



Studying Inquiry-Based Science Learning Through Researcher-Supported Lesson Study in Malaysia: A Two-School Case Study

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ABSTRACT

Lesson Study, as part of professional learning communities, has gained attention in Malaysia as a strategy for examining and refining classroom practice. This two-school case study examined how inquiry-based science learning became visible and examinable within researcher-supported Lesson Study informed by Japanese practices. Across one primary and one lower-secondary school, teachers collaboratively planned and enacted two research lessons on the lever system in each setting. Data included direct lesson observations, video recordings, lesson plan, and post-lesson discussions. Four authors independently scored the lessons using the Reformed Teaching Observation Protocol (RTOP), with consensus scores used descriptively rather than inferentially. A qualitative inquiry-structure analysis examined four dimensions: problem framing, experimentation and data collection, evidence-to-explanation reasoning, and material-inquiry alignment. RTOP scores ranged from 43 to 62, while lesson evidence showed that all four lessons contained inquiry-oriented elements but differed in coherence. Lesson Study discussions surfaced recurring problems in framing investigable questions, guiding data collection, supporting evidence-based reasoning, and aligning materials with scientific purposes. The documented revision from Lesson C to Lesson D further showed how identified pedagogical problems could inform subsequent redesign of the task and materials. The study does not establish longitudinal teacher growth or student learning effects; instead, it shows how Lesson Study can make the epistemic coherence of inquiry visible for collaborative professional examination. Contextual constraints included curriculum pacing, planning time, and students' limited familiarity with sustained inquiry.

Keywords: Lesson Study, Science, Inquiry-based learning

INTRODUCTION

Improving the quality of science teaching requires more than the introduction of new curriculum goals or policy directives. It also requires sustained opportunities for teachers to learn collaboratively, examine practice, and refine instruction in response to students' learning needs. Within this broader agenda of instructional improvement, professional learning communities have been widely promoted as a means of supporting teacher development through shared reflection, collective responsibility, and pedagogical dialogue (Doğan e. al., 2016). Lesson Study, as one form of collaborative professional learning, has attracted attention because it allows teachers to jointly plan, observe, analyse, and revise classroom lessons in a systematic and practice-based manner (Willems & Bossche, 2019).

Lesson Study has been discussed internationally as an approach that can deepen teachers' attention to student



thinking, strengthen pedagogical reasoning, and support instructional improvement (Lewis, 2016). Rather than viewing teaching as an individual activity, Lesson Study positions teaching as a collective object of inquiry. Through collaborative lesson planning and post-lesson reflection, teachers are able to examine how instructional design shapes student learning and identify points for improvement. Such a process is particularly relevant in science education, where effective teaching often depends on careful orchestration of questions, materials, evidence, and discussion.

At the same time, inquiry-based learning continues to be emphasised in science education because of its potential to engage students in asking questions, conducting investigations, interpreting evidence, and constructing scientific understanding. Inquiry-based learning is often associated with active learning, conceptual reasoning, and scientific literacy (Mizwar et al., 2026; Arifin et al., 2025). However, the implementation of inquiry-based learning in classrooms remains challenging. Teachers may value inquiry in principle but struggle to translate it into classroom practice, particularly when faced with curriculum coverage pressures, examination demands, limited time, and uneven student readiness.

These challenges suggest that inquiry-based learning should not be understood simply as a teaching strategy to be adopted, but as a complex pedagogical practice that requires professional learning, experimentation, and reflection. Lesson Study may therefore offer a valuable mechanism for supporting inquiry-based science teaching because it provides teachers with a structured opportunity to collaboratively examine how inquiry is designed and enacted in real classrooms.

This study examined how researcher-supported Lesson Study informed by Japanese practices can be used to study inquiry-based science teaching in the Malaysian context. The study focuses not only on whether research lessons contain inquiry-oriented activity, but also on how the coherence of inquiry becomes visible through the relationship among investigable problems, experimental procedures, evidence generation, and explanation construction. This provides a science-specific extension to existing Lesson Study literature: rather than treating Lesson Study only as a professional development structure, the study uses it as a methodological lens for examining the epistemic organisation of inquiry in enacted lessons. By analysing both classroom enactment and post-lesson professional examination, the study also distinguishes between the identification of pedagogical problems and stronger evidence of enacted instructional revision. In doing so, it contributes to local discussions on teacher development and science pedagogy and to international debates concerning the principled adaptation of Lesson Study across educational contexts.

LITERATURE REVIEW

Introducing Japanese Lesson Study into Different Educational Contexts

The international visibility of Japanese Lesson Study was greatly shaped by the work of Stigler and Hiebert (1999), who drew attention to the ways in which Japanese teachers engaged in collaborative lesson planning and instructional improvement. Since then, Lesson Study has been recognised as a form of teacher professional development that supports close attention to instructional design, student thinking, and the refinement of classroom practice.

In Japanese Lesson Study, the lesson plan is not merely a teaching script, but a pedagogical hypothesis that anticipates student responses, possible difficulties, and intended learning outcomes (Fujii, 2014). During the post-lesson discussion, teachers and other participants examine the relationship between the lesson as planned and the lesson as enacted, including whether the instructional task successfully elicited the intended student thinking (Fujii, 2016). Observational evidence of students' responses becomes central to the discussion, as teachers analyse how learning unfolded during the lesson (Saito, 2012).

