high school students exposed to IBL showed significant improvements in both critical and creative thinking. Unlike traditional content-focused methods, IBL engages students in active problem-solving and independent thinking, leading to greater cognitive development.

Table 6. Post- Performance Level of the Students on their Scientific Thinking Skills as to Problem-Solving Thinking Skills After the Exposure to Inquiry-based Learning and Cross-Cutting Concepts

Inquiry-based Learning Group	Cross-cutting Integration Group	Mean	Mean Diff	Std. Deviation	f	Verbal Interpretation
Structured Inquiry	Pattern	88.08	6.47	8.238	38	S
	Cause and Effect	89.55	4.29	8.436	38	VS
	Ave. Mean	**88.82**	**5.39**	**8.315**	**76**	**VS**
Confirmation Inquiry	Pattern	92.45	7	6.538	38	VS
	Cause and Effect	89.97	6.1	6.796	38	VS
	Ave. Mean	**91.21**	**6.55**	**6.740**	**76**	**VS**
Total	Pattern	90.26	6.73	7.707	76	VS
	Cause and Effect	89.76	5.19	7.612	76	VS
	Overall Mean	**90.01**	**5.96**	**7.638**	**152**	**VS**

Legend: *75.00 = Did Not Meet Expectation; 75.01 – 81.49 = Fairly Satisfactory; 81.50 – 88.49 = Satisfactory; 88.50 – 94.49 = Very Satisfactory; 94.50 – 100.00 = Outstanding*

Table 6 reveals a continued upward trend in the problem-solving scientific thinking levels of learner-respondents across the different learning setups, except for the Structured-Pattern Group. For most groups, performance levels improved from satisfactory to very satisfactory, indicating a significant enhancement in students' ability to analyze problems more thoroughly, identify effective strategies, and apply adaptive thinking in complex or unfamiliar scenarios. This improvement suggests that the learning interventions provided meaningful opportunities for students to develop more strategic, reflective, and independent problem-solving approaches. During the experiment, the students investigated the historical climatic data where they collected and analyzed real historical data, identified trends or patterns which involved interpreting complex information and applying it to real-world contexts which is a key-element of problem solving. They also examined actual temperature data over a decade which required them to analyze critically, form evidence-based conclusion and understand causal relationship. The cause-and-effect flow charts enhanced their abilities to sequence events logically, identify the root causes and understand systemic interactions which are skills that are useful in analyzing complex environmental problems. In addition, students analyzed star characteristics (color, size and temperature) and are prompted to draw cause-and-effect conclusions. This encouraged scientific reasoning and helps students investigate celestial movement as a problem to solve. Students also simulated real-world astronomical observations using virtual tool such as Stellarium to solve the problem of constellation visibility, forming conclusions about Earth's motion and perspective. Notably, the highest post-performance mean was recorded in the Confirmation-Pattern Group, which not only outperformed the other groups in this domain but also achieved the highest post-test mean across all three domains assessed—problem-solving, critical thinking, and creative thinking. This result underscores the potential effectiveness of the Confirmation-Pattern approach in stimulating comprehensive cognitive development. However, the Structured-Pattern Group did not show the same level of progress, maintaining only a satisfactory rating post-intervention. This may imply that the structured-pattern approach offered less cognitive flexibility or fewer opportunities for students to engage in deeper problem analysis and innovative solution-finding.

These findings highlight the importance of IBL integrated with CCC in shaping learners' cognitive outcomes and suggest that approaches encouraging inquiry, reflection, and flexible thinking may be particularly effective in enhancing scientific problem-solving skills. This result is parallel to the study of Gunawan et.al (2020) when inquiry model is combined with other teaching techniques it improves students' problem-solving skills. Overall, Tables 1 to 6 reveal a consistently positive outcome across all assessed domains—namely, critical scientific thinking skills, creative scientific thinking skills, and problem-solving scientific thinking skills. Each domain exhibited a marked increase from students' pre-performance to their post-performance scores. This significant improvement strongly indicates that students were able to effectively develop and enhance these essential thinking skills after being exposed to the inquiry-based learning (IBL) approach integrated with cross-cutting concepts (CCCs). The upward trend in performance suggests that the instructional strategy not only deepened students' conceptual understanding but also empowered them to think more critically, creatively, and analytically—skills that are foundational for academic success and meaningful engagement with real-world scientific problems.

