Inquiry-Based Research Lessons in Science 8: Augmenting Teacher's Professional Knowledge and Students' Scientific Literacy

Kathrin P. Fidelino[a], Elisa N. Chua[b]

[a] *kathrin.fidelino@deped.gov.ph*, [b]*elisa.chua@lspu.edu.ph*
[a]*Department of Education, Division of Tayabas City, 4327, Philippines*
[b]*Laguna State Polytechnic University, San Pablo Campus, 4000, Philippines*

Abstract

This research investigates the impact of incorporating Inquiry-Based Research Lessons (IBRL) on teacher professional knowledge and student scientific literacy in Science 8. The study involved 85 Buenaventura Alandy National High School students, divided into two sections with similar scientific literacy levels. One section was exposed to the first implementation of research lessons, while the other experienced the second. The research process included careful planning and preparation of instruments. These instruments were validated by experts and revised as needed. Data collection involved pre-assessment tests for students and self-assessment for teachers. Employing a mixed-methods approach, the study examines the effectiveness of IBRL through qualitative classroom observations, teacher interviews, and student focus group discussions alongside quantitative pre- and post-assessment measures. Findings showed that Science teachers had high levels of professional knowledge in science content, pedagogical content, and curriculum. Implementing IBRL led to a substantial increase in the percentage of students classified as Proficient or Advanced in scientific literacy across the competencies of Explain Phenomena, Evaluate and Design, and Interpret Evidence. While there was no significant correlation between the overall effectiveness of lessons and teachers' professional knowledge, correlations were found between specific aspects of teacher knowledge and lesson effectiveness. Statistical analysis indicated a significant improvement in student performance on scientific literacy post-IBRL exposure. These results highlight the value of integrating inquiry-based approaches into science education to improve teaching practices and student learning outcomes.

Keywords: Inquiry-Based Research Lessons (IBRL); Students' Scientific Literacy; Teacher's Professional Knowledge; Lesson Study.

1. Introduction

Science is pivotal in advancing human knowledge, fostering innovation, and addressing societal challenges. Through systematic inquiry, experimentation, and investigation, science empowers us to comprehend how nature works, reveal basic realities, and discover solutions to complicated issues (American Association for the Advancement of Science, 2020). Scientific research drives technological advancements, medical breakthroughs, and environmental conservation efforts, ultimately improving the quality of life for individuals and communities worldwide. Moreover, a strong foundation in science education cultivates critical thinking skills, encourages curiosity, and promotes evidence-based decision-making, empowering individuals to navigate an increasingly complex and interconnected world (National Science Board, 2021).

Science education equips individuals with the knowledge, skills, and attitudes to engage meaningfully with scientific concepts, processes, and practices. Science education fosters inquiry-based learning and critical thinking skills by providing students with opportunities to explore the natural world, conduct experiments, and analyze data (American Association for the Advancement of Science, 2018). Furthermore, science education promotes scientific literacy, enabling individuals to understand scientific principles, evaluate scientific information, and make informed decisions about personal and societal issues. A strong science education curriculum prepares future generations to tackle global challenges, drive innovation, and contribute to scientific progress (UNESCO, 2020).

Learning science gives a higher quality of life, solves current social issues, grows interest and aptitude in the natural sciences, and promotes more scientific research. An individual with a good enough understanding of science can easily apply that knowledge to other fields. Science should, therefore, be taught to learners early in the school day (Nasution, 2018).

Inquiry-based learning principles help science education advance, and the concept of constructivism is recognized (Javier & Aliazas, 2022). Both the teacher and the student should be able to respond appropriately to the modern pedagogical approaches that must be adopted for the twenty-first century. Learners must be taught considerably more critical thinking and survival skills in the rapidly evolving and rich world of digital technology. Rather than concentrating on material or exam-oriented theories, teachers should consider how their instruction engages students and how constructivist ideas help them understand the natural world. Learners should be taught how to discover the information and abilities that are useful in everyday life, and that may be used as teaching materials (Nuangchalerm, 2014).

The Philippines underwent a thorough curriculum change in recent years, which resulted in the 2013 implementation of the Enhanced Basic Education Curriculum (K–12). The new science curriculum aims to produce productive, scientific, technological, and environmentally literate individuals who can solve complex problems, practice responsible conservation, be creative and inventive citizens, make well-informed decisions, and communicate effectively. This aligns with the intention to promote scientific literacy in students and transform them into knowledgeable, engaged citizens capable of forming opinions and choices on applying scientific information that could impact the environment, society, or health (Official Gazette of the Republic Philippines, p. 2). Thus, for in-service teachers to properly comprehend the goals of curriculum reform and acquire new pedagogical techniques, various education stakeholders must undertake teacher training efforts (Gutierez, 2015).

The Department of Education (DepEd) releases the accompanying policy on The Learning Action Cell (LAC) as a school-based K–12 Basic Education Program School-Based Continuing Professional Development Strategy for the Improvement of Teaching and Learning in compliance with the implementation of Republic Act No. 10533, also known as the Enhanced Basic Education Act of 2013. Using this guideline, DepEd demonstrates its commitment to developing teacher potential that is oriented towards their success in the profession and promotes the continuous professional growth of its teaching staff based on the lifelong learning principle (DepEd Order No. 35, s. 2016).

Additionally, various teacher training methods are used throughout DepEd to improve teaching-learning processes. Most of the time, however, these are typically top-down procedures where expert information is communicated or transferred. Lectures, workshops, short-term courses, and cascaded or echo-rich teacher training courses are good examples. Other top-down training programs, e.g., B. programs for distance study and scholarships, will be carried out over time. More seldom, but still present in some DepEd schools and departments, are bottom-up teacher training programs in which colleagues prepare courses together, conduct action research as a group, and study curriculum and pedagogy together. One way to improve teaching practices and learning outcomes is by intensifying professional learning communities through lesson study.