Much of the early international interest in Lesson Study focused on mathematics education, where the process was closely linked to problem-solving instruction. Research in the United States, for example, has shown that Lesson Study can help teachers pay closer attention to student mathematical thinking, improve the design of problem-solving lessons, and make productive use of instructional materials and external expertise (Alston et al., 2011; Fernandez et al., 2003; Lewis et al., 2012). These studies have suggested that Lesson Study can be adapted across contexts, although such adaptation requires more than simple replication.



Compared with mathematics, less research has examined the use of Lesson Study to support inquiry-based learning in science (Hatanaka, 2017). This is an important gap because inquiry-based science learning shares some features with mathematical problem solving, such as the need for purposeful questioning and evidence-based reasoning, while also involving distinct processes such as experimentation, observation, measurement, and interpretation of scientific data. As a result, it cannot be assumed that findings about mathematics-focused Lesson Study transfer directly to science education without empirical examination.

Inquiry-Based Science Lessons in Japanese Lesson Study

In Japan, Lesson Study is conducted across subject areas and may be organised by schools, educational authorities, or research associations. One of the more structured forms of Lesson Study occurs in research-designated schools that engage in sustained lesson research with support from external advisors (Hatanaka, 2017). In science education, such Lesson Study often focuses on the design and examination of inquiry-based lessons grounded in curriculum goals and textbook content.

Japanese science lessons typically emphasise structured inquiry in which students investigate scientific questions through observation and experimentation in order to build conceptual understanding (Hatanaka, 2017). Within Lesson Study, attention is often given to the formulation of inquiry questions, the anticipated and actual student responses, and the quality of materials and procedures used for experimentation. Thus, inquiry is not treated simply as student activity, but as a carefully designed pedagogical process.

If Japanese science Lesson Study is to inform teaching in other settings, it is necessary to examine whether inquiry-based learning can be meaningfully studied through Lesson Study in those settings and whether the underlying pedagogical resources and principles remain useful when curriculum structures, classroom cultures, and student experiences differ. This makes the contextual examination of Lesson Study in science education especially important.

Research Questions

This study addressed the following research questions:

1. What inquiry-based learning characteristics are evident in science research lessons conducted through researcher-supported Lesson Study informed by Japanese practices?
2. Which aspects of inquiry-based science learning become objects of professional examination during the Lesson Study process?

METHODS

Research Design

This study employed a two-school case study design using qualitative classroom and discussion data supported by descriptive RTOP scores. A case study approach was appropriate because it enabled in-depth examination of how inquiry-based learning was designed, enacted, and professionally examined within Lesson Study in real school settings (Lapoule & Lynch, 2018). The study did not seek to estimate causal effects of Lesson Study or to generalise statistically from the four research lessons. Instead, it generated detailed, context-dependent evidence concerning the inquiry characteristics of the lessons, the pedagogical problems that became visible, and the revisions documented within the Lesson Study process.

The selected schools were ordinary public schools rather than elite or highly specialised institutions. They were chosen primarily because school leaders supported the implementation of Lesson Study and granted permission for the research. Administrative support was a critical condition for the conduct of the study, given the demands of organising collaborative planning meetings, lesson observations, and post-lesson discussions.

The participants included 25 teachers across the two sites, including lesson planners, teaching teachers, observing teachers, and several teachers from nearby schools who participated as observers. Data were



generated through direct lesson observation, participation in post-lesson discussions, video recordings of the lessons and discussions, and analysis of lesson artefacts.

Research Sites and Lesson Study Context

Two school-based groups were involved in the study. School T was a primary school, and School BL was a lower secondary school. Both schools are referred to by pseudonyms to preserve anonymity. The study was conducted in 2023. The primary school Lesson Study cycle took place in July, while the lower secondary school cycle took place in November.

In each school, two science lessons were planned and implemented as research lessons. The topic selected for both settings was the lever system. This topic was chosen because it appears in both primary and secondary science curricula, making it suitable for implementation across school levels. In addition, the lever system lends itself well to inquiry-oriented investigation because students can design and carry out experiments, observe outcomes, and derive scientific relationships from evidence.

Planning Stage in Lesson Study

During the Lesson Study process, teachers collaborated to design science lessons on the lever system. The researchers acted as external advisors and provided support based on their expertise in science education and Lesson Study. This support focused especially on inquiry-based learning and included the sharing of science textbooks, educational videos, and teaching materials associated with the topic of levers.

The teachers first determined the grade level and lesson focus appropriate to their school context and then designed two research lessons. Lesson planning took place through a combination of online and face-to-face meetings. During these meetings, the researchers introduced key ideas related to inquiry-based learning, discussed the selection and use of teaching materials, and supported the teachers in designing lessons that could engage students in investigation, evidence gathering, and conceptual reasoning.

Lesson Implementation

Before each research lesson, a pre-lesson meeting was conducted to explain the lesson plan to observers. In both schools, observers included teachers from the school itself and teachers from nearby schools. The researchers and lesson planners therefore introduced the Lesson Study process and explained the lesson objectives and structure before observation began.