Table 7. Test of the Significant Difference in the Pre-Performance Levels of the Four Groups of Students

Source	F	Sig.	Partial Eta Squared
Creative Thinking			
Inquiry-based Learning Alone	1.735	.221	.014
Cross-cutting Integration Alone	1.605	.207	.011
Interaction	.095	.759	.001
Critical Thinking			
Inquiry-based Learning Alone	.100	.752	.001
Cross-cutting Integration Alone	.100	.752	.001
Interaction	1.616	.210	.017
Problem-solving Scientific Thinking			
Inquiry-based Learning Alone	.865	.354	.006
Cross-cutting Integration Alone	.624	.431	.004
Interaction	1.961	.168	.020

***Legend:** * - Significant at a = 0.05. For Partial Eta Squared, < .010 = Very Small Effect; .011 – .059 = Small Effect; .060 – .139 = Moderate Effect; ≥ .140 = Large Effect*

Table 7 presents the results of a two-way ANOVA conducted to analyze the pre-performance levels of students in three key domains: creative thinking, critical thinking, and scientific problem-solving. These performance levels were categorized based on two factors: the type of Inquiry-Based Learning (IBL) implemented—Structured versus Confirmation—and the type of Crosscutting Concept (CCC) integrated—Patterns versus Cause and Effect. The statistical analysis reveals that there were no significant differences among the groups in terms of their initial skill levels across all three domains. This suggests that, prior to the intervention, students in all groupings exhibited comparable abilities in creative, critical, and scientific thinking.

Such findings are important because they establish a fair and balanced baseline for measuring the effects of the intervention. By ensuring that all groups started from a similar level of competency, the researcher was able to reduce potential bias and strengthen the internal validity of the study. This careful consideration of prior student performance allowed for more accurate attribution of any observed improvements to the specific instructional strategies employed, rather than to pre-existing differences in student ability. Consequently, the groupings used in the study were appropriately matched and well-suited for a meaningful comparison of the impact of different IBL and CCC integration strategies.

These findings mean that the students were initially chosen and heterogeneously placed by skill, but the pre-performance scores reflect an equal beginning performance, attesting to the fairness of comparison groups. Because the students had not yet been given the intervention, no instructional benefit had yet affected their thinking skills—so there were equal scores to begin. In addition, the application of standardized test items to all groups yielded an equal baseline measure, minimizing the likelihood of variation due to item difficulty or familiarity. And finally, all groups had been taught the same general science in previous quarters, so they were equally prepared beforehand.

Table 8. Test of the Significant Difference in the Post-Performance Levels of the Four Groups of Students on their Scientific Thinking Skills After the Exposure to Inquiry-based Learning and Cross-Cutting Concepts

Source	F	Sig.	Partial Eta Squared
Creative Thinking			
Inquiry-based Learning Alone	.496	.482	.003
Cross-cutting Integration Alone	.279	.598	.002
Interaction	.175	.676	.001
Critical Thinking			
Inquiry-based Learning Alone	1.317	.253	.009
Cross-cutting Integration Alone	.805	.371	.005
Interaction	7.127	.008	.046
Problem-solving Scientific Thinking			
Inquiry-based Learning Alone	3.824	.052	.025
Cross-cutting Integration Alone	.167	.684	.001
Interaction	2.597	.109	.017

Legend: ** - Significant at a = 0.05. For Partial Eta Squared, < .010 = Very Small Effect; .011 – .059 = Small Effect; .060 – .139 = Moderate Effect; ≥ .140 = Large Effect*

Table 8 shows a Two-Way ANOVA analysis of students' post-performance levels in three domains—creative thinking, critical thinking, and problem-solving scientific thinking—categorized by inquiry-based learning type (Structured vs. Confirmation) and cross-cutting concept integration (Patterns vs. Cause and Effect). No statistically significant main effects on either the inquiry learning category or the type of cross-cutting integration were found. No significant interaction effects were also found for any of the domains, since all p-values were greater than 0.05, and the partial eta squared values were all very small to small in magnitude. This suggests that none of the four instructional designs (Structured–Pattern, Structured–Cause and Effect, Confirmation–Pattern, Confirmation–Cause and Effect) were found to perform statistically better on the post-test in all of the domains. Overall, these results suggest that all of the four instructional designs were equally effective in improving the scientific thinking ability of the students since all treatments gave an increase to their post-performance test when compared to their pre-performance test. While score gains were found in all instances, no specific combination of inquiry type and cross-cutting integration led to statistically larger post-test performance gains.