Most professional development initiatives in the Philippines are focused on helping teachers become more knowledgeable and proficient, changing their teaching practices, and modeling inquiry-based teaching by actively involving them as learners instead of information gatherers (Aliazas et al., 2023). However, how the investigation will be applied in scientific education is still out in the air, even with these continued efforts at teacher professional development. Researchers see Lesson study as a potentially useful school career development activity that might be implemented in the Philippines (Gutierez, 2015).

A professional development approach called Lesson Study has originated in Japan. With the help of LS's professional development model, educators may collaborate to learn and become better educators. It is based on a cycle in which educators from the same community of practice collaborate to identify a problem or objective for the classroom, create a lesson plan together, and then implement the plan with other professionals and colleagues. LS is a professional development method that encourages reflective teaching (Elipane, 2017).

Additionally, lesson study became well-known worldwide in K–12 education, teacher preparation, and university settings as a means of faculty development since it was acknowledged as a contributing factor to the consistent advancement of mathematics and scientific instruction in Japan. Because of the international employment and education that resulted from ASEAN integration in 2015, the Philippine education system faces challenges from the rise of LS as a career development model in the ASEAN countries.

Effective science teachers play a crucial role in fostering student learning, engagement, and achievement in science education. Research has shown that well-prepared and knowledgeable science teachers who utilize inquiry-based teaching strategies, provide hands-on learning experiences, and create supportive learning environments can significantly enhance students' conceptual understanding of science and promote positive attitudes toward the subject (Bybee, 2014). Moreover, effective science teachers possess strong pedagogical content knowledge, adaptability, and a passion for teaching, enabling them to cater to diverse student needs and inspire lifelong curiosity and interest in science (National Research Council, 2015).

The 21st century demands that education continue to provide life skills in the next generation so they can compete and survive in the global community. The development of technology, critical thinking, effective and efficient communication, flexibility, productivity, innovation, and responsibility are among the necessary life skills. Through education, students acquire life skills, which are then measured by their learning objectives (Andrini, 2016). Teachers should be able to address the learning demands of their students to meet the demand (Labitad & Lomibao, 2021).

Globally, the COVID-19 epidemic has drastically changed the nature of schooling. The Department of Education (DepEd) in the Philippines has made it possible for students of all backgrounds to continue their education using a variety of alternative learning modalities, such as online, blended learning, TV-based, radio-based, and modular instruction. However, implementing modular instruction presented teachers with several difficulties (Labitad & Lomibao, 2021).

At the beginning of classes under the New Normal, empirical observations and interviews among fellow science teachers in the City Schools Division of the City of Tayabas led to various positive and negative feedback. Everyone is glad that despite the situation, the Department of Education has managed to continue its advocacy of promoting the education of learners across the nation. This is shown in every basic education learning continuity plan in every school. Likewise, ready-made modules, working texts, and other supplementary materials were made available to the teachers and students. However, teachers found that most learners are unfamiliar with this type of distance learning. Most learners cannot answer the learning tasks due to limited guidance from teachers and parents. In science, teachers have identified the need to improve the given modules and work texts to improve inquiry-based learning. Science teachers themselves are not fully ready to face the situation of how inquiry-based teaching and learning can be advocated (Maylani & Georgia, 2019).

Moreover, for the past four years of teaching Science 8 at Buenaventura Alandy National High School, students' poor achievement levels in science have been documented. The mean percentage score for the quarterly exam was less than 70%, and almost half of the competencies in Science 8 were under the level of least mastered. With the current situation, the researcher thinks of a teaching approach that will encourage the students to be engaged, motivated, and understand the concept of the subject matter and augment the teacher's professional knowledge and students' scientific literacy through Lesson Study.

2. Objectives of the Study

This research aimed to determine the improvement of teachers' professional knowledge and students' scientific literacy in Science 8 through Inquiry-Based Research Lessons (IBRL). Specifically, the study sought to assess the professional knowledge of Science teachers in terms of science content, pedagogical content, and the science curriculum. It aimed to compare the pre-assessment and post-assessment performance scores of Junior High School students in Science 8 regarding their scientific literacy, focusing on their ability to explain phenomena, evaluate and design experiments, and interpret evidence. Additionally, the study sought to understand the respondents' perceptions of the effectiveness of designed research lessons in terms of the relationship and its change, cognition of children, pedagogical skills, structure of the lesson, and quality of learning. Furthermore, it aimed to determine if there is a significant relationship between the perceived effectiveness of designed inquiry-based research lessons and teachers' professional knowledge. Lastly, the research intended to identify if there is a significant difference between the pre-assessment and post-assessment performance scores of students before and after exposure to inquiry-based research lessons, specifically in their ability to explain phenomena, evaluate and design experiments, and interpret evidence.

3. Methodology

The study adopts a mixed-methods research approach, combining qualitative and quantitative methodologies to comprehensively evaluate the efficacy of inquiry-based research lessons in enhancing teacher professional knowledge and student scientific literacy in Science 8. Qualitative data entail classroom observations, teacher interviews, and student focus group discussions, while quantitative data involve pre- and post-assessment measures administered to students and self-assessment tools completed by teachers.

Purposive sampling was utilized to select 85 Grade 8 students from Buenaventura Alandy National High School, drawn from two sections based on similar scientific literacy levels. Additionally, four science teachers, encompassing the entire population of specialized teachers from the same school, were purposively chosen.

A comprehensive set of research instruments was employed to collect data. These included a Research Lesson plan, pre-/post-assessment tools for students' scientific literacy, a survey or interview guide for student feedback, a Rubric for Professional Knowledge of Science Teachers, and an Evaluation of Research Lesson form for observers. These instruments were meticulously designed, drawing from existing resources and expert input.