During the lesson, the teaching teacher enacted the collaboratively designed lesson plan, while the observing teachers focused closely on student learning processes, especially students' engagement with experimentation and discussion. In keeping with Japanese Lesson Study practices, observers were not confined to the back of the room; they were allowed to move among student groups, closely observe students' work, and gather detailed information about students' responses and difficulties.

Post-Lesson Discussion

After each lesson, the teaching teacher, observing teachers, and researchers participated in a post-lesson discussion. The teaching teacher reflected on the lesson goals, what went well, what did not proceed as intended, and what difficulties emerged during implementation. Observers then shared evidence-based comments drawn from their observations of students and asked questions about the lesson design and enactment. The researchers also contributed comments, responded to questions, and offered suggestions for lesson improvement. These discussions were treated as an important part of the Lesson Study process because they revealed what aspects of inquiry-based learning became visible as objects of professional examination.

Analysis of Inquiry-Based Learning in the Research Lessons

To examine the inquiry characteristics of the research lessons, two complementary forms of analysis were used: descriptive RTOP scoring and qualitative inquiry-structure analysis.



The Reformed Teaching Observation Protocol (RTOP) is an observation instrument designed to assess the degree to which classroom teaching reflects scientific inquiry and constructivist learning principles (Piburn & Sawada, 2000; Sawada et al., 2002). RTOP consists of 25 items covering lesson design and implementation, content, and classroom culture, with a maximum score of 100. In this study, four authors independently observed and scored the lessons, after which a final score for each lesson was determined through discussion and consensus. The inter-rater agreement obtained among the four raters, and the consensus RTOP scores were used as descriptive indicators of the characteristics of each research lesson. The scores were interpreted comparatively to illustrate variation in the extent to which inquiry-oriented and active-learning features were evident across the lessons. However, differences among the four RTOP scores were not treated as evidence of statistically significant improvement or instructional effectiveness.

Inquiry-based learning was also examined through qualitative lesson-structure analysis. Inquiry was conceptualised as engagement with a meaningful scientific problem through investigation and the use of evidence to construct an answer or explanation. Rather than creating an additional numerical inquiry score, the analysis traced lesson evidence across four dimensions: (1) problem framing, (2) experimentation and data collection, (3) evidence-to-explanation reasoning, and (4) material-inquiry alignment. These dimensions were used as analytic categories for examining the coherence of inquiry, not as a quantitative scale. The analysis therefore asked whether students were oriented to an investigable problem, whether experimental procedures enabled relevant evidence to be generated and recorded, whether students were supported to interpret evidence in relation to the scientific idea, and whether the materials and apparatus were suitable for the intended investigation.

Table 1. Analytical Framework for Inquiry-Structure Analysis

Inquiry dimension	Operational focus	Evidence considered
Problem framing	Whether students were oriented to a clear, investigable scientific problem and understood what the investigation was intended to address.	Teacher questions; connection between stimulus and task; observable indications of students' understanding of the investigation purpose.
Experimentation and data collection	Whether procedures and guidance enabled students to manipulate relevant conditions, make observations or measurements, and record usable evidence.	Experimental procedures; teacher guidance; student records or products; observed difficulties in varying, observing, measuring, or recording.
Evidence-to-explanation reasoning	Whether students were supported to compare results, identify relationships or patterns, and connect evidence to a scientific answer or explanation.	Student responses; group reporting; teacher questioning; movement from experimental results to conceptual conclusions.
Material-inquiry alignment	Whether apparatus, measurement tools, and instructional materials enabled valid investigation of the intended scientific relationship.	Suitability of apparatus and tools; accuracy and interpretability of generated data; alignment between materials, task, and scientific purpose.

Analytical Coding and Analysis of Aspects Examined in Lesson Study

To identify which aspects of inquiry-based science learning became objects of professional examination, the research lessons and post-lesson discussions were reviewed for episodes concerning the four dimensions in Table 1. The unit of interpretation was a concrete lesson or discussion episode in which participants addressed



the clarity of the problem, the conduct or recording of the experiment, the interpretation of evidence, or the suitability of materials. The four dimensions were used as qualitative coding categories rather than scored criteria; consequently, the analysis does not present numerical cross-lesson ratings for these dimensions.

Interpretive claims were anchored to observable lesson events, student products or responses described in the records, and issues raised during post-lesson discussion. In reporting the findings, evidence that a pedagogical problem became visible was distinguished from evidence that teachers subsequently enacted a revision. This distinction is important because identifying or discussing a problem does not by itself demonstrate sustained teacher learning. Where the manuscript documents a subsequent change, such as the reconstruction of the task and materials between Lessons C and D, that change is reported as evidence of enacted instructional revision rather than as proof of long-term professional growth.

Researcher Role and Analytical Reflexivity

The study was intentionally researcher-supported. Researchers acted as external advisors during planning, introduced resources related to inquiry-based learning, participated in post-lesson discussions, and were also involved in observation and analysis. This dual role could influence both lesson enactment and subsequent interpretation. The manuscript therefore treats researcher support as part of the study context rather than assuming complete observer neutrality. Findings are reported cautiously by distinguishing classroom evidence and teacher-identified issues from interpretations supported or extended by external advisors, and by avoiding causal claims that the Lesson Study process itself produced teacher or student outcomes.

