Journal of Innovative Physics Teaching
Volume 4, Issue 2 Desember 2026, 205- 216
ISSN: 3021-8551 (Online)
Doi: https://doi.org/10.24036/jipt/vol4-iss2/148
https://jipt.ppj.unp.ac.id/index.php/jipt

Evaluation of the Syntax Gap in Problem-Based Learning (PBL) and Science Literacy: A Multi-Case Analysis of Madrasah Science Teacher Supervision Results

Pipi Deswita[1*], Rahma Dani[2], Azizah Rahmy[3], Festiyed[4], Skunda Diliarosta[5], Fatni Mufit[6]
[1,2,3,4,5,6] Department of Natural Sciences, Faculty of Mathematics and Natural Science, Universitas Negeri Padang, 25132 Indonesia.
[1] Department of Physics Education, Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Imam Bonjol Padang, 25126 Indonesia.

Article Info

Article history:

Received June 06, 2026
Revised July 19, 2026
Accepted July 27, 2026

Keywords:

Science Literacy
Problem-Based Learning
Syntax Gap
Academic Supervision
Multi-Case Study

ABSTRACT

The low achievement of students' science literacy in Indonesia demands a radical instructional evaluation of innovative learning models such as Problem-Based Learning (PBL) at the school level. This study aims to deeply analyze the phenomenon of the syntax gap in the PBL model based on empirical data from the academic supervision of science teachers in madrasahs. Using a qualitative approach with a multi-case study design, this research examines teaching module documents, supervision recordings, and student scientific competency achievement sheets in two cases of science teachers at MTsN 17 Tanah Datar. The results of the cross-case analysis prove the existence of persistent procedural discrepancies between the written scenarios and classroom realizations, with an average implementation gap of the syntax ranging from 30.2% to 38.4%. The sharpest decline in teaching performance was consistently found in critical phases, particularly during the solution development stage and joint evaluation with students. The impact of the syntax gap directly affects the weak mastery of scientific literacy among students, which remains in the moderate to low category, especially in the aspects of scientific reasoning and evidence-based decision-making. These findings underscore the importance of reconstructing the paradigm of academic supervision from merely a formal administrative instrument to a continuous clinical evaluation function in order to uphold the pedagogical quality of science teachers in the field.

***Correspondence:**
Pipi Deswita, Department of Physics Education, Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Imam Bonjol Padang, 25126 Indonesia.
· email : pipideswita@uinib.ac.id , Phone: 082288792445

INTRODUCTION

The ability to think critically amidst the rapid development of technology has now become the main indicator in measuring the level of scientific literacy in modern society. Theoretical mastery of scientific concepts is no longer sufficient if not accompanied by the skill to evaluate data for decision making (Feldman, 2000; Osborne & Allchin, 2025). In order to achieve that competence, the learning environment must be conditioned to provide authentic experiences that integrate various dynamics of socio-scientific issues (Cayci, 2020; Högström et al., 2025; Khairrunisa et al., 2025). The essence of this literacy has a broad impact on strengthening both cognitive aspects and the social skills of students, particularly in terms of communication, problem-solving, and teamwork (Seema, 2024; UNESCO, 2018). The introduction of this scientific climate needs to be stimulated from childhood to spark innovative thinking through a student-centered instructional approach (Li & Guo, 2021; Sanjiartha et al., 2024).

Theoretically, the sequential syntax of the PBL model is not merely a procedural checklist but a cognitive scaffolding mechanism rooted in constructivist learning theories. Each structural phase from orientation to the ill structured problem, through self-directed inquiry, to the final presentation serves a distinct epistemological function in knowledge construction. When instructional fidelity is compromised, the cognitive load on students becomes unmanageable, disrupting the transition from novice to expert problem solvers. Therefore, maintaining strict adherence to the PBL syntax is theoretically imperative to ensure that the intended cognitive and metacognitive processes are actually triggered during the learning experience (Supiandi & Julung, 2016).

The quality of science education in Indonesia currently still requires serious improvement due to low achievements on an international scale. Periodic reports from the Program for International Student Assessment (PISA) show that only about 34% of students in Indonesia are able to reach Level 2 in science proficiency (OECD, 2023). One of the tactical steps offered by experts to bridge this competency gap is the utilization of the Problem-Based Learning (PBL) model based on socio-scientific issues (Khairrunisa et al., 2025). Empirically, the PBL framework has proven effective in accelerating content understanding, mastery of scientific procedures, and the formation of positive student attitudes toward science (Funa & Prudente, 2021; Inayah & Solihat, 2024). The optimization of this problem-based model has become a crucial agenda to align the quality of graduates with the human resource needs of the 21st century.

