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ANALYZING THE STRENGTHENING OF INTERPRETATION AND EVALUATION THROUGH SCHOOL ENVIRONMENT OBSERVATION IN ELEMENTARY IPAS LEARNING

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ABSTRACT

Research on strengthening critical thinking through contextual learning has rarely examined the dimensions of interpretation and evaluation as distinct constructs, particularly by using school environment observation as the primary learning strategy in elementary education. This study aimed to analyze the process of strengthening these two dimensions in ecosystem-themed IPAS learning. A qualitative approach with a single-case study design was employed. Data were collected through classroom observations, a modified analytic performance assessment rubric adapted from established critical thinking frameworks to assess the interpretation and evaluation dimensions, semi-structured interviews, and documentation. The rubric operationalized each dimension into observable behavioral indicators and was reviewed by experts prior to implementation. Improvements were identified through changes in students' performance across repeated observation activities, triangulated with interview data, classroom field notes, and students' written reports. Data were analyzed using Miles and Huberman's interactive model, including data reduction, data display, and conclusion drawing/verification.The findings indicate that, in the initial phase, students tended to record only general characteristics and experienced difficulty relating observational data. Following repeated school environment observations supported by probing questions, students demonstrated substantial progress in the interpretation dimension by classifying findings based on meaningful patterns, relating soil conditions to plant health, and explaining causal relationships among observed phenomena. Improvement in the evaluation dimension was evident during group and whole-class discussions, where students progressed from expressing unsupported opinions to comparing findings across groups, assessing the credibility and adequacy of evidence, revising their arguments based on agreed criteria, and providing evidence-based justifications for their conclusions. The findings suggest that the synergy of authentic learning experiences, teacher scaffolding, and collaborative social interaction plays a central role in strengthening students' interpretation and evaluation skills within elementary IPAS learning.

Keywords: interpretation; evaluation; observation; science

INTRODUCTION

The changes in the lives of the global community marked by the industrial revolution 4.0 which touched all levels of society have also changed the world of education by making the ability to think at a higher level (*higher-order thinking skills/HOTS*) as a very important ability for students (Dafit & Mustika, 2021). The ability to think analytically plays an important role because it helps everyone analyze data, handle complex problems, and make informed decisions (Dilah, 2023) In the study of Natural and Social Sciences (IPAS) learning, there are two key dimensions in critical thinking that are very relevant, namely interpretation and evaluation (Oktiningrum *et al*., 2025). The interpretation aspect refers to the ability to

understand, construct meaning, and draw conclusions from a data, statement, or observed phenomenon. Meanwhile, evaluation is the ability to assess the credibility of a statement or the quality of a procedure based on existing standards and evidence (Dafit & Mustika, 2021). Mastery of the interpretation and evaluation dimensions enables students not only to memorize scientific facts but also to understand the processes underlying scientific phenomena and critically assess the validity of evidence and claims, which constitute the foundation of scientific literacy. However, previous studies have primarily examined the effectiveness of school environment observation in improving overall learning outcomes or general critical thinking skills, with limited attention to how this learning approach specifically strengthens the interpretation and evaluation dimensions of critical thinking in elementary IPAS learning. Consequently, the mechanisms through which school environment observation contributes to these two critical thinking dimensions remain insufficiently understood.

Accordingly, this study addresses the following research question: How does school environment observation strengthen the interpretation and evaluation dimensions of critical thinking among fifth-grade students in elementary IPAS learning? Based on this research question, the operational hypothesis is formulated as follows: School environment observation significantly strengthens students' interpretation and evaluation dimensions of critical thinking in elementary IPAS learning. By explicitly examining these two dimensions, this study contributes to the literature by providing empirical evidence on the specific cognitive processes through which authentic environmental observation supports the development of critical thinking in elementary education. (Wicaksono *et al*., 2019).