FINDINGS

Inquiry-Based Learning in the Research Lessons

Each of the research lessons was rated independently using the Reformed Teaching Observation Protocol (RTOP). Inter-rater reliability was assessed by means of the intraclass correlation coefficient (ICC). In terms of inter-rater agreement, the results showed that there is considerable agreement between the four raters (ICC = .82, 95% CI [.70, .90]). After the independent rating of RTOP scores, differences between the raters were resolved item by item, taking into account videotapes of the lesson and observational data. The resulting consensus ratings were then used for the purpose of descriptive analysis.

An overview of the four research lessons is presented in Table 2.

Table 2. Lesson Study Implementation

	A	B	C	D
School	Primary School in Penang		Junior Secondary School in Penang	
Day	July 2023		November 2023	
Grade	Grade 4	Grade 6	Form 2 (14y)	Form 2 (14y)
Aim of the lesson	Changing the position of the weights and investigating how the inclination changes.	Investigating the conditions for equilibrium in a first-class lever.	Investigating the conditions for equilibrium in a third-class lever.	Investigating the conditions for equilibrium in a first-class lever.
RTOP Score	51	62	43	45

The RTOP scores ranged from 43 to 62 across the four research lessons. According to one interpretation of RTOP scores, lessons scoring 29 or below are typically classified as traditional lecture, scores of 50 or above



indicate active learning, and scores in between suggest active lecture (Kulpa, 2021). These scores are reported as descriptive indicators and are not used to establish statistically meaningful differences among lessons. When considered alongside the lesson-structure analysis, they suggest that the observed lessons incorporated varying degrees of active and inquiry-oriented teaching rather than functioning as predominantly traditional teacher-centred lessons. The RTOP findings therefore serve as complementary evidence, while the qualitative analysis of the inquiry process provides the primary basis for interpreting how inquiry-based learning was enacted in each lesson.

Across all four lessons, students worked in groups and carried out experiments in response to teacher-provided questions. In Lesson A, Grade 4 students investigated how changing the position of weights affected the tilt of the lever arm. In Lesson B, Grade 6 students explored conditions under which a first-class lever could be balanced. In the lower-secondary school, Lessons C and D involved Form 2 students investigating lever equilibrium, with Lesson C focusing on a third-class lever and Lesson D on a first-class lever. These activities provide evidence that the lessons incorporated inquiry-oriented investigation, but the analysis did not treat hands-on participation alone as sufficient evidence of coherent inquiry. Student-level observations were considered where available: for example, some Lesson A students drew the apparatus rather than recording the

required change in tilt, Lesson B students generated several correct balance combinations, and Lesson C students had difficulty producing valid, interpretable data because of limitations in the experimental arrangement. Together, these episodes show that inquiry was present but varied in how effectively problem, procedure, evidence, and explanation were connected.

Challenges in Studying Inquiry-Based Learning Through Lesson Study

During the post-lesson discussions, teachers who had planned and taught the lessons identified several difficulties in implementing inquiry-based learning. Although Japanese textbooks and instructional materials were introduced during planning and inquiry-based learning was promoted as a pedagogical direction, teachers noted that differences between the two curriculum contexts made direct implementation challenging.

One issue concerned the structure and pacing of curriculum content. Teachers pointed out that the organisation of science content differed across contexts. In their view, Japanese materials often presented content in a more detailed and sequential way, with scientific ideas built gradually through multiple experimental conditions. By contrast, the local curriculum placed pressure on teachers to cover a larger amount of content in less time. As a result, teachers felt that adopting a highly structured, step-by-step inquiry sequence would require more lesson time than was realistically available.

This tension was visible during the planning of Lessons A and B. Initially, the primary school teacher intended to use the experiment presented in the local textbook, in which students investigate how the amount of force changes when the fulcrum is moved. However, the Japanese materials introduced a more analytically structured approach in which different lever relationships were isolated and examined separately. Teachers perceived this approach as pedagogically rich but difficult to implement within existing time constraints.

Teachers also reported that students were not yet accustomed to learning through sustained inquiry. Because students varied considerably in prior knowledge and academic ability, some were able to engage meaningfully in the experiments, while others tended to follow procedures without fully understanding the concepts involved. This suggested that inquiry-based learning was not yet a familiar classroom routine for many students and that students needed more regular opportunities to develop inquiry habits and reasoning.

A further challenge concerned lesson planning itself. Teachers noted that even with three planning meetings, designing inquiry-oriented lessons remained difficult. The lesson plans required repeated revisions, especially where the rationale for lesson flow, experiment design, or expected learning outcomes was unclear. Considerable time was needed to build shared understanding among participants about how inquiry should be structured and what students were expected to learn from the experiments. These difficulties indicated that teachers were still developing experience in planning inquiry-based science lessons and that Lesson Study made these challenges visible.