The success of implementing the PBL model in the classroom often faces significant deviations when confronted with real-world realities. Instructional barriers often arise when the learning scenarios designed in the lesson plan (RPP) are not fully realized during the teacher's interaction with students (Tsakeni et al., 2025). This procedural inconsistency adversely affects the development of science process skills and the independence of students' critical thinking. This condition underscores the importance of measurable academic supervision for science subject teachers. Through an appropriate evaluation scheme, the learning process can be monitored to remain aligned with the target of achieving scientific literacy competencies.

Academic supervision activities play a very vital role in facilitating the improvement of teacher professionalism in schools. Through targeted coaching, the quality of teaching methodologies can be improved while simultaneously encouraging the emergence of various learning innovations (Imamah et al., 2025; Tidjani & Lailiyah, 2023). Unfortunately, previous studies still often view the supervision program merely as a formal document to fulfill the administrative needs of the institution. In-depth investigations that utilize recorded data from supervision results as clinical evaluation materials to dissect the constraints of the PBL model are still very rare. The gap in the literature is what has caused the root of the problems in problem-based science teaching to remain poorly understood.

From a theoretical standpoint, addressing these instructional deviations requires shifting the paradigm of academic supervision from a bureaucratic evaluation to a clinical, reflective practice. Grounded in adult learning theory and reflective practice frameworks, effective supervision operates through collaborative, evidence-based dialogues that prompt teachers to critically deconstruct their pedagogical choices. By utilizing concrete observational data regarding syntax deviations, supervisors can guide teachers in bridging the gap between their pedagogical knowledge and actual classroom execution, thereby transforming supervision into a formative mechanism for continuous professional growth (Zahrotunnaqiyahi et al., 2026).

The madrasah governance system already has a systematic regulation in executing the supervision program, starting from classroom monitoring to reflection sessions with teachers. This two-way communication space has great potential to identify and correct teachers' weaknesses in executing the stages of learning (Tidjani & Lailiyah, 2023). Field evaluation results indicate that the weak points or syntax gaps are most often found in the problem mapping phase and the independent solution-seeking phase by students. However, failure in these two crucial phases risks stifling the development of critical reasoning and problem-solving skills that are being built. The focus on improvement in this area needs to be encouraged so that the supervisory function can have an immediate impact overall student competence and academic achievement.

This research is designed to map in detail the location of discrepancies or syntax gaps in the PBL model based on the track record of science teachers' supervision in madrasahs. The multi-case analysis approach was deliberately chosen so that patterns of instructional deviations in several locations could be comprehensively compared. The output of this analysis is projected to produce a new blueprint for the ideal science teaching methods for educators. On the other hand, the scientific recommendations from this research can serve as a reference for madrasah heads to develop sharper clinical supervision strategies. Ultimately, reduction of the teaching syntax gap will become the primary key to significantly boosting the performance of students' science literacy.

METHODS

Research Design

A qualitative approach with a multi-case study design was chosen in this research to deeply explore the phenomenon of syntax gap in the PBL model. The use of a multi-case study design allows researchers to conduct a comprehensive comparative analysis of supervision data from several different madrasahs (Yin, 2009) This approach is very effective in identifying patterns of instructional deviations that are either constant or contextual in the field (Gustafsson & Gustafsson, 2017; Patton, 2014). The main characteristic of this study focuses on mapping the discrepancies between learning planning documents, the realization of syntax in the classroom, and its impact on students' science literacy achievements. Thru clearly defined case boundaries, researchers can construct a stronger theoretical understanding of the factors triggering these syntactic failures (Creswell & Poth, 2016).

Subjects and Research Context

The selection of research subjects was conducted using purposive sampling techniques to ensure a rich and relevant data representation aligned with the research objectives. The cases analyzed in this study include the academic supervision results from three Madrasah Tsanawiyah (MTs) that have formally implemented the Merdeka Curriculum and the PBL model in Padang City. The inclusion criteria for subjects include certified science teachers (integrated physics/biology/chemistry) who have a documented record of at least two cycles of clinical supervision in the last academic year (Patton, 2014) The focus on the madrasah environment was deliberately chosen due to the unique cultural aspects of instructional governance and specific religious oversight structures (Rozi, 2016). The diversity of characteristics from the three madrasah locations is expected to provide a thick description of data related to the syntax gap phenomenon.