However, the reality in many elementary schools is still concerning. Social studies learning is often fixated on the teacher-centered paradigm and is only oriented towards memorizing abstract concepts from available textbooks (Nisa *et al*., 2025; Zahra *et al*., 2025). Conventional approaches such as lectures are predominantly used, thus minimizing the opportunity for students to be actively involved in the process of knowledge construction through hands-on experience (Hasanah & Surakarta, 2024). As a result, students' critical thinking skills, especially in interpreting data and evaluating evidence, are not honed properly. Students will more often be passive recipients of information than as active explorers who build self-understanding (Azizah *et al*., 2025). This condition creates a gap between the demands of the curriculum that prioritizes HOTS and actual learning practices in the field (Sudiryo *et al*., 2024).

Various kinds of pedagogical innovations have been proposed and researched by various educational practitioners to bridge the existing gaps. Some of them are inquiry-based learning and contextual learning which consistently show a positive impact on students' critical thinking development (Damanaik, 2023; Fitriyani & Teguh Nugroho, 2022). A number of studies have also shown that inquiry learning is able to improve students' ability to interpret and evaluate through direct student involvement in investigation, data analysis, and scientific problem-solving discoveries (Ramadhani *et al*., 2024). This finding is further strengthened by the results of other research that states

that collaborative inquiry-based learning models are able to significantly improve the critical thinking skills of elementary school students, especially in the aspects of analysis and evaluation (Yusuf & Hendra, 2023). Structured inquiry-based learning encourages students' active involvement in the process of interpreting phenomena and evaluating evidence-based information (Rahmawati, 2025; D. C. Rahmawati & Dwiprabowo, 2020). An authentic and hands-on experience-based learning environment makes an important contribution to building a deeper conceptual understanding, so that students are able to develop interpreting and evaluating skills in a more meaningful way (Hasanah & Surakarta, 2024)

Although there is evidence of the success of this approach, there are still gaps in the research that previous studies have done (Oktiningrum *et al*., 2025; Semara *et al*., 2024). First, most previous studies have focused on improving critical thinking as a general construct or on overall cognitive learning outcomes. Only a limited number of studies have specifically and comprehensively examined the two core dimensions of critical thinking, namely interpretation and evaluation, as distinct and independently measurable constructs. In this study, interpretation is operationally defined as students' ability to understand, identify, classify, and explain the meaning of information or phenomena obtained through observations of the school environment. The behavioral indicators of this dimension include: (1) identifying relevant facts or information, (2) classifying objects or phenomena based on specific characteristics, (3) explaining the relationships among observed phenomena, and (4) drawing meaningful conclusions from the observation results. Meanwhile, evaluation is operationally defined as students' ability to assess the credibility of information, examine the accuracy and adequacy of the evidence obtained, compare alternative explanations, and provide logical justification when drawing conclusions or making decisions. The behavioral indicators of the evaluation dimension include: (1) assessing the accuracy of observational data, (2) distinguishing facts from opinions, (3) evaluating the strength of evidence supporting a particular claim, and (4) providing evidence-based justification for the conclusions reached. By operationally defining these two dimensions, this study not only measures improvements in critical thinking as a general construct but also identifies the strengthening process of each dimension more specifically within the context of elementary school IPAS learning. (Mahmudah & Watini, 2022; F. P. Rahmawati & Pamungkas, 2026).

Second, the exploration of learning strategies tends to be limited to the application of certain models such as problem-based learning or discovery learning in the classroom, while the potential for direct observation activities of the school environment as the main strategy that intrinsically develops these two dimensions is still underexplored (Amin *et al*., 2024; Helmarini & Gusmasari, 2022). The school environment, which is often seen only as a backdrop, is actually a natural laboratory rich in contextual and easily accessible scientific phenomena (Scott, 2025). Therefore, research that specifically places school environmental observation as the core of the strategy to strengthen students' interpretive and evaluative abilities in elementary school IPAS is still relatively limited and is an area

that has not been optimally worked on (Azizah *et al*., 2025).