The results can be interpreted from several perspectives. First, both the confirmation and structured inquiry approaches successfully engaged students in meaningful, student-centered scientific activities. These strategies promoted active participation, critical thinking, and hands-on exploration, allowing learners to construct knowledge through direct experience and guided investigation. This outcome aligns with the findings of Toma (2022), which revealed that confirmation and structured inquiry approaches did not result in statistically significant differences in students' achievement motivation when compared to traditional lecture-based teaching methods. This suggests that while both inquiry-based approaches foster deeper engagement and experiential learning, their impact on motivation may be comparable to more conventional strategies, depending on how they are implemented and the context in which they are applied. Nevertheless, their strength lies in enhancing students' involvement in the learning process, encouraging them to take ownership of their learning through exploration and inquiry.

Similarly, pattern and cause-and-effect notions are as effective in creating mental relationships with scientific phenomena in nature which is also stated in NextGenSci (2020) that these concepts help students from coherent mental models and improve their ability to predict and explain natural events. Hence, all the implemented learning models contributed to creating positive and engaging learning environments, which in turn fostered student participation and active involvement in the learning process. These favorable conditions led to consistent and comparable improvements across various domains, resulting in relatively equal gains in student performance and skill development. This suggests that the instructional strategies were effective in supporting diverse learners and promoting meaningful learning experiences.

Table 9. Test of the Significant Difference in Scientific Thinking Skills of the Students in their Pre-Performance and Post-Performance when Grouped according to Structured and Confirmation Inquiry Approaches

Group	Paired Differences (Pre-test vs. Post-test)					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% CID				
				Lower	Upper			
Structured-Pattern	-12.66	5.76	.94	-14.55	-10.76	-13.54*	37	<.001
Structured-Cause&Effect	-14.08	6.05	.98	-16.07	-12.09	-14.35*	37	<.001
Confirmation-Pattern	-15.45	6.84	1.11	-17.70	-13.20	-13.92*	37	<.001
Confirmation-Cause&Effect	-14.87	6.30	1.02	-16.94	-12.80	-14.55*	37	<.001

Legend: *Significant at a* = 0.05*

Table 9 presents the results of the test of the significant difference in scientific thinking skills of the students in their pre-performance and post-performance when grouped according to structured and confirmation inquiry approaches. All four groups attained statistically significant differences in their post-performance scores with p-values of less than .001. The Structured-Pattern group recorded a mean gain of 12.66 points, whereas the Structured-Cause-and-Effect group attained a greater gain of 14.08 points. Between the Confirmation Inquiry groups, the Pattern group recorded the highest gain of 15.45 points, followed closely by the Cause-and-Effect group with a gain of 14.87 points. These results confirm all instruction methods utilized in the study to be effective in enhancing learners' scientific thinking skills. The substantial gains realized during observation can be attributed to several instructional factors. First, the models of inquiry employed—Structured and Confirmation Inquiry—both constructivist in nature, inviting students to construct meaning through active participation and guided discovery. Confirmation Inquiry, in particular, may have yielded higher gains due to the consolidation of known concepts, which allows for more internalization and logical testing of ideas. Second, the integration of cross-cutting concepts such as patterns and cause-and-effect relationships may have allowed for the construction of conceptual relationships among subjects, enabling higher-order thinking. The structuring of activities, consistent with John Dewey's cycle of inquiry and grounded in actual PISA-based test items, may have allowed for students' greater engagement, learning relevance, and performance measurement.

The results in Table 9 have both practical and theoretical implications. First, the results show that within a short time frame (e.g., within a certain grading period) systematic pedagogical innovations can produce measurable learning improvements. Second, the results validate the flexible use of either Structured or Confirmation Inquiry, or either Pattern or Cause-and-Effect cross-cutting strategies, to augment the critical, creative, and problem-solving scientific thinking of students. This attests to the feasibility of these instructional designs in accordance with the MATATAG Curriculum and Basic Education Development Plan (BEDP) 2030. Third, the study attests to the worth of heterogeneously grouped classes, where students of varying ability can equally enjoy inquiry-based, conceptually integrated science learning. These practices are crucial in preparing Filipino learners for international tests like PISA 2025 and for long-term scientific literacy and capability.