The study procedure commenced with meticulous planning and preparation of instruments, including the identification of learning competencies, development of a Table of Specification, construction of assessment tools, and modification of self-assessment and evaluation instruments. Subsequently, the instruments underwent rigorous validation by subject matter experts and experienced educators, followed by pilot testing and reliability assessments.

Formal permissions were sought from relevant authorities, including the school principal and the school division Superintendent, to conduct the research in compliance with ethical guidelines and institutional regulations. Participants were duly informed about the purpose and procedures of the study, ensuring informed consent and confidentiality.

Data collection encompassed various phases, including the administration of pre-assessment tests to students, completion of self-assessment tools by teachers, and the collaborative implementation of inquiry-based research lessons guided by the Lesson Study process. Post-assessment tests were administered subsequently, followed by interviews or focus group discussions with teachers and students to gather qualitative insights.

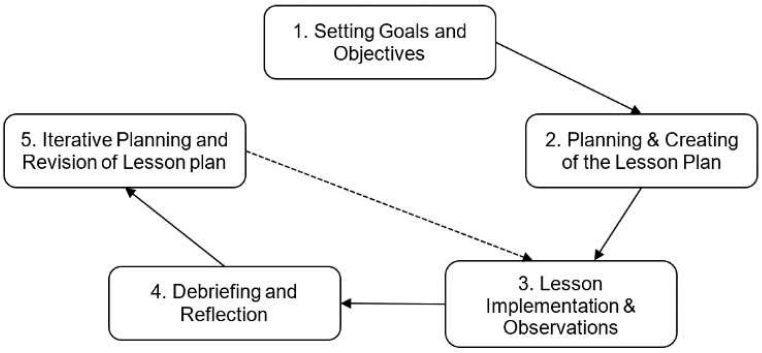

Fig. 1. Process of Lesson Study

Statistical analyses included descriptive statistics to summarize teacher professional knowledge and perceptions of lesson effectiveness, paired t-tests to assess changes in student performance pre- and post-intervention, and correlation analyses to examine the relationship between lesson effectiveness and teacher professional knowledge. Qualitative data were thematically analyzed to identify patterns and insights.

The integration of qualitative and quantitative findings facilitated a comprehensive understanding of the impact of inquiry-based research lessons on both teachers and students, thereby enriching the study's insights and implications.

4. Results and Discussion

The professional knowledge of science teachers was rigorously assessed across three pivotal domains: science content, pedagogical content, and science curriculum.

Table 1. Professional Knowledge of Science Teachers as to Science Content

Indicators	Mean	SD	VI
1. I have an extensive knowledge of basic science concepts and their applications to daily life and other disciplines.	3.70	.483	HP
2. I have a mastery of concepts considered important for all students and those that serve as enrichment topics for a particular grade or year level and can identify and address science misconceptions of students and in textbooks.	3.80	.422	HP
3. I have a good grasp of the complex relationship between science and technology, that technology is not just applied science but is a cultural response of people to problems and opportunities that then shape the way they live, think, and work.	3.90	.316	HP
4. I stay informed about recent developments in scientific research, leveraging this knowledge to inspire learners and create engaging and interesting science teaching experiences.	3.60	.516	HP
5. I know how to connect my learning to what should be taught and how to incorporate new scientific knowledge into practice.	3.80	.422	HP
Overall	3.76	.363	HP

Legend: 1.0-1.49 Not Performed (NP); 1.50-2.49 Lowly Performed (LP); 2.50-3.49 Averagely Performed (AP); 3.50-4.00 Highly Performed (HP).

Table 1 shows the outcomes of a self-assessment conducted to measure the professional knowledge of science teachers concerning science content. The data portrays a commendable level of proficiency among the surveyed teachers, underscoring a strong foundation for effective science education.

Upon examination of the data, several contributing factors to the high performance of science teachers in terms of their professional knowledge of science content emerge. Firstly, the teachers boast robust educational backgrounds, predominantly holding science-related undergraduate degrees, thereby fostering a solid grounding in the subject matter. Moreover, a significant proportion of these educators have pursued advanced studies, attaining master's degrees, thereby enriching their expertise and pedagogical understanding. Furthermore, their cumulative teaching experience, ranging from 4 to 22 years, empowers them to refine their instructional methodologies over time, adapting and honing their techniques to meet evolving student needs. Notably, an unwavering commitment to continuous professional development is evident, as evidenced by their proactive participation in training sessions and seminars dedicated to science content. This ongoing pursuit of knowledge equips them to remain abreast of cutting-edge scientific discoveries and pedagogical strategies, thereby facilitating the delivery of intricate scientific concepts with efficacy and enthusiasm.

Table 2. Professional Knowledge of Science Teachers as to Pedagogical Content

Indicators	Mean	SD	VI
1. I not only have a strong background in my subject matter but also know how to develop learners' deeper understanding of the subject matter.	3.70	.483	HP
2. I am aware of suitable science goals and learning programs for his or her students, knowing that these will necessitate change over time depending on the circumstances of learners and other relevant factors.	3.90	.316	HP
3. I know a wide range of ways in which learners are likely to learn science best, building on prior knowledge and experiences and mental constructs to introduce new experiences and ideas.	3.80	.422	HP
4. I know how to engage learners in discussions so that he or she clarifies and develops their understanding of scientific concepts under investigation.	3.90	.316	HP
5. I demonstrate strong pedagogical content knowledge by skillfully integrating subject matter expertise with effective teaching strategies, ensuring a deep understanding of how to convey complex concepts in a clear and accessible manner, and fostering meaningful learning experiences for students.	3.80	.422	HP
Overall	3.82	.333	HP

Legend: 1.0-1.49 Not Performed (NP); 1.50-2.49 Lowly Performed (LP); 2.50-3.49 Averagely Performed (AP); 3.50-4.00 Highly Performed (HP).