Aspects of Inquiry-Based Learning Examined During Lesson Study

Analysis of the research lessons and post-lesson discussions showed that participants examined the same four dimensions identified in the analytical framework: problem framing, experimentation and data collection, evidence-to-explanation reasoning, and material-inquiry alignment. The following sections present concrete lesson and discussion evidence for each dimension rather than assigning a numerical score to the dimensions.

Clarifying the Problems Students Were Expected to Investigate

One recurring issue concerned whether the lesson clearly established the inquiry problem for students. In inquiry-based learning, students should not simply perform activities; they should understand the question they are investigating and why the investigation matters.

In Lesson A, for example, students watched a video related to seesaw movement before beginning the experiment. Although the video had the potential to help students think about balance and lever conditions, the teacher did not explicitly connect the video to a clear investigable question. As a result, students were shown an interesting phenomenon, but they were not strongly oriented to the specific problem that the experiment was intended to address. The post-lesson discussion suggested that students would likely have engaged more purposefully had the teacher explicitly asked a question such as under what conditions one side of the seesaw goes down.

A similar issue emerged in Lesson B. The teacher showed a video involving apples and lever balance and then asked students about the relationship between rod length and number of apples. However, the experimental task that followed did not align clearly with the scenario presented in the video. This mismatch created confusion, indicating that the opening stimulus and the actual inquiry task need to be more closely connected.

In Lesson C, the teacher used examples from everyday life, such as a seesaw and a fishing rod, to introduce the idea of levers. While this helped illustrate that levers are relevant in real life, it did not sufficiently clarify the particular equilibrium problem that students were expected to investigate in the lesson. The Lesson Study discussions therefore highlighted the importance of making the inquiry question explicit and ensuring that introductory materials directly support the investigation students are asked to conduct.

Guiding Students to Conduct Experiments and Collect Data Properly

A second area of examination concerned the quality of guidance provided during experimentation. Inquiry-based learning does not imply the absence of teacher support. Rather, it requires purposeful guidance so that students understand procedures, collect relevant evidence, and remain focused on the problem being investigated.

In Lesson A, students were instructed to record their results on whiteboards, but the instructions were not sufficiently clear. Some students drew the experimental apparatus instead of recording how the tilt changed when weights were moved to different positions. This indicated that students had not fully understood what data needed to be collected. The discussion after the lesson highlighted the need for more explicit procedural guidance, especially regarding what students were expected to vary, observe, and record.

In Lesson C, the difficulty was even more pronounced. Students were expected to investigate the equilibrium of a third-class lever, yet the demonstration and apparatus did not adequately support that goal. The experimental arrangement used in the lesson created confusion because the apparatus, procedures, and measurement tools were not well aligned with the intended investigation. This made it difficult for students to collect valid data and to understand what they were supposed to be testing. The discussions revealed that successful inquiry depends not only on student activity but also on careful alignment between scientific purpose, experimental design, and available resources.

Supporting Students in Identifying Answers from Experimental Results

A third issue examined during Lesson Study was how teachers helped students interpret evidence and construct



scientific understanding from their experiments. In inquiry-based learning, experiments are not an end in themselves; they are a means through which students identify relationships, patterns, and explanations.

In Lesson A, after the experiment, group representatives presented their results. The teacher then concluded that changing the position of the weights changed the tilt of the balance arm. However, the discussion indicated that this summary remained too general. A stronger inquiry-oriented conclusion would have helped students identify that the distance from the fulcrum mattered and that this relationship explained why the lever tilted in particular ways.

Similarly, in Lesson B, students found several correct combinations that could balance the lever, but the teacher moved quickly from these outcomes to the formal equilibrium equation by calling on a student who already knew the correct answer. Although the correct concept was introduced, the post-lesson discussion suggested that the lesson would have been more inquiry-oriented if students had first been guided to compare results, look for patterns, and infer the relationship themselves. This showed that inquiry-based teaching requires teachers to mediate between evidence and concept formation rather than simply confirming correct answers after experimentation.

Improving Materials for Inquiry-Based Learning

The fourth aspect examined during Lesson Study concerned the suitability of instructional materials and apparatus. The research lessons showed that inquiry-based learning depends heavily on whether the materials and tools allow students to generate meaningful evidence.

This issue was especially visible in the lower secondary school. In Lesson C, the apparatus and measurement tools were not well suited to investigating the conditions of equilibrium for a third-class lever. The lever arm, weights, and spring scales did not allow students to obtain accurate and interpretable values. The design of the task was therefore compromised by the limitations of the materials.

The clearest evidence of enacted instructional revision occurred between Lessons C and D (Table 3). Following the difficulties identified in Lesson C, the teaching teacher and observing teachers revisited the experimental setup, reconstructed the task, and modified the materials before the later lesson. This documented sequence shows that the Lesson Study process did more than surface a pedagogical problem: it was followed by an enacted redesign of the subsequent lesson. The evidence does not, however, establish a longitudinal change in teacher competence or a measured improvement in student learning. It demonstrates a concrete, case-specific revision to task and material design in response to issues made visible through lesson observation and discussion.