4. Conclusions

The findings of the study showed that there is no significant difference between the scientific thinking skills of the students in the pre-performance and post-performance when grouped according to structured and confirmation inquiry approaches. The interventions, Inquiry-based Learning and Cross-cutting Integration, reveal no significant differences in pre-performance levels of students across the three scientific thinking skills, and the observed effects were generally small to very small suggesting that prior to the intervention, students across groups had relatively similar baseline capabilities in the assessed domains. In addition, none of the four instructional designs (Structured–Pattern, Structured–Cause and Effect, Confirmation–Pattern, Confirmation–Cause and Effect) were found to perform statistically better on the post-performance in all of the domains. Overall, these results suggest that all of the four instructional designs were equally effective in improving the scientific thinking ability of the students. All four groups attained statistically significant differences in their post-performance scores with p-values of less than .001. The Structured-Pattern group recorded a mean gain of 12.66 points, whereas the Structured-Cause-and-Effect group attained a greater gain of 14.08 points. Between the Confirmation Inquiry groups, the Pattern group recorded the highest gain of 15.45 points, followed closely by the Cause-and-Effect group with a gain of 14.87 points. These results confirm all instruction methods utilized in the study to be effective in enhancing learners' scientific thinking skills.

REFERENCES

1. Acdedios. (2019, December 3). PISA 2018 Results: Philippines Ranks Lowest in Reading. PISA 2018. https://www.philippinesbasiceducation.us/2019/12/pisa-2018- results-philippines-rank.html
2. Aditomo, A., & Klieme, E. (2020). Forms of inquiry-based science instruction and their relations with learning outcomes: Evidence from high and low-performing education systems. International Journal of Science Education, 42(4), 504-525.
3. Afful, A. M., Hamilton, M., & Kootsookos, A. (2020).Towards space science education: Astudy of students' perceptions of the role and value of a space science program. ActaAstronautica, 167, 351–359.
4. Ahmad, M. S., Rahayu, Y. S., & Sukarmin, S. (2023). Training Scientific Literacy Skills Through Inquiry Learning with Chemcollective's Virtual Laboratory on Chemical Equilibrium. Jurnal Penelitian Pendidikan Sains (JPPS), 12(2), 155–175. https://doi.org/10.26740/jpps.v12n2.p155-175
5. Andersen, L. (2022). Use of Crosscutting Concepts as Epistemic Heuristics. In *Proceedings of the 16th International Conference of the Learning Sciences-ICLS 2022, pp. 1205-1208*. International Society of the Learning Sciences.
6. Antonio, R.P. & Prudente M.S. (2024). Effects of inquiry-based approaches on students' higher-order thinking skills in science: A meta-analysis. *International Journal of Education in Mathematics, Science and Technology (IJEMST, 12*(1), 251-281. http://doi.org/10.46328/ijemst.3216
7. Aytac, T., & Selen Kula, S. (2020). The Effect of Student-Centered Approaches on Students' Creative Thinking Skills: A Meta-Analysis Study. *International Journal of Contemporary Educational Research*, *7*, 2148–3868. https://doi.org/10.33200/ijcer.723894
8. Baur, A., & Emden, M. (2020). How to open inquiry teaching? An alternative teaching scaffold to foster students' inquiry skills. Chemistry Teacher International, 3(1). https://doi.org/10.1515/cti-2019-0013
9. Beaty, R. E., Cortes, R. A., Merseal, H. M., Hardiman, M. M., & Green, A. E. (2023). Brain networks supporting scientific creative thinking.*Psychology of Aesthetics, Creativity, and the Arts.* Advance online publication. https://doi.org/10.1037/aca0000603
10. Berie, Z., Damtie, D., & Bogale, Y. N. (2022). Inquiry-Based Learning in Science Education: A Content Analysis of Research Papers in Ethiopia (2010–2021). *Education Research International*, *2022*(1), 6329643.