Data Sources and Instruments

The main data sources for this research were obtained thru triangulation from academic supervision portfolio documents, field notes from class observations, and post-observation interview transcripts. The analyzed supervision documents include the PBL syntax conformity assessment sheets filled out by the head of the madrasah or the supervising (Glickman et al., 2001). The supporting data collection instruments were designed using text content analysis guidelines and semi-structured interview guides validated by educational evaluation experts (Sugiyono, 2013). The presence of the researcher in this qualitative study acts as a key instrument (human instrument) to interpret the meaning behind the quantitative data of the supervision sheet (Kodasseri & KP, 2025). This holistic data collection is aimed at objectively confirming the location of procedural discrepancies without neglecting the classroom context.

Data Analysis Techniques

The data analysis procedure was conducted using the constant comparative analysis technique adapted for multi-case studies. The stages of data analysis begin with conducting within-case analysis to understand the unique characteristics of syntactic deviations in each madrasa independently (Peredaryenko & Krauss, 2013). The next step is to conduct cross-case analysis to identify common patterns, anomalies, and variable interactions that trigger the emergence of syntax gaps across all locations (Huberman, 2014). The process of coding textual data is supported by the use of computer-based qualitative data analysis software to maintain objectivity and accuracy in the grouping of theoretical themes. The final synthesis of this comparative analysis is projected to yield a new proposition regarding the ideal structure for science teacher development.

Data Validity (Trustworthiness)

The validity and credibility of the findings of this study are ensured thru the application of four criteria for the validity of qualitative data. The strategy of source triangulation and method triangulation was strictly applied by comparing the consistency between supervisory administrative documents, learning video recordings, and teacher acknowledgments (Denzin, 2017). The researcher also conducted member checking by returning the draft interview transcripts and theme analysis results to the science teachers and relevant supervisors to verify the accuracy of the data interpretation (Tisdell, Merriam, & Stuckey-Peyrot, 2025). In addition, the transferability of the research results is pursued by compiling a highly detailed descriptive report on the sociocultural context of the madrasah and the characteristics of the subjects (Geertz, 1973). All audit trails of the research implementation are systematically stored to meet the aspects of dependability and confirmability of the research.

RESULTS AND DISCUSSION

Results

The empirical findings of this study are constructed through data triangulation, combining teaching module documents, instructional supervision records, and student science literacy achievement sheets. These data sources were analyzed concurrently to ensure the validity and objectivity of the field mapping regarding syntactic gaps. The presentation of findings is organized into two main analytical stages to maintain the depth and systematic nature of the qualitative discussion. The first stage focuses on within-case analysis to examine the dynamics and characteristics of learning implementation in each madrasah independently. This is followed by a cross-case analysis to map comprehensive discrepancy patterns and formulate a theoretical synthesis.

Within-Case Analysis

Case 1: Procedural Discrepancy and Inquiry Reduction

The lesson plan prepared by the teacher in Case 1 of the teaching module on the human respiratory system actually includes components of the PBL model. The supervisor's assessment shows that the teacher has made an effort to design the instructional flow from problem orientation to evaluation. However, real classroom visualization shows significant deviations because the PBL syntax steps have not been fully executed. The main obstacle recommended by the supervisor is the lack of independent scientific inquiry activities by the students, such as the practical on the impact of smoking on the respiratory organs. As a result, the dominant use of audiovisual media centered on the teacher has not yet been able to stimulate students' critical thinking skills and scientific literacy independently. The level of real implementation of each core stage of PBL in Case 1 is quantitatively presented in Table 1.

Table 1. Implementation of PBL Syntax in Case 1

PBL Stage	Standard (%)	Implementation (%)	Gap (%)
Problem orientation	100	72.0	28.0
Student organization	100	78.0	22.0
Independent investigation	100	69.0	31.0
Development and presentation	100	66.0	34.0
Evaluation	100	64.0	36.0
Average	100	69.8	30.2
Problem orientation	100	72.0	28.0

The data in Table 1 shows that the fulfillment of the standard operational procedures of the Problem-Based Learning (PBL) model in Case 1 generally still leaves an average gap of 30.2%. The highest discrepancy figure is specifically found in the evaluation stage with a gap reaching 36.0%, followed by the development and presentation phase with a gap of 34.0%. The high percentage of gaps in these two final syntaxes indicates that instructional interaction in the classroom is still dominated by the active role of the teacher (teacher-centered). The limited exploration space directly impacts the minimal involvement of students in higher-order thinking skills activities to critique the problem-solving process. As a result, the accumulation of procedural deviations from the investigation phase to the evaluation phase becomes the main factor hindering the optimization of students' science literacy achievements in madrasahs.