Table 3. Documented Revision from Lesson C to Lesson D

Aspect	Evidence from Lesson C	Documented response before Lesson D
Experimental setup and apparatus	Apparatus and measurement tools were not well suited to the intended investigation of third-class lever equilibrium.	The experimental setup was revisited and materials were modified.
Task-design alignment	The arrangement of apparatus, procedures, and measurement tools was not adequately aligned with the intended scientific investigation.	The task was reconstructed before the later research lesson.
Interpretability of evidence	Students had difficulty obtaining accurate and interpretable values from the available setup.	The redesign was intended to provide materials and procedures that better supported inquiry.

Note. The table documents enacted redesign; the study did not collect sufficient longitudinal student-outcome



data to claim that the revision produced sustained improvement.

DISCUSSION

This study contributes to research on inquiry-based science education by showing how researcher-supported Lesson Study can make the internal coherence of inquiry visible for systematic professional examination. Its theoretical contribution is more specific than the general proposition that Lesson Study supports teacher professional development. The findings suggest a science-specific analytical perspective in which the quality of inquiry depends on alignment among four epistemically connected elements: the problem students are asked to investigate, the procedures through which evidence is generated, the reasoning that connects evidence to explanation, and the materials that make the investigation possible. Lesson Study provides a setting in which these relationships can be examined against enacted classroom evidence.

A key finding is that hands-on experimental activity alone did not ensure coherent inquiry-based learning. Students in all four lessons participated in experiments, yet the inquiry process was weakened when the problem was unclear, data-recording expectations were ambiguous, experimental tools did not generate interpretable evidence, or conceptual conclusions were supplied before students had sufficiently compared results. This finding is consistent with work emphasising that inquiry-based teaching requires careful orchestration of questions, procedures, evidence, and conceptual explanations (Kersting et al., 2023; Sawada et al., 2002). The present study extends this point by showing how these elements can become explicit objects of collaborative examination during Lesson Study.

The findings also clarify the level of claim that can be made about professional learning. Collaborative planning and post-lesson discussions clearly exposed instructional decisions concerning investigable questions, procedural guidance, evidence interpretation, and material selection. Exposure and discussion of these issues are evidence that pedagogical problems became available for professional examination; they are not, by themselves, evidence of sustained teacher learning or professional growth. The strongest evidence of enacted change in this study is the documented reconstruction of the task, setup, and materials between Lessons C and D. Accordingly, the study distinguishes problem identification, professional discussion, enacted lesson revision, and longer-term professional learning as related but analytically different outcomes.

The study therefore supports conceptualising inquiry-based learning as a form of pedagogical design rather than a fixed instructional method. Teachers had to consider how a scientific question, experimental arrangement, student action, evidence, and conceptual explanation should work together within local classroom conditions. This is consistent with Fujii's (2014, 2016) view of the Lesson Study plan as a pedagogical hypothesis that anticipates student responses, learning difficulties, and instructional possibilities. In science, that hypothesis also includes whether the apparatus and procedures will generate evidence that students can meaningfully interpret.

From an international perspective, the study illustrates why educational practices should be adapted rather than directly transferred across systems. Japanese-inspired Lesson Study and instructional materials provided pedagogical resources, but their use in Malaysia exposed tensions involving curriculum pacing, available lesson time, local curriculum sequencing, and students' prior experience with inquiry. These findings are consistent with studies showing that Lesson Study can travel across contexts but requires thoughtful adaptation (Fujii, 2014; Lim et al., 2018; Saito, 2012). The contribution here is to show that adaptation in science involves not only organisational features of Lesson Study but also the local feasibility of the problem-investigation-evidence-explanation sequence itself.

The findings further indicate that the enactment of inquiry is shaped by structural conditions as well as instructional knowledge. Teachers identified limited instructional time, curriculum pressure, and students' unfamiliarity with sustained inquiry as constraints. These concerns echo broader science-education research showing that inquiry is influenced by institutional and curricular conditions as well as teacher knowledge and beliefs (Alake-Tuenter et al., 2012; Kersting et al., 2023). Within the cases studied here, Lesson Study created a structured space in which these constraints could be discussed and, in some instances, addressed through concrete lesson redesign (Akita & Sakamoto, 2017; Lewis & Hurd, 2011; Rahim et al., 2015).



Taken together, the study makes three bounded contributions. First, it illustrates the use of Lesson Study as a methodological lens for studying the epistemic coherence of inquiry-based science lessons. Second, it provides case-based evidence that weaknesses in inquiry can be located at the connections among problem framing, experimental design, evidence collection, explanation construction, and material suitability. Third, it shows how a researcher-supported Lesson Study process can surface these problems and, in at least one documented sequence, lead to an enacted redesign of a subsequent research lesson. These contributions are descriptive and explanatory within the two cases rather than causal claims about the general effectiveness of Lesson Study.

Overall, strengthening inquiry-based science teaching requires more than promoting inquiry as a pedagogical ideal or equating inquiry with student activity. Teachers need opportunities to examine how scientific problems, experimental procedures, evidence, explanations, and materials function together in actual classrooms. The present cases indicate that Lesson Study can provide such an examination structure, while also showing that claims about sustained teacher learning and student outcomes require evidence beyond short-term lesson observation and discussion.