Based on the above identification of gaps, this research comes with a double novelty, namely: first, this research specifically focuses on the analysis of strengthening the two dimensions of specific critical thinking, namely interpretation and evaluation, not as part of a general construct. Second, this study explores and analyzes the effectiveness of school environmental observation not only as a supporting activity, but as a key contextual learning strategy that is systematically designed to hone these two skills. The school environment is positioned as an active learning medium and resource that facilitates hands-on empirical experiences, where students collect data, discover patterns, and test their understanding of IPAS concepts (Scott, 2025). Through observation, students are trained to perform mini-scientific procedures such as observing, taking notes, interpreting findings, and evaluating the cause-and-effect relationships they find. Research has shown that scientific inquiry-based learning and research-based learning are able to develop students' science process and critical thinking skills through hands-on investigative activities and evidence-based analysis (Azizah *et al*., 2025)Regarding social studies learning in elementary schools, the implementation of school environmental observation can be one of the efforts that can be made to strengthen the dimension of student interpretation and evaluation. The reinforcement is operationalized through improving students' ability to interpret observed data and phenomena appropriately, explain the cause-and-effect relationship of observed phenomena based on scientific concepts, and provide logical assessments or evaluations supported by evidence collected during observation.

METHODS

This study employed a qualitative approach using a single-case study research design. This design was selected because it enables researchers to explore and understand phenomena in depth within their real-life context, where the phenomenon cannot be separated from the social environment in which it occurs. A case study approach facilitates a comprehensive examination of students' experiences, interactions, and learning dynamics through multiple sources of evidence, including classroom observations, semi-structured interviews, and supporting documents. This approach is particularly appropriate for investigating classroom learning processes by considering students' social, cognitive, and emotional dimensions.

To assess the dimensions of interpretation and evaluation, the researchers developed an analytic assessment rubric adapted from the critical thinking framework proposed by Facione and supported by relevant literature on critical thinking assessment in elementary education. The rubric was designed to operationalize each dimension into observable behavioral indicators that could be identified during students' participation in school environment observation activities. The interpretation dimension included indicators such as identifying relevant information, classifying observed phenomena, explaining relationships among phenomena, and drawing meaningful conclusions. The evaluation dimension comprised indicators related to assessing the credibility and accuracy of evidence, distinguishing facts from opinions, evaluating the strength of

supporting evidence, and providing logical, evidence-based justification for conclusions.

Prior to data collection, the rubric underwent an expert review process involving three experts in elementary education, science education, and educational assessment. The experts evaluated the rubric in terms of content relevance, construct clarity, language appropriateness, and the alignment of indicators with the intended dimensions of critical thinking. Their feedback was used to revise the wording of several indicators, improve the scoring descriptors, and enhance the overall clarity of the instrument. The revised rubric was subsequently piloted with a small group of students to ensure its practicality and consistency before being employed as the primary assessment instrument in this study.(Ribut *et al*., 2024). As the principal investigator who also serves as a teacher in the classroom studied, the author is in a position to conduct intensive participatory observations and collect rich and contextual data (Haki et al., 2024).

This research was carried out at Celep 3 State Elementary School, Kedawung District, Sragen Regency. The subjects of the study included 28 students of class V (age 10-11 years) consisting of 13 male students and 15 female students. The selection of grade V is based on the consideration that students at this level already have sufficient basic reading, writing, and communication skills to engage in more structured observational and discussion activities. The sample was selected *purposively* with the following criteria: (1) students are taking science subjects with the theme "Ecosystem", and (2) classroom teachers are willing to collaborate in the implementation of new learning strategies. The research was conducted during a single full theme learning cycle, which took place in four meetings during April 2026. The data collection instruments used include:

1. Student Activity Observation Sheet: Used to document student engagement during the process of environmental observation, discussion, and presentation. This sheet contains behavioral indicators related to the dimensions of interpretation (e.g., recording data in detail, asking explanatory questions) and evaluation (e.g., comparing findings with hypotheses, providing a reason for a conclusion).
2. Performance *Assessment Rubric*: A rubric developed by researchers based on the *modified Critical Thinking Rubric* framework of the Association of American Colleges and Universities (AAC&U, 2023). This rubric is used to assess students' products (observation reports) and their performance during discussions. The assessment scale uses Likert 1-4 (1= Very Poor, 4= Very Good) with descriptors for each level in the interpretation and evaluation aspects.
3. Semi-Structured Interview Guidelines: Used to explore students' understanding, feelings, and reflections on their learning experiences after conducting environmental observations. Example question: "How do you determine whether a plant in the school yard is healthy or not? What evidence are you using?"
4. Documentation: In the form of photos and video recordings during the observation process as well as the results of student work (notes,

diagrams, reports). This documentation serves as a data triangulation to reinforce findings from other instruments.

The research procedure follows the stages of observation-based learning which consists of three main phases:

1. Preparation Phase: Teachers introduce the basic concept of the ecosystem and its components. Students are divided into six heterogeneous groups. Each group was given an observation guide worksheet that contained *guiding questions* designed to stimulate interpretation skills (e.g., "Observe the types of plants in the school garden. Group them by the characteristics you see.") and evaluation (e.g., "In your observations, which areas of the school environment are the most fertile? Give reasons based on the evidence you gathered.").
2. Implementation Phase: During the two meetings, each group made observations in a predetermined area of the school environment (school garden, front yard, parking area, and park). They collect data, take notes, and take photos. The teacher acts as a facilitator who guides students with probing questions to encourage deeper analysis.
3. Analysis & Reflection *Phase*: Students in their groups analyze the data that has been collected, compile a simple report, and present their findings in class. The class discussion session was facilitated by the teacher to challenge students to assess the findings of other groups and reflect on their thought processes.

Data analysis was carried out continuously during and after data collection by following the Miles & Huberman interactive model which consists of three interrelated activity streams, namely data reduction, data presentation, and conclusion/verification. *First*, data from all sources is reduced through the process of categorizing the data. Data coding was carried out thematically based on two main dimensions of the study, namely the code for interpretation indicators (INT) and the code for evaluation (EVA) (Pulungan, 2021). *Second*, The encoded data is presented in the form of tables, matrices, and descriptive narratives to facilitate the identification of relationships and patterns. *Third*, conclusions are drawn continuously by checking the consistency of the initial findings against existing data. Data validity (*trustworthiness*) is maintained through source triangulation techniques, namely comparing data from observations, interviews, and documents, triangulating methods, and checking members (*member checking*) by presenting a summary of the findings to several participating students for confirmation.

RESULTS AND DISCUSSION

The implementation of school environment observation shows an observed impact on strengthening the two dimensions of students' critical thinking. Student performance data measured using assessment rubrics at the beginning (pre-observation) and end (post-observation) of the research cycle showed a significant improvement. The results of the average score recapitulation for each aspect are presented in the following table:

Table 1. Comparison of Average Scores of Students' Interpretation and Evaluation Ability

Assessment Aspects	Indicator Descriptor	Pre-Observation Average Score	Post-observation average score	Improvement
Interpretation (INT)				
INT-1	Record/describe observation data objectively and in detail	1.8	3.4	+1.6
INT-2	Classify or categorize data based on observed patterns/characteristics	1.5	3.1	+1.6
INT-3	Connecting data/facts to each other	1.3	2.9	+1.6
INT-4	Explain possible cause-and-effect relationships of phenomena	1.2	2.7	+1.5
Evaluation (EVA)				
EVA-1	Assess the quality/relevance of the data collected	1.4	2.8	+1.4
EVA-2	Comparing findings with hypotheses or preliminary knowledge	1.3	2.8	+1.5
EVA-3	Provide conclusions supported by observational evidence	1.2	2.9	+1.7
EVA-4	Submit criticism or suggestions for improvement based on specific criteria	1.1	2.5	+1.4
Overall Average Score		**1.35**	**2.88**	**+1.53**

Rating Scale:
1=Very Lacking,
2=Less,
3=Good,
4=Excellent

Based on Table 1, there is an increase in all indicators for both dimensions. The highest increase was seen in the indicator "Providing conclusions supported by observational evidence" (EVA-3) with an increase of 1.7 points. This indicates that direct experience in collecting and processing empirical data is very helpful for students in building an argument that has a basis. When viewed as a whole, the average score of students increased from 1.35, which means it is in the "Less" category, to 2.88 which is close to the "Good" category.