Case 2: Time Allocation and Contextual Constraints

In Case 2, the teacher's lesson plan formally incorporated all syntactic components of the PBL model. The teacher also attempted to utilize audiovisual media and guide students through basic scientific investigations during practical lessons on the topic of matter changes. However, actual classroom implementation revealed a significantly larger discrepancy compared to Case 1. Academic supervision records highlighted critical issues, specifically poor time management and the ineffective use of triggering questions to activate students' prior knowledge at the beginning of the session. The percentages of actual implementation and the extent of syntax gaps across each core PBL stage in Case 2 are detailed in Table 2.

Table 2. Implementation of PBL Syntax in Case 2

PBL Stage	Standard (%)	Implementation (%)	Gap (%)
Problem orientation	100	65.0	35.0
Student organization	100	70.0	30.0
Independent investigation	100	60.0	40.0
Development and presentation	100	58.0	42.0
Evaluation	100	55.0	45.0
Average	100	61.6	38.4
Problem orientation	100	65.0	35.0

The data in Table 2 confirms that the implementation of the Problem-Based Learning (PBL) model in Case 2 faced quite serious procedural obstacles, leaving an average gap of 38.4%. The most significant decline in instructional performance occurred sequentially at the evaluation stage with a gap of 45.0%, and the development and presentation phase with a gap of 42.0%. The very large deficits in these final phases strongly indicate that the process of joint reflection and the space for students to build scientific arguments did not run effectively in the classroom. These limitations were exacerbated by interaction patterns that tended to revert to the lecture method due to the teacher's unpreparedness in managing time and forming differentiated groups. The multiplicative impact of this high syntactic gap ultimately limits the space for students' logical reasoning exploration, which is a primary prerequ isite for fostering scientific literacy skills and critical thinking capabilities.

Cross-Case Analysis

Comparative Synthesis of Instructional Gap Patterns in PBL Syntax This cross-case analysis stage aims to map the common threads and consistency of discrepancy patterns occurring in both research locations comparatively. Thru this comparison, the researcher can see the extent of the tendency for the decline in the quality of problem-based learning model implementation in each madrasa. Data recordings from both cases indicate a similarity in the structure of obstacles, although quantitatively, the gap in Case 2 is relatively larger. The visualization of the comparison of the percentage of actual implementation between PBL syntax from the two research subjects is presented in detail in Table 3.

Table 3. Comparison of PBL Implementation

PBL Stage	Case 1 (%)	Case 2 (%)
Problem orientation	72.0	65.0
Student organization	78.0	70.0
Independent investigation	69.0	60.0
Development and presentation	66.0	58.0
Evaluation	64.0	55.0

The comparative data in Table 3 consistently show a trend where the percentage of PBL model implementation decreases as the complexity and stages of syntax increase. The problem orientation and student organization phases occupy the highest implementation levels in both cases due to their still formal administrative procedural nature. On the contrary, the instructional performance of teachers experiences a sharp decline when entering the phases of independent investigation, solution development, and evaluation. This linear decline serves as empirical evidence that educators in madrasahs still face significant challenges in stimulating high-level cognitive processes and students' scientific argumentation. As a result, this uniform syntax gap pattern confirms that the structuring of future clinical supervision programs should focus on monitoring these critical phases in order to escalate students' science literacy.