LIMITATIONS

Several limitations bound the interpretation of this study. First, the analysis is based on four research lessons in two schools and is intended to provide case-based understanding rather than statistical generalisation. Second, researchers served simultaneously as external advisors, observers, discussion participants, and analysts. Although this role was intrinsic to the researcher-supported Lesson Study design and is made explicit in the analysis, researcher influence on lesson planning and interpretation cannot be eliminated. Third, the RTOP results are consensus scores, and the manuscript does not report a formal inter-rater agreement statistic; they should therefore be interpreted descriptively. The four inquiry dimensions likewise function as qualitative analytic categories rather than a validated numerical scale for comparing lessons.

The study also did not collect systematic pre-post measures of teacher competence, longitudinal changes in teaching practice, or student learning outcomes. Student-level evidence is limited to observable classroom responses and products described in the lesson records, such as recording difficulties, balancing combinations, and problems generating interpretable data. Consequently, the findings support claims about inquiry characteristics, pedagogical problems made visible, and documented lesson revision, but not claims of sustained professional growth or improved student achievement. Future studies should follow multiple Lesson Study cycles and combine observation with independently coded lesson evidence, teacher interviews or knowledge measures, and student reasoning or conceptual-learning outcomes.

CONCLUSION

This study examined the inquiry characteristics of four science research lessons conducted through researcher-supported Lesson Study informed by Japanese practices in two Malaysian schools. Descriptive RTOP scores and qualitative inquiry-structure analysis showed that all four lessons contained inquiry-oriented activity, but the coherence of inquiry depended on how clearly the scientific problem, experimental procedures, evidence, explanation, and materials were aligned.

Four dimensions became central to professional examination during the Lesson Study process: problem framing, experimentation and data collection, evidence-to-explanation reasoning, and material-inquiry alignment. Classroom evidence showed that weaknesses in any one of these dimensions could disrupt the inquiry process. The revision from Lesson C to Lesson D additionally documented an enacted redesign of the task, experimental setup, and materials following problems identified in the earlier lesson.

The cases also revealed implementation challenges related to curriculum structure, planning time, experimental design, and students' limited familiarity with inquiry-oriented learning. These findings reinforce the need for context-sensitive adaptation when Lesson Study and inquiry-oriented resources are introduced across educational systems.

Overall, the study contributes a bounded, science-specific perspective on Lesson Study as a mechanism for making the epistemic structure of inquiry visible and discussable. It does not establish causal effects, sustained



teacher growth, or student achievement gains. Rather, it demonstrates how collaborative examination of enacted lessons can reveal misalignments in inquiry design and can inform concrete revisions that warrant further longitudinal investigation.

Implications For Practice and Research

The implications extend beyond a single national context. First, professional learning for inquiry-based science should create structured opportunities for teachers to examine enacted lessons, not merely receive general guidance about inquiry. Lesson Study offers one possible structure because planning, observation, evidence-based discussion, and revision can make specific weaknesses in inquiry design visible.

Second, professional development should focus on the pedagogical and epistemic connections that make inquiry meaningful: framing an investigable problem, designing procedures that generate usable evidence, supporting students to interpret that evidence, and selecting or adapting materials that represent the intended scientific relationship. These dimensions can also provide a practical framework for lesson planning and post-lesson discussion.

Third, cross-context use of Lesson Study should be approached as principled adaptation rather than direct transfer. Japanese Lesson Study practices and science materials were useful resources in the present cases, but their enactment required reinterpretation in relation to Malaysian curriculum pacing, classroom time, students' prior inquiry experience, and available materials.

Finally, future research should examine whether the pedagogical issues surfaced during Lesson Study led to sustained changes across multiple cycles. Longitudinal studies should follow teacher planning and classroom enactment over time, incorporate independent or formally calibrated coding where feasible, and examine student-level outcomes such as scientific reasoning, use of evidence, quality of explanations, and conceptual understanding. Research across a wider range of schools could also investigate how leadership, curriculum flexibility, teacher motivation, and school-university partnerships support or constrain sustained inquiry-oriented Lesson Study.

Ethics Statement

This study was conducted as non-interventional research in ordinary school settings. At the time of data collection, the study did not require formal institutional ethics approval because it did not involve clinical procedures, experimental treatment, psychological intervention, or the collection of sensitive personal data. Nevertheless, the study was carried out in accordance with the ethical requirements and expectations for educational research involving human participants. Permission to conduct the study was obtained from the participating schools. Informed consent was obtained from the participating teachers, and consent/permission was also obtained for student participation in classroom observations and lesson activities. Participation was voluntary, and participants were informed about the purpose of the study, the nature of the data collection, and their right to withdraw. To protect confidentiality, the names of schools, teachers, and students were anonymized using pseudonyms. All video recordings, lesson artefacts, observation data, and discussion records were used only for research purposes and were stored securely. Thus, although formal ethics approval was not applicable for this study, appropriate ethical safeguards were implemented to ensure voluntary participation, informed consent, confidentiality, anonymity, and responsible handling of research data.

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REFERENCES

1. Arifin, Z., Saputro, S., & Kamari, A. (2025). The effect of inquiry-based learning on students' critical thinking skills in science education: A systematic review and meta-analysis. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(3), em2592.