Table 2 explores into science teachers' professional knowledge concerning pedagogical content, revealing consistently high performance across various indicators. Educators demonstrate adeptness in both subject matter comprehension and effective teaching methodologies, adeptly fostering students' profound understanding of scientific concepts.

The noteworthy performance of science teachers concerning their professional knowledge of pedagogical content can be attributed to several pivotal factors. Firstly, their extensive teaching tenure empowers them to refine and perfect their instructional strategies over time, garnering practical insights into effective teaching and learning processes. Additionally, a significant proportion of these educators have pursued advanced studies, securing master's degrees, thereby amplifying their proficiency in both science content and pedagogy. Furthermore, consistent participation in diverse training programs and seminars, including those mandated by DepEd orders such as DepEd Order No. 53, series of 2003, underscores their commitment to staying abreast of contemporary educational practices. Such sustained professional development initiatives are instrumental in ensuring that their teaching methodologies remain contemporary and impactful. Furthermore, a systematic approach to professional growth, facilitated by regular classroom observations, empowers teachers to reflect on and enhance their pedagogical practices, fostering continual improvement and adaptability in response to student needs.

Table 3. Professional Knowledge of Science Teachers as to Science Curriculum

Indicators	Mean	SD	VI
1. I understand the philosophy and the place of science in the structure of the overall curriculum at the basic education level.	3.80	.422	HP
2. I know the content and connections of science across the different science disciplines at the basic education level and with other curricular areas.	3.80	.422	HP
3. I understand that the science education needs of all students (the future citizens) are different from the science education needs of students who have an interest in scientific careers.	3.60	.516	HP
4. I know laboratory equipment, tools, and other instructional materials to be able to work with students with varying learning needs.	3.80	.422	HP
5. I know the characteristics of good science textbooks and other instructional materials that would bring about meaningful learning for students.	3.70	.483	HP
Overall	3.74	.366	HP

Legend: 1.0-1.49 Not Performed (NP); 1.50-2.49 Lowly Performed (LP); 2.50-3.49 Averagely Performed (AP); 3.50-4.00 Highly Performed (HP).

Table 3 offers an assessment of science teachers' professional knowledge pertaining to the science curriculum, revealing consistently robust performance across diverse metrics. Educators exhibit a comprehensive grasp of the curriculum's philosophy, role within the educational landscape, and interdisciplinary connections, underscoring their proficiency in fostering meaningful learning experiences within the science curriculum.

The commendable performance of science teachers concerning their professional knowledge of the science curriculum can be attributed to a confluence of key factors. Firstly, their extensive teaching experience fosters a nuanced understanding of the curriculum's objectives and its integration with other disciplines. Additionally, a significant proportion of these educators possess advanced qualifications, including master's degrees, which equip them with a thorough understanding of curriculum development principles. Moreover, their unwavering commitment to continuous professional development ensures they remain updated on evolving curriculum guidelines and educational best practices. Furthermore, regular classroom observations afford teachers invaluable feedback, enabling them to refine their instructional strategies and ensure alignment with curriculum standards.

The synthesis of findings from Tables 1 to 3 underscores the remarkable proficiency of science teachers across three pivotal domains—science content, pedagogical content, and science curriculum. Their consistently high performance underscores their capability to deliver effective and engaging science education, thereby nurturing students' curiosity and proficiency in STEM disciplines. According to the National Research Council (2012), science educators who remain abreast of contemporary research and advancements in their field are better poised to infuse authentic scientific practices into their teaching, thereby fostering students' enduring interest and proficiency in STEM disciplines.

Table 4. Pre-assessment and Post-assessment Performance Scores in Scientific Literacy: Explaining Phenomena

TEST SCORES	PRE-ASSESSMENT		POST-ASSESSMENT	
	f	%	f	%
6 – 7 (Advance Scientific Literacy)	0	0.00	18	21.18
4 – 5 (Proficient Scientific Literacy)	2	2.35	50	58.82
2 – 3 (Emerging Scientific Literacy)	36	42.35	17	20.00
0 – 1 (Basic Scientific Literacy)	47	55.29	0	0.00
Total	85	100	85	100

Legend: f = Frequency, % = Percentage

Table 4 presents pre-assessment and post-assessment performance scores in scientific literacy, focusing on the ability to explain phenomena. Initially, most students struggled, with no students achieving Advance Scientific Literacy and only a few reaching the Proficient level. However, after inquiry-based research lessons, significant improvement was observed, with many students attaining Advance Scientific Literacy, and the majority reaching the Proficient level. The post-assessment scores reflect a complete elimination of students in the Basic category, highlighting substantial progress.

Table 5. Pre-assessment and Post-assessment Performance Scores in Scientific Literacy: Evaluating and Designing

TEST SCORES	PRE-ASSESSMENT		POST-ASSESSMENT	
	f	%	f	%
6 (Advance Scientific Literacy)	0	0.00	25	29.41
4 – 5 (Proficient Scientific Literacy)	9	10.59	46	54.12
2 – 3 (Emerging Scientific Literacy)	40	47.06	14	16.47
0 – 1 (Basic Scientific Literacy)	36	42.35	0	0.00
Total	85	100	85	100

Legend: f = Frequency, % = Percentage

Table 5 illustrates pre-assessment and post-assessment performance scores in scientific literacy, with a focus on students' ability to evaluate and design. Initially, most students were at lower literacy levels, but after the intervention, a considerable number achieved Advance Scientific Literacy and the majority reached the Proficient level. Moreover, there was a significant reduction in the number of students in the Emerging category, with none remaining in the Basic category, indicating substantial improvement.