The observation activities carried out can provide opportunities for students to interact directly with real objects, which is the main driver in honing interpretation skills. At the beginning of the meeting, many students find it difficult to describe anything other than a very common trait (e.g., "the leaves are green"). However, after being given a boost by using worksheets containing more specific guide

questions, the quality of their narrative descriptions improved sharply. For example, one group observing plants in the school garden was able to produce more detailed records than before: "The spinach plant in plot A has dark green leaves, smooth surfaces, and there are some small holes that may have been eaten by caterpillars. Meanwhile, in plot B, the leaves are slightly yellowish-green, smaller in size, and the surrounding soil looks dry (Group 3 Report Document)".

Students' ability to categorize and connect observational data developed considerably throughout the learning process. Rather than merely recording what they observed, students began to organize their findings into meaningful categories. For example, they classified plants into categories such as *healthy* and *unhealthy* based on observable characteristics, including leaf color, stem strength, and the presence or absence of pests. They also started to relate environmental conditions, such as soil moisture, sunlight exposure, and plant health, indicating an emerging ability to interpret evidence through causal reasoning.

This interpretative process is reflected in the following student statement:

"At first I thought a yellow plant must be sick. But after seeing that the soil was also dry and comparing it with the plants near the water tap, whose leaves were greener, I think it was probably caused by a lack of water rather than pests." (Student S12, Interview)

Similarly, another student explained:

"We first grouped the plants by leaf color, but then we realized that not all yellow leaves meant the plant was damaged. We had to look at the soil and the surrounding conditions before deciding." (Student S07, Interview)

These statements demonstrate that students no longer relied on a single observable characteristic but began integrating multiple sources of evidence before drawing conclusions. This finding was further supported by classroom field notes:

Field Note 4: "Students in Group 2 repeatedly returned to the observation site to compare soil moisture and leaf conditions. They discussed differing opinions before agreeing that environmental conditions should be considered alongside visible plant characteristics."

Variations were also identified across student groups. Group 1 tended to classify plants solely based on visible physical characteristics, such as leaf color and plant size, resulting in relatively simple interpretations. In contrast, Group 2 demonstrated more advanced interpretative reasoning by relating multiple variables, including soil moisture, sunlight exposure, and plant condition, before reaching a conclusion. Meanwhile, Group 3 actively compared findings among different observation locations and frequently revised their initial interpretations after discussing contradictory evidence with peers.

The evaluation dimension also became increasingly evident during group discussions. Students not only interpreted observational evidence but also questioned the credibility and adequacy of that evidence before accepting a conclusion. One student stated:

"We couldn't immediately say the plant was unhealthy because another group found a similar plant that was still growing well. So we checked the soil again and compared our observations before deciding." (Student S15, Interview)

This evaluative process was corroborated by classroom observations:

Field Note 7: "Students challenged one another's conclusions by asking for additional evidence and requesting that observations be repeated. Several students changed their initial conclusions after comparing evidence collected by different groups."

These findings indicate that school environment observation supported not only students' ability to interpret environmental phenomena but also their capacity to evaluate evidence critically by comparing alternative explanations, reconsidering initial assumptions, and justifying conclusions using empirical evidence. The variation observed across groups further illustrates differences in the depth of interpretation and evaluation, reflecting the progressive development of critical thinking during authentic environmental observation activities.