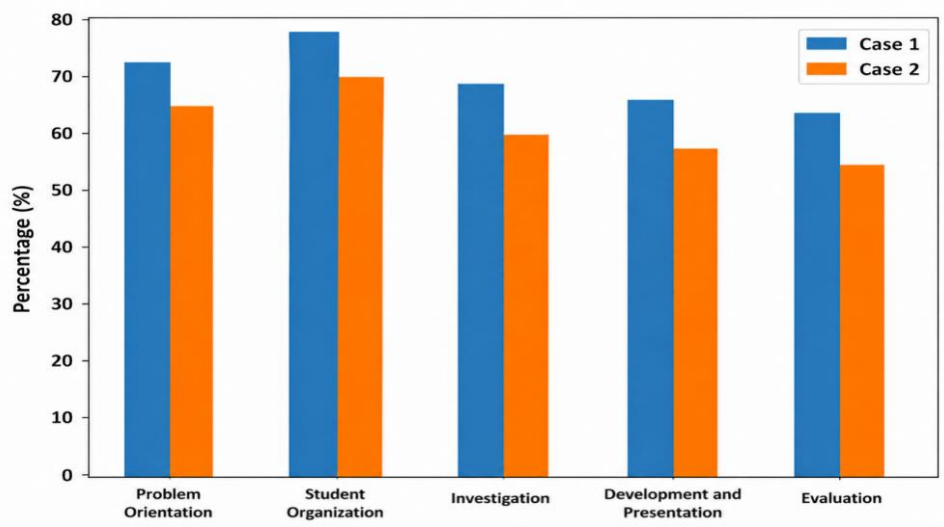

Figure 1. Comparison of PBL Syntax Implementation in Case 1 and Case 2

Figure 1 illustrates a comparative analysis of the implementation levels of the Problem-Based Learning (PBL) framework between Case 1 and Case 2 across five principal stages. Overall, all phases in Case 2 exhibit diminished values relative to Case 1. The most notable decrease is evident in the solution development phase (66.0% vs 58.0%) and the evaluation phase (64.0% vs 55.0%), both of which represent higher-order thinking stages in project-based learning (PBL). Statistically, the average implementation in Case 1 is 69.8%, whereas in Case 2 it is 61.6%, resulting in a difference of 8.2%. This signifies a moderate disparity in the quality of PBL implementation between the two scenarios. The persistent decline from the early to the last stage suggests that increased complexity in PBL terminology correlates with a reduced implementation level in the classroom.

Students' Scientific Literacy Achievement

The measurement of students' science literacy success in this study is comprehensively analyzed using four main performance indicators. The first indicator focuses on the mastery of conceptual science knowledge to measure the extent of students' theoretical understanding of the natural phenomena being studied. The next aspect is data interpretation skills, where students are required to read, analyze, and conclude scientific information presented in the form of tables or graphs. Furthermore, the scientific reasoning indicator is used to evaluate students' ability to construct logical arguments and conduct investigations based on empirical evidence. This assessment matrix concludes with decision-making parameters, which test students' critical thinking sharpness in formulating tactical solutions to real-world socio-scientific issues.

Table 4. Students' Scientific Literacy Achievement

Scientific Literacy Aspect	Case 1 (%)	Case 2 (%)
Conceptual understanding	75.0	70.0
Data interpretation	68.0	60.0
Scientific reasoning	65.0	58.0
Decision-making	62.0	55.0
Average	67.5	60.8

Achievement data in Table 4 shows that the science literacy performance of students in both cases has a linear tendency that is directly proportional to the quality of the implementation of the teacher's teaching syntax. The aspect of conceptual understanding scored the highest in both locations because teachers still predominantly facilitated the transfer of theoretical knowledge based on materials in the classroom. On the contrary, a significant degradation in achievement is observed in the parameters of scientific reasoning and decision-making, where the lowest scores are found in Case 2 with percentages of 58.0% and 55.0%, respectively. The low scores in these essential aspects serve as concrete evidence that the syntax gap in the final phase of PBL directly impacts the weakness in students' critical reasoning construction. These empirical conditions underscore the urgency for supervisors to structurally oversee the improvement of science teachers' pedagogical performance in order to enhance students' scientific literacy in madrasah.