11. Board of Regents of the University of Wisconsin System. (2022). *Inquiry-Based Learning*. University of Wisconsin Extended Campus. https://ce.uwex.edu/tip-sheets/Inquiry-basedlearning.pdf#:~:text=With%20inquiry-based%20learning%2C%20the%20learner%20selects%20a%20topic,concludes%20with%20a%20written%20report%2C%20presentation%2C%20or%20both.
12. Brunsell, E., Alderton, E. D., & Morris, J. (2021). Integrating Crosscutting Concepts and Literacy Strategies to Support Visual Literacy. *Science Scope*, *44*(6), 48-55.
13. Chandraja, C. V., Ajayan, T., Raskin, S., & George, M. (2024). INNOVATIVE PEDAGOGIES: ADAPTING TEACHING STRATEGIES FOR MODERN LEARNING ENVIRONMENTS. *21st Century Teaching and Learning in Classrooms*, 978-93-6252-523–9. https://www.iipseries.org/assets/docupload/rsl2024AFB362D7F2D6F33.pdf
14. Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2021). 21st century skills development through inquiry-based learning from theory to practice. Springer International Publishing.
15. Coffman, T. (2017). Inquiry-based learning: Designing instruction to promote higher level thinking. Rowman & Littlefield.
16. Council, N. R. (2012). A framework for K-12 science education. In *National Academies Press eBooks*. https://doi.org/10.17226/13165
17. DC Francisco, C., & C. Celon, L. (2020). *Teachers' Instructional Practices and Its Effects on Students' Academic Performance* [Research Paper, Bulacan State University]. https://files.eric.ed.gov/fulltext/ED607985.pdf
18. Department of Education. (2022, June 2). *DepEd to launch Basic Education Development Plan 2030 as strategic roadmap for basic education* | https://www.deped.gov.ph/2022/06/02/deped-to-launch-basic-education-development-plan-2030-as-strategic-roadmap-for-basic-education/#:~:text=June%202,%202022%20%E2%80%94%20The%20Department%20of%20Education%20(DepEd)%20is
19. Dwita Dana Pradipta, Madlazim, & Eko Hariyono. (2021). The Effectiveness of Science Learning Tools Based on Education Sustainable Development (ESD) to Improve Problem-Solving Skills. *IJORER : International Journal of Recent Educational Research*, *2*(3), 342-353. https://doi.org/10.46245/ijorer.v2i3.113
20. Fatimah, S., Rosidin, D. N., & Hidayat, A. (2022). Student-based Learning in The Perspective of Constructivism Theory and Maieutics Method. International Journal Of Social Science And Human Research, 5(5), 1632-1637.
21. Garcia, R., Tan, R. D., Florendo, J., & Santos, N. (2020, October 22). *Student-Centered Learning in General EducationinaPrivate University in Manila: an analysis*. https://journals.acspublisher.com/index.php/cijahe/article/view/13131
22. García-Carmona, A. (2023). Scientific thinking and critical thinking in science education. *Science & Education*. https://doi.org/10.1007/s11191-023-00460-5
23. Gholam, A. P. (2019). Inquiry-based learning: Student teachers' challenges and perceptions. *Journal of Inquiry and Action in Education*, *10*(2), 6.
24. Goggins, M., Haas, A., Grapin, S., Llosa, L., & Lee, O. (2019, September). *Integrating Crosscutting Concepts into Science Instruction*. NSTA. https://www.nsta.org/science-and-children/science-and-children-september-2019/integrating-crosscutting-concepts-0
25. Gunawan, G., Harjono, A., Nisyah, M., Kusdiastuti, M., & Herayanti, L. (2020). Improving Students' Problem-Solving Skills Using Inquiry Learning Model Combined with Advance Organizer. International Journal of Instruction, 13(4), 427-442. https://doi.org/10.29333/iji.2020.13427a
26. Harri, V. (2019, July 19). *Introducing middle school students to the crosscutting concepts : Classroom Science*. California Classroom Science. https://classroomscience.org/articles/ngss/next-generations-science-standards/introducing-middle-school-students-crosscutting-concepts#:~:text=The%20seven%20crosscutting%20concepts%20are%20patterns%3B%20cause%20and,matter%3B%20structure%20and%20function%3B%20and%20stability%20and%20change
27. Kaluzeviciute, G., & Willemsen, J. (2020). Scientific thinking styles: The different ways of thinking in psychoanalytic case studies. *The International Journal of Psychoanalysis*, *101*(5), 900-922. https://doi.org/10.1080/00207578.2020.1796491
28. Kaplan, Z. (2023, June 27). *What is creative thinking? Definition and examples*. Forage. https://www.theforage.com/blog/skills/creative-thinking
29. Kelp, N. C., McCartney, M., Sarvary, M. A., Shaffer, J. F., & Wolyniak, M. J. (2023). Developing science Literacy in Students and Society: Theory, research, and practice. *Journal of Microbiology and Biology Education*, *24*(2). https://doi.org/10.1128/jmbe.00058-23
30. Krit, P., Som, R & Chai, S. (2024). The Influence of Inquiry-Based Learning on High School Students' Critical and Creative Thinking Skills. Journal of Loomingulisus ja Innovatsioon, 1(4), 190-198.https://doi.org/10.70177/innovatsioon.v1i4.1706
31. Mahanal, S., Zubaidah, S., Sumiati, I. D., Sari, T. M., & Ismirawati, N. (2019). RICOSRE: A Learning Model to Develop Critical Thinking Skills for Students with Different Academic Abilities. *International Journal of Instruction*, *12*(2), 417-434.
32. McMurdock, M. (2023, July 28). *Crisis in teaching quality may explain stagnant learning recovery, report finds.* American's Education News Report. https://www.the74million.org/article/crisis-in-teaching-quality-may-explain-stagnant-learning-new-report-finds/
33. Momoh, O. (2024, July 24). *Population: Definition in Statistics and how to Measure it*. Investopedia. https://www.investopedia.com/terms/p/population.asp
34. National Science Teaching Association. (2019). *Integrating Crosscutting Concepts into Science Instruction*. https://www.nsta.org/science-and-children/science-and-children-september-2019/integrating-crosscutting-concepts-0#:~:text=In%20this%20section,%20we%20provide%20classroom%20vignettes%20of%20how%20a
35. Next Gen ASET. (2019). *Crosscutting Concepts (CCC)s*. https://www.nextgenaset.org/crosscutting-concepts-cccs/
36. NextGenScience. (2020). *Crosscutting concepts*. Next Generation Science Standards. https://www.nextgenscience.org/
37. Ningtyas, P.K., Widarti, H.R., Parlan, P., Rahayu, S., & Dasna, I.W. (2024). Enhancing students' abilities and skills through science leaning integrated STEM: A systematic literature review. International Journal of Education in Mathematics, Science, and Technology (IJEMST), 12(5), 1161-1181. https://doi.org/10.46328/ijemst.4292