Table 6. Pre-assessment and Post-assessment Performance Scores in Scientific Literacy: Interpreting Evidence

TEST SCORES	PRE-ASSESSMENT		POST-ASSESSMENT	
	f	%	f	%
6 – 7 (Advance Scientific Literacy)	0	0.00	41	48.24
4 – 5 (Proficient Scientific Literacy)	15	2.35	40	47.06
2 – 3 (Emerging Scientific Literacy)	49	42.35	4	4.71
0 – 1 (Basic Scientific Literacy)	21	55.29	0	0.00
Total	85	100	85	100

Legend: f = Frequency, % = Percentage

Table 6 displays pre-assessment and post-assessment performance scores in scientific literacy, emphasizing students' ability to interpret evidence. Initially, the majority of students demonstrated low literacy levels, but following the intervention, there was notable enhancement. Many students achieved Advance Scientific Literacy and a substantial number reached the Proficient level. Additionally, the number of students in the Emerging category decreased significantly, with none remaining in the Basic category, indicating considerable progress.

Based on Tables 4 to 6, prior to the inquiry-based research lessons, most students exhibited Basic or Emerging Scientific Literacy across all competencies. However, following the intervention, a significant increase was observed in students classified as Proficient or Advanced in scientific literacy across all competencies. This improvement is attributed to the active engagement, critical thinking exercises, and collaborative learning inherent in the inquiry-based approach, fostering a deeper understanding of scientific concepts and processes.

The study of Lazonder and Harmsen (2016) provides empirical support for the substantial improvements

IJRP.ORG
International Journal of Research Publications
ISSN: 2708-3578 (Online)

in scientific literacy evidenced by the pre-assessment and post-assessment scores of Grade 8 students. Their meta-analysis underscores the effectiveness of inquiry-based methodologies in enhancing students' abilities to explain phenomena, evaluate and design experiments, and interpret evidence, aligning closely with the observed enhancements in assessment scores.

Table 7. Perceived Effectiveness of Designed Research Lessons

Indicators	Mean	SD	VI
Relationship and its Change			
1. Students show varied facial expressions and body language.	3.80	.422	HE
2. The students are able to see and hear.	3.90	.316	HE
3. The students communicate with each other.	3.70	.483	HE
4. The teacher has a good relationship with students (trust).	4.00	.000	HE
Overall	3.85	.269	HE
Cognition of Children	**Mean**	**SD**	**VI**
1. Students explore learning, stumble, and struggle.	3.70	.483	HE
2. Students are allowed to make mistakes.	3.70	.483	HE
3. Teachers only guide when necessary.	3.60	.516	HE
Overall	3.67	.274	HE
Pedagogical Skills	**Mean**	**SD**	**VI**
1. Teaching strategy is engaging.	4.00	.000	HE
2. Teacher employs I-R-E (teacher initiates questions, students respond and teacher evaluates responses).	3.90	.316	HE
3. It is a dialogue and not a monologue.	3.90	.316	HE
Overall	3.93	.391	HE
Structure of lesson	**Mean**	**SD**	**VI**
1. Learning objectives are clear.	4.00	.000	HE
2. It is built on prior knowledge.	3.90	.316	HE
3. The opening activity is engaging.	4.00	.000	HE
4. Instructional Strategies/Learning Activities are effective.	4.00	.000	HE
5. Closure is effective.	4.00	.000	HE
6. There are quality assessments.	3.80	.422	HE
Overall	3.95	.082	HE
Quality of Learning	**Mean**	**SD**	**VI**
1. There is a learning experience for students where students are actively engaged in an educational encounter and they have the opportunity to acquire new knowledge, skills, or insights.	3.90	.316	HE
2. There is a quality of verbal information (oral discourse and written information).	3.70	.483	HE
3. There is a realistic level of tasks.	3.80	.422	HE
4. There is an efficiency of learning.	3.60	.516	HE
Overall	3.75	.287	HE

Legend: 1.0-1.49 Not Observed/Not Effective (NE); 1.50-2.49 Fairly Observed/Partially Effective (PE); 2.50-3.49 Observed/Effective (E); 3.50-4.00 Strongly Observed/Highly Effective (HE).

Table 7 evaluates the perceived effectiveness of designed research lessons across various indicators, including relationship dynamics, cognitive development, pedagogical effectiveness, lesson structure, and quality of learning experiences. The high mean scores across all indicators suggest that the designed research lessons effectively promote positive learning experiences. Students demonstrate active engagement, exploration, and effective communication, fostering a supportive learning environment conducive to cognitive development. Teachers employ engaging teaching strategies, clear learning objectives, and effective instructional techniques, contributing to structured and impactful lesson delivery. Moreover, the quality of learning experiences is characterized by active engagement, acquisition of new knowledge and skills, and realistic task levels, indicative of efficient and meaningful learning outcomes.

The study of Bae and Kim (2017) examined the effects of inquiry-based learning on elementary students' science achievement and attitudes, finding that IBL positively influences the relationship dynamics between students and teachers, fostering positive interactions and collaboration in the classroom. Additionally, Hong and Choi (2019) meta-analysis indicates that IBL significantly enhances students' cognitive engagement and science process skills, fostering a deeper interest in science. Llewellyn (2015) explored the effectiveness of formative assessment in a web-based inquiry-learning environment, highlighting the role of pedagogical strategies in facilitating inquiry-based experiences. Similarly, Hsu (2017) found that problem-based and inquiry-based approaches significantly improve students' achievement in geometry courses, emphasizing the importance of structured lessons in promoting deeper conceptual understanding.