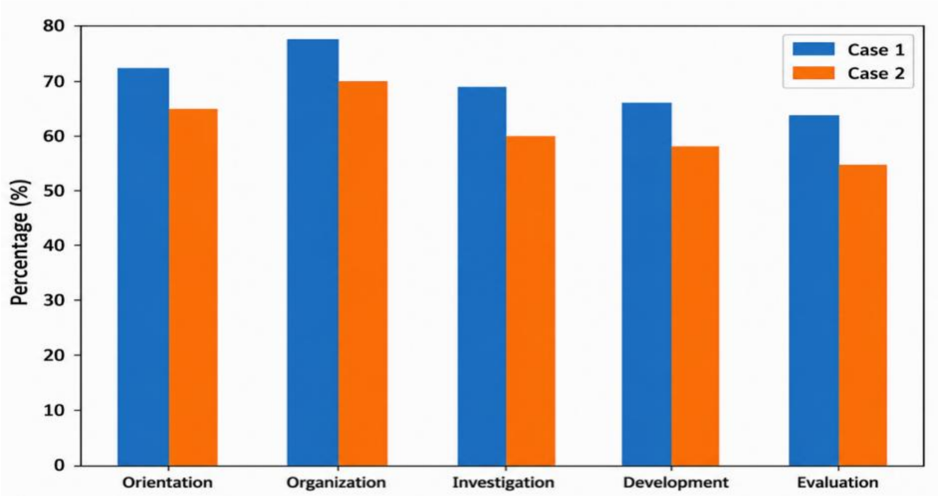

Figure 2. Comparison of Students' Scientific Literacy Achievement

Figure 2 shows a comparison of students' science literacy achievements in four aspects: concept understanding, data interpretation, scientific reasoning, and decision-making. The results show that Case 1 consistently has higher achievements compared to Case 2 in all aspects. The average science literacy achievement in Case 1 is 67.5%, while in Case 2 it is 60.8%, with a difference of 6.7%. The largest differences are seen in the aspects of data interpretation (68.0% vs 60.0%) and scientific reasoning (65.0% vs 58.0%), indicating that students' higher-order thinking skills are still relatively low. This analysis indicates a positive relationship between the implementation of PBL syntax and students' science literacy achievements, where an improvement in the quality of PBL implementation tends to be followed by an increase in science literacy skills.

Discussion

The findings of this research reveal a persistent and significant discrepancy between the conceptual design in the teaching module and the instructional actualization of the PBL model in the classroom, with an average gap reaching 30.2% to 38.4%. This phenomenon reinforces the thesis that the effectiveness of the problem-based learning model does not merely rely on the elegance of the preparation documents, but rather on the rigor of the pedagogical execution quality of science teachers in the field. The structural discrepancy is in line with previous studies that highlight the frequent divergence between the intended curriculum and the curriculum actually implemented in schools (Tsakeni et al, 2025). Considering that the largest gap peaks during the solution development and evaluation phases, the main essence of the PBL philosophy as a driver of critical thinking is not fully conveyed. The low implementation in those critical phases confirms that the classroom atmosphere in madrasahs is still trapped in a conventional instructional pattern that is teacher-centered. This empirical condition clearly contradicts the fundamental principles of constructivism, which demand the active involvement of students in independently building knowledge through a series of authentic learning experiences (Tohari & Rahman, 2024).

The direct consequence of this syntactic deviation is a measurable decline in students' scientific literacy, particularly in the domains of scientific inquiry and data evaluation (OECD, 2023). When the 'guiding investigation' and 'developing artifacts' phases are truncated by teachers, students are deprived of the cognitive struggle necessary to interpret empirical evidence and construct evidence-based arguments (Kapur, 2016). In the context of international assessment frameworks like PISA, scientific literacy is not merely about recalling scientific facts, but about applying them to evaluate real-world dilemmas. Therefore, the observed syntax gaps in madrasah classrooms do not just represent a failure in lesson delivery; they represent a systemic failure to cultivate the specific epistemic competencies required for modern scientific citizenship (Osborne & Allchin, 2025).

Academic supervision conducted by the head of the madrasah and supervisory inspectors holds a very strategic position in unraveling the root causes of teachers' instructional constraints in the classroom. Instructional supervision activities that are meticulously designed have proven capable of acting as a sharp pedagogical reflection mirror to instantly detect teaching deviations (Imamah et al., 2025). However, the practical reality in the madrasah environment shows that the supervisory function so far still operates sub optimally because it tends to get trapped in merely fulfilling formal administrative paperwork. Supervision sheet data is rarely followed up as a clinical database to design continuous professional development programs for science teachers who experience syntactic difficulties. As a result, the function of learning quality control becomes ineffective and does not have a transformative impact on improving teachers' teaching competencies or enhancing students' learning outcomes.

To transition supervision from an administrative burden to a clinical intervention, the post observation conference must be restructured as a collaborative meaning-making space rather than a top-down evaluation (Knight, 2017). In this clinical model, the supervisor utilizes the recorded syntax gaps as objective prompts for reflection, asking probing questions that guide the teacher to self-identify their pedagogical missteps without feeling defensive. For instance, if a supervisor notes that the 'problem orientation' phase was rushed, the reflective dialogue would focus specifically on the teacher's questioning techniques and time management strategies (Berland et al., 2016). This evidence-based coaching cycle ensures that professional development is highly contextualized, directly targeting the specific instructional bottlenecks identified during the multi-case analysis (Glanz & Zepeda, 2015).