38. OECD (2023), PISA 2022 Results (Volume I): The State of Learning and Equity in Education, PISA, OECD Publishing, Paris, https://doi.org/10.1787/53f23881-en.

39. Organization on Economic and Cultural Development [OECD]. (2003). Scientific Literacy. The PISA 2003 Assessment Framework - Math, Reading, Science and Problem-Solving Knowledge and Skills, 133–152 https://www.oecd.org/education/school/

40. Öztürk, B., Kaya, M., & Demir, M. (2022). Does inquiry-based learning model improve learning outcomes A second-order meta-analysis. *Journal of Pedagogical Research*. https://doi.org/10.33902/jpr.202217481

41. Paolini, A. (2015). Enhancing teaching effectiveness and student learning outcomes. *The Journal of Effective Teaching*, *15*, 20–33. https://files.eric.ed.gov/fulltext/EJ1060429.pdf

42. Penini, M. (2024, August 9). *What is Inquiry-Based Learning? Types, Phases, and Benefits - Acer for Education*. Acer for Education. https://acerforeducation.acer.com/education-trends/inquiry-based-learning-what-it-is-types-and-phases/#:~:text=Inquiry-based%20learning%20is%20an%20active%20learning%20method%20that%20encourages%20students

43. PISA 2025 Science Framework. (2023). https://pisa-framework.oecd.org/science-2025/

44. Qamariyah, S. N., Rahayu, S., Fajaroh, F., & Alsulami, N. M. (2021). The Effect of Implementation of Inquiry-Based Learning with Socio-Scientific Issues on Students' Higher-Order Thinking Skills. Journal of Science Learning, 4(3), 210-218.

45. Rahman, M. M. (2019). 21st century skill'problem solving': Defining the concept. *Rahman, MM (2019). 21st Century Skill "Problem Solving": Defining the Concept. Asian Journal of Interdisciplinary Research*, *2*(1), 64-74.