2. Alake-Tuenter, E., Biemans, H. J., Tobi, H., Wals, A. E., Oosterheert, I., & Mulder, M. (2012). Inquiry-based science education competencies of primary school teachers: A literature study and critical review of the American National Science Education Standards. *International Journal of Science Education*, 34(17), 2609-2640.
3. Akita, K., & Sakamoto, A. (2017). Lesson study and teachers' professional development in Japan. In K. Wood & S. Sithamparam (Eds.), *Realising Learning: Teachers' professional development through lesson and learning study* (pp. 25–40). Routledge.
4. Alston, A. S., Pedrick, L., Morris, K. P., & Basu, R. (2011). Lesson study as a tool for developing teachers' close attention to students' mathematical thinking. In L. C. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education* (pp. 135–151). Dordrecht, the Netherlands: Springer.
5. Doğan, S., Pringle, R. M., & Mesa, J. (2016). The impacts of professional learning communities on science teachers' knowledge, practice and student learning: a review. *Professional Development in Education*, 42, 569 - 588. <https://doi.org/10.1080/19415257.2015.1065899>
6. Fernandez, C., Cannon, J., & Chokshi, S. (2003). A US-Japan lesson study collaboration reveals critical lenses for examining practice. *Teaching and Teacher Education*, 19(2), 171–185. [doi.org/10.1016/S0742-051X\(02\)001026](https://doi.org/10.1016/S0742-051X(02)001026)
7. Fujii, T. (2014). Implementing Japanese lesson study in foreign countries: misconceptions revealed. *Mathematics Teacher Education and Development*, 16(1), 1-18.
8. Fujii, T. (2016). *What can we learn from the Japanese model of professional growth from novice to expert?* [Presentation]. Centre for Mathematical Sciences, Cambridge University.
9. Hatanaka, T. (2017). Describing and analysing Inquiry-based science teaching in Japanese lesson study, *Journal of Science and Mathematics Education in Southeast Asia*, 40(2), 122-141. http://www.recsam.edu.my/sub_JSMSEA/index.php/journal-collection/journals-2010-2019/2017
10. Kersting, M., Karlsen, S., Ødegaard, M., Olufsen, M., Kjærnsli, M., & Suhr Lunde, M. L. (2023). Studying the quality of inquiry-based teaching in science classrooms. A systematic video study of inquiry-based science teaching in primary and lower-secondary schools. *International Journal of Science Education*, 45(17), 1463-1484.
11. Kulpa, S. (2021). *An investigation of success factors in a high school algebra I program*. Lindenwood University.
12. Lapoule, P., & Lynch, R. (2018). The case study method: exploring the link between teaching and research. *Journal of Higher Education Policy and Management*, 40(5), 485-500.
13. Lewis, C. C., Perry, R. R., Friedkin, S., & Roth, J. R. (2012). Improving teaching does improve teachers: Evidence from lesson study. *Journal of teacher education*, 63(5), 368-375.
14. Lewis, C. (2016). How does lesson study improve mathematics instruction?. *ZDM*, 48, 571-580. <https://doi.org/10.1007/s11858-016-0792-x>
15. Lewis, C., & Hurd, J. (2011). *Lesson study step by step: How teacher learning communities improve instruction*. Portsmouth, NH: Heinemann.
16. Lim, C. S., Teh, K. H., & Chiew, C. M. (2018). Promoting and implementing lesson study in Malaysia: Issue of sustainability. *Mathematics Lesson Study Around the World: Theoretical and Methodological Issues*, 47-64.
17. Mizwar, M., Setiawan, H., Rogahang, M. K., & Tikulembang, G. A. (2026). Implementation of the inquiry learning model to enhance junior high school students' scientific literacy: A qualitative study. *Priviet Social Sciences Journal*. <https://doi.org/10.55942/pssj.v6i3.1261>
18. Piburn, M., & Sawada, D. (2000). *Reformed teaching observation protocol (RTOP): Reference manual* (ACEPT Technical Report No. IN00-3). Arizona Collaborative for Excellence in the Preparation of Teachers. <https://eric.ed.gov/?id=ED447205>
19. Rahim, S., Sulaiman, S., & Sulaiman, T. (2015). Teacher professional development through lesson study in secondary schools. *Advanced Science Letters*, 21, 2360-2364. doi.org/10.1166/asl.2015.6276
20. Saito, E. (2012). Key issues of lesson study in Japan and the United States: a literature review. *Professional Development in Education*, 38(5), 777-789.
21. Sawada, D., Piburn, M. D., Judson, E., Turley, J., Falconer, K., Benford, R. & Bloom, I. (2002). Measuring reform practices in science and mathematics classrooms: the reformed teaching observation protocol. *School Science and Mathematics*, 102(6), 245–253.



22. Stigler, J. W., and Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: Free Press.
23. Willems, I., & Van den Bossche, P. (2019). Lesson Study effectiveness for teachers' professional learning: A best evidence synthesis. *International Journal for Lesson and Learning Studies*, 8(4), 257–271. <https://doi.org/10.1108/IJLLS-04-2019-0031>