The acceleration of students' science literacy achievements through the PBL model ultimately culminates in the simultaneous integration of three main components. These components include the readiness of teaching module documents that are accommodative to socio-scientific issues, the consistency of teachers in executing the learning syntax in the classroom, and the support of academic supervision that is reflective-clinical in nature. The great potential of the PBL model to produce a scientifically literate generation cannot be realized if there is a flaw in any of these systemic elements. Policy makers in madrasahs must begin to formulate a teacher development scheme focused on the tactical and sustainable reduction of the syntax gap. Through a strong synergy between planning, implementation, and evidence-based supervision, the governance of science education in madrasahs can be optimized toward 21st-century quality standards.

The operational dynamics of the PBL model in the classroom often clash with various sociocultural realities and the level of technical readiness in the field. Instructional barriers often arise when the learning scenarios meticulously designed in the Lesson Plan (RPP) or teaching module are not fully realized during the teacher's interaction with students (Tsakeni et al., 2025). This discrepancy is generally triggered by the teacher's inability to manage unstructured class dynamics, especially when facilitating group debates that consume a lot of time. As a result, teachers tend to take shortcuts by cutting crucial syntactic steps at the end of the session to catch up on the lesson material. This procedural inconsistency negatively impacts the development of science process skills and stifles the critical thinking independence that students are building in the classroom.

CONCLUSION

This research proves the existence of a significant gap (syntax gap) between the conceptual planning and the operational realization of the Problem-Based Learning (PBL) model in science education within the madrasah environment. Although educators have developed problem-based teaching modules with a theoretically sound structure, the real implementation in the classroom shows an average discrepancy ranging from 30.2% to 38.4%, especially in the phases of solution development and final evaluation. These procedural obstacles directly impact students' science literacy achievements, which tend to be stagnant in the moderate to low category, particularly in the domains of scientific reasoning and evidence-based decision-making. These findings affirm that the effectiveness of the PBL model is not only determined by the quality of the preparation documents but also by the consistency and depth of the teacher's instructional execution in each phase of learning. On the other hand, academic supervision activities have proven to have strategic potential as a pedagogical reflection instrument to clinically detect deviations in teacher instruction. However, the utilization of field supervision programs so far remains suboptimal as it tends to get trapped in merely fulfilling administrative document formalities. Therefore, systematic steps are needed to reconstruct the science teacher competency model while shifting the paradigm of academic supervision toward a sustainable professional development function to boost students' scientific literacy.

REFERENCE

Berland, L. K., Schwarz, C. V, Krist, C., Kenyon, L., Lo, A. S., & Reiser, B. J. (2016). *Epistemologies in Practice: Making Scientific Practices Meaningful for Students. Journal of Research in Science Teaching*, 53(7), 1082–1112.

Cayci, B. (2020). *A Study on The Effectiveness of a Teaching Based on Socio-Scientific Issues in the Training of Pre-Service Teachers*. *Cypriot Journal of Educational Sciences*, 15(2), 220–231.

Creswell, J. W., & Poth, C. N. (2016). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches (4th ed.)*. Sage Publications.

Denzin, N. K. (2017). *The Research Act: A Theoretical Introduction to Sociological Methods*. Routledge.

Feldman, A. (2000). *Decision Making in The Practical Domain: a Model of Practical Conceptual Change*. *Science Education*, 84(5), 606–623.

Funa, A. A., & Prudente, M. S. (2021). *Effectiveness of Problem-Based Learning on Secondary Students' Achievement in Science: A Meta-Analysis*. *International Journal of Instruction*, 14(4), 69–84.

Geertz, C. (1973). *The Interpretation of Cultures: Selected Essays.* Basic Books, New York.

Glanz, J., & Zepeda, S. J. (2015). *Supervision: New Perspectives for Theory and Practice*.

Bloomsbury Publishing USA.

Glickman, C. D., Gordon, S. P., & Ross-Gordon, J. M. (2001). *Supervision and Instructional Leadership: A Developmental Approach*. Allyn & Bacon.

Gustafsson, J., & Gustafsson, J. (2017). *Single Case Studies Vs. Multiple Case Studies: A Comparative Study*. *International Journal of Applied Business and Economic Research*, 15(1), 1-10.

Högström, P., Gericke, N., Wallin, J., & Bergman, E. (2025). *Teaching Socioscientific Issues: A Systematic Review. Science & Education*, 34(5), 3079–3122.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook (3rd ed.)*. Sage Publications.

Imamah, I., Umah, L. R., & Septiana, N. (2025). *Building a Pedagogical Innovation Ecosystem: The Role of Clinical Supervision in Improving The Quality of Madrasah Aliyah*. *Managere: Indonesian Journal of Educational Management,* 7(2), 125–136.