These findings are in line with the theory *embodied cognition* which emphasizes that human cognition can be formed through the interaction between the body, sensorimotor activity, and its environment. From this point of view, the thought process does not only occur within the mind, but can also be influenced by physical experience and direct involvement with the object of learning (Castro-Alonso *et al*., 2024). Learning experiences where students can directly see, touch, and smell observed objects provide rich cognitive input, which then facilitates students in forming cognitive constructs and interpreting the phenomena that occur. These results are also in line with previous research findings that real-world context-based learning can improve students' analytical skills because information can be processed in authentic and meaningful situations (Firmansyah et al., 2017; Nur *et al*., 2023)

During the analysis phase and the class discussion process, the growth of the evaluation dimension in students is most noticeable. The environment provides facts and experiences that can be observed by all groups, but their initial interpretations may differ. It is this difference that drives the need to evaluate. For example, two groups differed in assessing the "most fertile place" in the school. Group 1 reasoned that the school garden was the most fertile place because there were many types of plants growing there. In contrast to the opinion of Group 2 who argue that the most fertile place is under a large tree in the front yard because there are many wild plants that are quite dense and the soil looks darker than other places.

Teacher-facilitated discussion activities are used to direct students to not only defend their opinions, but also to evaluate their respective arguments based on evidence and fertility criteria that they have mutually agreed upon, such as plant diversity, soil color, soil moisture. A student from Group 2 eventually revised his assessment as follows:

"Our group saw a lot of plants, but after discussion, it turned out that in the school garden the plants were more diverse and looked deliberately planted, meaning that the soil was indeed suitable for planting. Under the tree, there is only one type of plant that is large in number, namely only the type of grass. Perhaps our arguments are not strong" (Notes of Observation, Discussion, Meeting,

4This event shows the development from simply having an opinion to making judgments based on the criteria and evidence found, which is the core of evaluation skills.

This improvement in evaluation skills was reflected in the increased scores on the EVA-2 and EVA-3 indicators. The students' final reports demonstrated a more organized structure, with conclusions consistently supported by statements such as *"Based on our observations…"* or *"This is evident from…"*. These findings indicate a growing metacognitive awareness of the importance of providing evidence-based justification. This result is consistent with the principles of the Argument-Driven Inquiry approach, which emphasizes the development of evaluative skills through drawing conclusions, supporting claims with evidence, and critically evaluating arguments through discussion and reflection. The school environment provides an authentic context for this process because the evidence is directly observable, verifiable, and open to re-examination by other students.

Nevertheless, several alternative factors should be considered when interpreting these findings. First, part of the improvement may be attributable to maturation effects, as students naturally develop higher-order thinking skills over the course of the learning period. Second, the dual role of the classroom teacher as researcher may have influenced students' engagement and performance through increased guidance, encouragement, or closer interaction, potentially contributing to the observed gains. Third, the novelty of conducting learning activities outside the classroom may have temporarily increased students' motivation and participation (novelty or Hawthorne effect), which could have positively affected their evaluation performance. Although these factors cannot be entirely ruled out, the consistency of evidence obtained from classroom observations, interview data, students' written reports, and repeated demonstrations of evidence-based reasoning across different student groups suggests that the observed improvement was not solely attributable to these alternative explanations. Future studies employing longitudinal designs, comparison groups, or independent classroom observers are recommended to better isolate the specific contribution of school environment observation to the development of students' evaluative thinking.

The success of strengthening the interpretation and evaluation dimension is not only due to the observation activities carried out alone, but also to the integration of three key factors revealed in the data analysis. These three factors include: (1) the authenticity of the context, namely the school environment, (2) cognitive learning support from teachers, and (3) social interaction of money occurs in small groups.