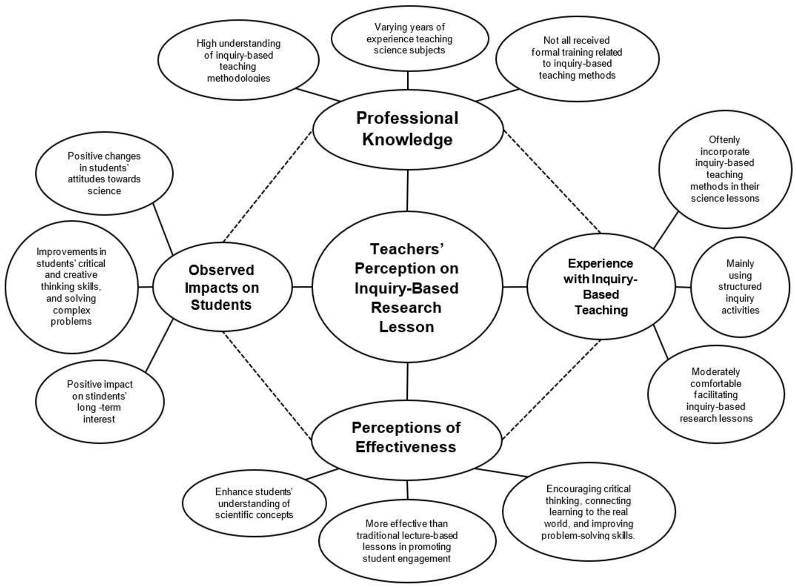

Fig. 2. Teachers' Perception of Inquiry-Based Research Lessons

Figure 2 presents teachers' perceptions of inquiry-based research lessons, highlighting key themes such as professional knowledge, experience, effectiveness, and observed impacts on students. Thematic analysis reveals positive perceptions regarding teachers' understanding and implementation of inquiry-based methodologies, with observed benefits including enhanced critical thinking and student engagement.

Similarly, Figure 3 illustrates students' perceptions, emphasizing themes such as understanding, engagement, effectiveness, and overall experience. Students express confidence in their understanding of scientific concepts and report active engagement and positive learning experiences during inquiry-based research lessons.

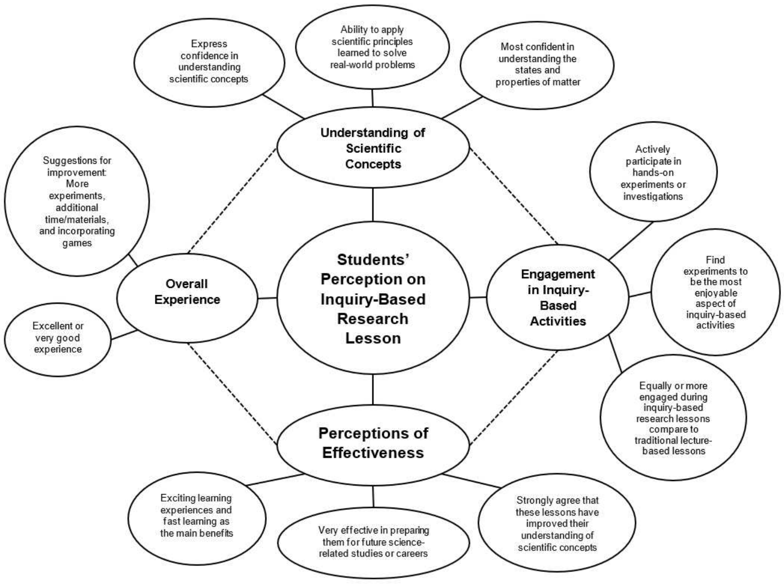

Fig. 3. Students' Perception of Inquiry-Based Research Lessons

Huang et al. (2017) conducted a case study on inquiry-based instruction and self-regulated learning strategies, finding that such approaches enhance students' engagement and promote a deeper understanding of content. These findings align with the positive perceptions of both teachers and students regarding the effectiveness of inquiry-based research lessons in promoting learning engagement and conceptual understanding.

Table 8. Correlations between Perceived Effectiveness of Designed Inquiry-Based Research Lessons and Teacher's Professional Knowledge

Designed Inquiry-Based Research Lesson	**Teacher's Professional Knowledge**		
	Knowledge of Science Content	Pedagogical Content Knowledge	Curriculum Knowledge
Relationship and its Change	.103	.037	-.102
Cognition of Learners	.375*	.326*	.149
Pedagogical Skills	.087	.032	-.086
Structure of Lesson	.457**	.373*	.491**
Quality of Learning	.106	.116	-.105

***Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). Verbal Interpretation of r-value: +1.0 Perfect positive +/- association +0.8 to +1.0 Very strong +/- association +0.6 to +0.8 Strong +/- association +0.4 to +0.6 Moderate +/- association +0.2 to +0.4 Weak +/- association 0.0 to +0.2 Very weak +/- or no association*

Table 8 reveals varied correlations between the perceived effectiveness of inquiry-based research lessons and teachers' professional knowledge. The Structure of the Lesson shows the strongest positive associations across all three dimensions of teacher knowledge, indicating that a well-organized instructional design significantly enhances the perceived effectiveness of inquiry-based lessons. The Cognition of Learners also correlates strongly with both science content knowledge and pedagogical content knowledge, emphasizing the importance of understanding students' cognitive processes for effective teaching. However, curriculum knowledge shows a less consistent correlation with perceived effectiveness, highlighting the multifaceted nature of teacher expertise. These findings suggest the need for comprehensive teacher development encompassing content knowledge, pedagogical skills, and curriculum understanding to improve instructional outcomes in inquiry-based learning.

The strong correlation between learners' cognition and teachers' knowledge of science content and pedagogical content knowledge, but not curriculum knowledge, can be attributed to the ability of teachers with strong content knowledge to design lessons that align with students' cognitive development and adapt instructional strategies to diverse learning needs. Curriculum knowledge, while important for planning, does not directly impact understanding students' cognitive processes.

The significant correlation between lesson structure and professional knowledge, including science content, pedagogical content knowledge, and curriculum knowledge, underscores the importance of a comprehensive understanding of these areas for effective lesson design. Proficient teachers can organize lessons with clear objectives and coherent materials, integrate strategies catering to diverse needs, and ensure alignment with educational standards.

In contrast, the weak or insignificant correlation between perceived effectiveness and factors like relationship changes in students, pedagogical skills, and quality of learning suggests that these elements may be influenced by factors beyond professional knowledge, such as student motivation and prior knowledge.