Inayah, D., & Solihat, N. (2024). *Problem Based Learning sebagai Strategi Meningkatkan Literasi Sains Siswa: Studi Literatur*. *Journals of Indonesian Multidisciplinary Research*, 3(2), 101–110.

Kapur, M. (2016). *Examining Productive Failure, Productive Success, Unproductive Failure, and Unproductive Success In Learning*. *Educational Psychologist*, 51(2), 289–299.

Khairrunisa, A. N., Yusup, I. R., & Paujiah, E. (2025). *Improving Students' Scientific Literacy Through a Problem-Based Learning Model Integrated with Socio-Scientific Issues on Ecosystem Learning. Biosfer: Jurnal Pendidikan Biologi*, 18(2), 276–289.

Knight, J. (2017). *The Impact Cycle: What Instructional Coaches Should do to Foster Powerful Improvements in Teaching*. Corwin Press.

Kodasseri, M. H., & KP, H. S. (2025). *Characteristics of Traditional Arabic Grammar Texts in The Curriculum of Pallidars Education in Malabar*. *Lahjatuna: Jurnal Pendidikan Bahasa Arab*, 5(1), 67–91.

Li, Y., & Guo, M. (2021). *Scientific Literacy in Communicating Science and Socio-Scientific Issues: Prospects and Challenges. Frontiers in Psychology*, 12(1), 1-15.

OECD. (2023). PISA 2022 *Results (Volume I): The State of Learning and Equity in Education*. OECD Publishing.

Osborne, J., & Allchin, D. (2025). *Science Literacy in The Twenty-First Century: Informed Trust and The Competent Outsider. International Journal of Science Education*, 47(15), 2134–2155.

Patton, M. Q. (2014). *Qualitative Research & Evaluation Methods: Integrating Theory and Practice (4th ed.).* Sage Publications.

Peredaryenko, M. S., & Krauss, S. E. (2013). *Calibrating the Human Instrument: Understanding the Interviewing Experience of Novice Qualitative Researchers. The Qualitative Report*, 18(43), 1–17.

Rozi, M. A. F. (2016). *Strategi Peningkatan Mutu Pendidikan Islam*. *EDUKASI: Jurnal Pendidikan Islam (e-Journal)*, 4(2), 322–336.

Sanjiartha, I. G. D., Suwindia, I. G., & Winangun, I. M. A. (2024). *Peran Literasi Sains dalam Membentuk Generasi Berfikir Kritis dan Inovatif: Kajian Literature Review*. *Education and Social Sciences Review*, 5(2), 120–128.

Seema, P. V. (2024). *Developing Scientific Literacy to Promote 21st Century Skills*. *Journal on School*

Educational Technology, 20(1), 1–4.

Sugiyono. (2013). *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif dan R&D*. Alfabeta.

Supiandi, M. I., & Julung, H. (2016). *Pengaruh Model Problem Based Learning (PBL) terhadap Kemampuan Memecahkan Masalah dan Hasil Belajar Kognitif Siswa Biologi SMA*. *Jurnal Pendidikan Sains*, 4(2), 60–64.

Tidjani, A., & Lailiyah, Z. (2023). *The Role of Academic Supervision in Improving Teacher Professionalism. Educenter Jurnal Ilmiah Pendidikan*, 2(2), 96–101.

Tohari, B., & Rahman, A. (2024). *Konstruktivisme Lev Semonovich Vygotsky dan Jerome Bruner: Model Pembelajaran Aktif dalam Pengembangan Kemampuan Kognitif Anak*. *Nusantara: Jurnal Pendidikan Indonesia*, 4(1), 209–228.

Tsakeni, M., Mosia, M., Egara, F. O., & Nwafor, S. C. (2025). *Bridging The Gap Between Intention and Enactment: a Bayesian Analysis of Pre-Service Teachers' Implementation of Inquiry-Based Practical Work in STEM (science-led) Classrooms*. *Frontiers in Education*, 10(1), 1-14.

UNESCO. (2018). *A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2*. UNESCO Institute for Statistics.

Yin, R. K. (2009). *Case Study Research: Design and Methods (4th ed.)*. Sage Publications.

Zahrotunnaqiyahi, E., Ultsa, F., & Rosmilawati, I. (2026). *Peran Supervisi Akademik dalam Mendorong Refleksi Diri Guru Pada Proses Pembelajaran*. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 11(1), 185–201.