46. Ras, A. (2024). *Philippine K to 12 Implementation: Difficulties,Coping Strategies, and Insights of Public School teachers* [MA Thesis, Rizal Memorial Colleges]. https://www.ijams-bbp.net/wp-content/uploads/2024/06/5-IJAMS-MAY-2024-400-416.pdf

47. Rodil, N. M. (2021, November 19). *PAGTANAW 2050: The Philippine Science, Technology, and Innovation Foresight*. https://www.nast.dost.gov.ph/index.php/pagtanaw-2050/595-pagtanaw-2050-the-philippine-foresight-key-descriptions

48. Romi, S. (2024, March 25). *From theory to practice: Hands-on learning in education academies 2024.* Life Conceptual. https://lifeconceptual.com/hands-on-learning-in-education-academies-2024/

49. Saparbaikyzy, S., Assilbayeva, F., Botabayeva, A., Kim, O., Akparova, Z., & Bekbayeva, M. (2023). A study on scientific thinking skills and professional experience of teachers. *International Journal of Education in Mathematics, Science and Technology*, *11*(3), 570-585.

50. Simply Psychology. (2024, February 1). *John Dewey on Education: Impact & Theory*. https://www.simplypsychology.org/john-dewey.html

51. Scholl, A. (2023). What is Inquiry-Based Learning? Types, benefits, examples. SplashLearn Blog – Educational Resources for Parents, Teachers & Kids. https://www.splashlearn.com/blog/what-is-inquiry-based-learning-a-complete-overview/#2

52. Schuler, M. (2024, March 13). *What is Inquiry-Based Learning? A guide for educators*. We Are Teachers. https://www.weareteachers.com/inquiry-based-learning/

53. Simply Psychology. (2023, July 31). *Convenience Sampling (Accidental Sampling): Definition, Method & Examples*. https://www.simplypsychology.org/convenience-sampling.html

54. Syahrın, A., Suwıgnyo, H., & Prıyatnı, E. T. (2019). Creative thinking patterns in student's scientific works. *Eurasian Journal of Educational Research*, *19*(81), 21-36.

55. Sotiriou, S. A., Lazoudis, A., & Bogner, F. X. (2020). Inquiry-based learning and E-learning: how to serve high and low achievers. Smart Learning Environments, 7(1), 29.

56. *STEM Innovation for Inclusion in Early Education (STEMIE)*. (n.d.). https://stemie.fpg.unc.edu/guide-cross-cutting-concepts

57. Taber, K. S. (2019). Constructivism in education. In IGI Global eBooks (pp. 312–342). https://doi.org/10.4018/978-1-5225-7507-8.ch015

58. Talampas, M. (2024). Into the lens of Inquiry-Based Learning (IBL): student's engagement, motivation, and attitudes among Grade 10 students of an integrated high school. *Pantao, International Journal of the Humanities and Social Sciences*. https://doi.org/10.69651/pijhss030323

59. Thi Tuan, N., & Ngoc Son, P. (2025). Enhancing scientific Competency in middle school students through Inquiry-Based Learning: A case study on Water in Life. *Journal of Science Education and Technology*. https://link.springer.com/article/10.1007/s10956-025-10227-y#citeas

60. Toma, R.B. Confirmation and Structured Inquiry Teaching: Does It Improve Students' Achievement Motivations in School Science?. *Can. J. Sci. Math. Techn. Educ.* **22**, 28–41 (2022). https://doi.org/10.1007/s42330-022-00197-3

61. Upen. (2021, June 18). *Difference between descriptive and experimental research*. Pediaa.Com. https://pediaa.com/difference-between-descriptive-and-experimental-research/

62. Worgan, M. (2023, January 8). *Inquiry-based Learning: Make your classroom More inclusive*. Cambridge University Press and Assessment. https://www.cambridge.org/elt/blog/2023/01/08/inquiry-based-learning-make-your-classroom-more-inclusive/

63. Working Voices. (2024, January 20). Scientific thinking skills - Definition, types and examples. *Working Voices*. https://www.workingvoices.com/insights/scientific-thinking/#:~:text=We%E2%80%99ve%20seen%20that%20scientific

64. Zajda, J. (2021). *Constructivist Learning Theory and Creating Effective Learning Environments*. https://doi.org/10.1007/978-3-030-71575-5_3

65. Zidny, R., & Eilks, I. (2020).Integrating perspectives from indigenous knowledge and Western science in secondary and higher chemistry learning to contribute to sustainability education. SustainableChemistry and Pharmacy, 16, 100229.

66. Zion, M., & Mendelovici, R. (2012). Moving from structured to open inquiry: challenges and limits. Science education international, 23(4), 383-399.