Overall, while no significant correlation exists between perceived effectiveness and professional knowledge across all dimensions, notable exceptions include the Cognition of Learners and the Structure of the Lesson, which show significant correlations with certain aspects of teacher expertise. This highlights the importance of specific teacher competencies in evaluating the effectiveness of inquiry-based approaches. Supporting these findings, Furtak et al. (2012) demonstrates that teachers with strong content and pedagogical knowledge are more successful in implementing inquiry-based lessons, promoting deeper scientific understanding. This aligns with the correlations observed between lesson structure, learners' cognition, and professional knowledge. Conversely, Baumert et al. (2010) suggests that curriculum knowledge impacts long-term teaching strategies more than immediate lesson effectiveness, explaining the lack of significant correlation observed in some areas. These insights emphasize the complex nature of teaching competencies and their varied impacts on educational outcomes.

Table 9. Test of difference between the pre-assessment and post-assessment score performances of the students on the Scientific Literacy

Scientific Literacy	Assessment Mean		Paired Differences: Mean Diff	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper	t	df	Sig. (2-tailed)
Explain Phenomena	Pre	1.39	-3.188	1.170	.127	-3.441	-2.936	-25.123	84	.000
	Post	4.58								
Evaluate and Design	Pre	1.82	-2.812	.945	.102	-3.016	-2.608	-27.437	84	.000
	Post	4.64								
Interpret Evidence	Pre	2.36	-3.000	.976	.106	-3.210	-2.790	-28.342	84	.000
	Post	5.36								
Overall			-9.000	1.826	.198	-9.394	-8.606	-45.448	84	.000

Table 9 demonstrates significant improvements in students' scientific literacy across three dimensions—Explaining Phenomena, Evaluating and Designing, and Interpreting Evidence—evidenced by substantial increases in post-assessment scores compared to pre-assessment scores. The data, with statistically significant paired differences ($p \leq 0.05$), indicates a notable enhancement in scientific literacy following the educational intervention, as reflected by an overall paired difference of -9.000. These results highlight the effectiveness of inquiry-based research lessons in improving students' comprehension and engagement with scientific concepts.

Several factors contribute to this improvement. Engaging activities like word games, experiments, and simulations spark student interest and participation, providing practical applications of scientific concepts. Socratic questioning promotes critical thinking and inquiry skills, while targeted activities on the particle nature of matter and physical changes help students build a strong conceptual framework. The 3D model-making performance task reinforces understanding and creativity in demonstrating particle behavior and physical transformations.

A systematic assessment approach, using pre- and post-assessments, enables teachers to track progress and identify areas needing reinforcement. This approach, similar to PISA's emphasis on real-world problem-solving and critical thinking, proves effective in evaluating educational outcomes and informing instructional strategies. The significant score increases across all dimensions affirm the success of the instructional intervention in promoting scientific literacy.

The student-centered, inquiry-based approach prioritizes active engagement, hands-on learning, and critical thinking development, creating a supportive learning environment that empowers students to explore, question, and construct their understanding of scientific concepts. This leads to improved scientific literacy outcomes. Laksana (2017) study on inquiry-based learning in natural science education aligns with these findings, highlighting the approach's effectiveness in fostering active learning, critical thinking, and deeper understanding of scientific phenomena. The significant improvements observed in pre- and post-assessment scores affirm the success of inquiry-based research lessons in enhancing scientific literacy.

5. Conclusion and Recommendation

The study concludes that there is no significant correlation between the overall effectiveness of inquiry-based research lessons and teachers' professional knowledge, except in the dimensions of learners' cognition and lesson structure. However, there is a significant improvement in students' scientific literacy, as evidenced by the differences in pre-assessment and post-assessment scores. Based on these findings, it is recommended that school administrations encourage inquiry-based teaching methods in science education due to their proven effectiveness. Additionally, fostering collaboration among teachers to share best practices, adopting lesson study as a professional development approach, and researching ways to enhance teachers' pedagogical and curriculum knowledge are suggested. Future studies should explore similar interventions in other subjects and grade levels to further validate these findings

Acknowledgements

The researcher would like to express the sincerest gratitude to the following persons who helped in one way or another to accomplish this study: Dr. Mario R. Briones, President of Laguna State Polytechnic University, for his outstanding leadership and genuine support in the field of research; Dr. Edilberto Z. Andal, Dean of CTE-GSAR, for his suggestions and comments regarding quality research and for making it possible to carry out this study; Dr. Elisa N. Chua, research adviser, for her invaluable guidance, support, and expertise throughout this research journey; Mr. John Vincent C. Aliazas, statistician, for his comments, suggestions, and statistical expertise regarding the study; Dr. Julie Fe D. Panoy, the researcher’s subject specialist, for sharing her expertise in the content of the material and giving her valuable comments and suggestions; Dr. Delon A. Ching, technical editor, for giving her constructive criticism and suggestions to improve the manuscript further; Dr. Celedonio B. Balderas Jr., Schools Division Superintendent, for allowing the researcher to conduct this study; Mrs. Evelyn R. Palambiano, Principal I, for allowing the researcher to conduct this study and for her undying support; Mrs. Venus M. Yagyagan, Mrs. Vivian Saavedra, and Mrs. Lesette O. Marquez, Science teachers whose participation was essential for the success of our research lesson; Mrs. Cherious Oblea, Mrs. Sharmaine Avilla, and Mr. Edmar Rada, who have been so helpful and cooperative in giving their support at all times and for making it possible to carry out this study; Dr. Pedro Jose De Castro, Dr. Michelle Cueto, Dr. Wins Dela Cruz, Mrs. Venus M. Yagyagan, Mr. Marvin J. Rosales, Mr. Rempson P. Sumilang, Mrs. Regicelle D. Cabaysa, validators of the research instruments, for their meticulous review, which has strengthened the integrity of the study; Dr. Michael Leonard D. Lubiano, Education Program Supervisor in Science, and Dr. Emelia R. Eclarin, Asst. Principal II, and the Knowledgeable others who enriched our lesson study with their expertise and insights; Mrs. Ada Loreen D. Enrico and Mia Ann Sara Mendoza, for lending their time and effort to help in any possible way; Grade 8 - Copper and Grade 8 - Silver, for their solidarity and cooperation during the experimentation period; Mr. Kelvin Paul Fidelino, Keila Fidelino, and Kisha Fidelino, for their unwavering support, love, and understanding throughout this research journey; Her Family, Friends, and Colleagues, who became the sources of encouragement to finish this material; Those whose names were not included but who have given their assistance in making this study possible; and above all, the Lord God Almighty for giving me the strength, knowledge, and guidance to undertake this research study.

References

American Association for the Advancement of Science. (2020). About AAAS. https://www.aaas.org/about-aaas

National Science Board. (2021). Science and Engineering Indicators 2021. National Science Foundation. https://ncses.nsf.gov/pubs/nsb20201/

American Association for the Advancement of Science. (2018). Vision and change in undergraduate biology education: Uniting research and practice. https://visionandchange.org/

United Nations Educational, Scientific and Cultural Organization [UNESCO]. (2020). Education for sustainable development goals: Learning objectives. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000368645

Nasution, W. N. (2018). The Effects Of Inquiry-Based Learning Approach And Emotional Intelligence On Students' Science Achievement Levels. Journal of Turkish Science Education, 15(4), 104–115. https://doi.org/10.12973/tused.10249a

Javier, M. J., & Aliazas, J. V. (2022). Community of Inquiry Framework in Basic Science Process During Synchronous Learning Modality. International Journal of Science, Technology, Engineering and Mathematics, 2(4), 92-113.

Nuangchalerm, P. (2014). Inquiry-based learning in China: Lesson learned for school science practices. Asian Social Science, 10(13), 64–71. https://doi.org/10.5539/ass.v10n13p64

Philippine Congress. (2013). Republic Act No. 10533: An Act Enhancing the Philippine Basic Education System by Strengthening Its Curriculum and Increasing the Number of Years for Basic Education, Appropriating Funds Therefor and for Other Purposes. Retrieved from https://www.officialgazette.gov.ph/2013/05/15/republic-act-no-10533/

Gutierez, S. B. (2015a). Collaborative professional learning through lesson study: Identifying the challenges of inquiry-based teaching. Issues in Educational Research, 25(2), 118–134.

Department of Education. (2016). DepEd Order No. 35, s. 2016: Policy Guidelines on the Implementation of the Learning Action Cell (LAC) as a K–12 Basic Education Program School-Based Continuing Professional Development Strategy for the Improvement of Teaching and Learning. Manila, Philippines

Aliazas, J. V., Del Rosario, A. L., & Andrade, R. (2023). Teaching Efficacy Structures and Influencing Factors in Promoting Success and Retention among Pre-Service Teachers. International Journal of Educational Management and Development Studies, 4(3), 90-109.

Elipane, L. E. (2017). Introducing lesson study as a professional development model in the islands of the Philippines. Advanced Science Letters, 23(2), 1126–1129. https://doi.org/10.1166/asl.2017.7514

Bybee, R. W. (2014). The case for STEM education: Challenges and opportunities. NSTA Press.

National Research Council. (2015). Science teachers' learning: Enhancing opportunities, creating supportive contexts. The National Academies Press.

Andrini, V. S. (2016). The Effectiveness of Inquiry Learning Method to Enhance Students ' Learning Outcome : A Theoretical and Empirical Review. Journal of Education and Practice, 7(3), 38–42.

Labitad, M. D., & Lomibao, L. S. (2021). The Experiences , Challenges and Perception on Online Lesson Study (O-LS) as Teacher Professional Development Program. American Journal of Educational Research, 9(10), 639–646. https://doi.org/10.12691/education-9-10-6

Maylani, L., & Georgia, P. (2019). Aja17-0078 aja17-0078.

National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. The National Academies Press. https://doi.org/10.17226/13165

Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. Review of Educational Research, 86(3), 681-718. DOI: 10.3102/0034654315627366

Bae, J., & Kim, M. (2017). The effects of inquiry-based learning on elementary students' science achievement and attitudes towards science: Evidence from South Korea. International Journal of Science Education, 39(15), 2078-2097

Hong, J. C., & Choi, A. (2019). The effects of inquiry-based learning on elementary students' science process skills and science attitudes: A meta-analysis. Journal of Science Education and Technology, 28(5), 541-553.

Llewellyn, D. (2015). Real-time formative assessment and pedagogic strategies in a web-based inquiry learning environment: The case of OER@AVU. Journal of Interactive Media in Education, 2015(1), 1-16.

Hsu, S. Y. (2017). A study on the effects of problem-based and inquiry-based learning approaches on students' achievement in geometry courses. EURASIA Journal of Mathematics, Science and Technology Education, 13(6), 1759-1770.

Huang, C. Y., Wu, H. K., & Huang, W. Y. (2017). Enhancing ninth graders' algebra learning: A case study of learning through inquiry-based instruction accompanied by the self-regulated learning strategy. EURASIA Journal of Mathematics, Science and Technology Education, 13(10), 6805-6826.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. Review of Educational Research, 82(3), 300-329. DOI: 10.3102/0034654312457206

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M., & Tsai, Y.-M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. American Educational Research Journal, 47(1), 133-180. DOI: 10.3102/0002831209345157

Laksana, D. N. L. (2017). the Effectiveness of Inquiry Based Learning for Natural Science Learning in Elementary School. Journal of Education Technology, 1(1), 1. https://doi.org/10.23887/jet.v1i1.10077