First, the school environment acts as an authentic, safe, and accessible learning context. This authenticity creates a very high relevance between ecosystem subject matter and student life, so that it can increase intrinsic motivation and depth of cognitive processes. Second, the role of the teacher as a facilitator through probing questions (e.g., "What's the difference?" "Why is that?" "Which data is the most convincing?") It serves as a scaffolding that gradually attracts students' levels of thinking from what was initially a concrete level to a more abstract and more critical level. Without guidance from teachers, observation can stop at data collection activities without continuing with in-depth analysis. Third, activities carried out in groups create a new social environment where students test each other's ideas,

correct misunderstandings, and build knowledge collaboratively. This interaction is a natural forum to practice evaluation skills in students, as students have to listen to and assess the arguments of others.

This research has several limitations. First, the design of a case study with a single class limits the generalization of findings. Second, the relatively short duration of the study, i.e. only one material, may not show the maximum and sustainable impact of this strategy. Third, the role of the researcher as a teacher may bring bias, even though it has been anticipated by triangulating the data.

Despite these limitations, this research has important implications both theoretically and practically. Theoretically, this study is expected to add empirical evidence on how direct and contextual learning experiences can shape various aspects of critical thinking skills. This is in line with the findings of Van Laar et al. regarding 21st *century skills*, particularly critical thinking and digital skills, which emphasize the importance of research that is more focused on developing specific aspects of 21st century skills, especially critical thinking skills. Practically, this study provides a model of learning strategies that are easy for elementary school teachers to adopt. Teachers don't need complicated tools or materials; It is enough to take advantage of the existing school environment with structured learning guides. A policy implication that can be suggested is the need for teacher training to design and guide environmental observation activities that are not just field trips, but are truly integrated with the goal of developing high-level thinking skills.

CONCLUSION

Based on the findings and discussion, this study concludes that school environment observation effectively strengthened the interpretation and evaluation dimensions of critical thinking among fifth-grade students in elementary IPAS learning. The strengthening of the interpretation dimension was reflected in students' improved ability to identify and organize observational data, classify findings based on meaningful patterns, explain causal relationships among observed phenomena, and construct evidence-based interpretations. Likewise, the evaluation dimension was strengthened through students' increasing ability to assess the credibility and adequacy of evidence, distinguish facts from opinions, formulate conclusions supported by empirical evidence, and critically evaluate alternative explanations using explicit criteria.

However, these conclusions should be interpreted within the context of the study's design. As this research employed a **single-case qualitative case study**, the findings are intended to provide an in-depth understanding of the observed learning process rather than statistical generalization to all elementary school settings. Therefore, the transferability of the findings is limited and depends on the similarity of educational contexts, participant characteristics, and instructional implementation. Future studies involving multiple schools, diverse participant groups, and comparative or longitudinal designs are recommended to examine the consistency and broader applicability of these findings across different educational settings.

The success of this strategy is supported by the synergy between the

authenticity of the school environment, the role of teachers as facilitators who provide cognitive scaffolding through guiding questions, and the dynamics of social interaction within learning groups. Based on these findings, several practical and policy recommendations can be proposed. At the school level, teachers are encouraged to integrate structured school environment observation activities into IPAS learning at least two to four times per semester, allowing students sufficient opportunities to develop interpretation and evaluation skills through repeated authentic experiences. Schools are also advised to develop a brief teacher training module (8–16 hours) focusing on the design of observation-based learning, the use of guiding questions to stimulate higher-order thinking, and the assessment of critical thinking through analytic rubrics.

At the district or education office level, professional development programs may incorporate workshops on implementing school environment observation as an inquiry-based learning strategy, accompanied by standardized examples of lesson plans, observation worksheets, and assessment instruments. To facilitate consistent implementation, the assessment rubric developed in this study may be adapted as a practical reference. Recommended assessment indicators include students' ability to identify relevant evidence, classify and interpret observed phenomena, explain causal relationships, evaluate the credibility and sufficiency of evidence, distinguish facts from opinions, and provide evidence-based justification for conclusions. Embedding these indicators into routine classroom assessment would enable teachers to monitor students' critical thinking development systematically while promoting more authentic and inquiry-oriented IPAS learning across elementary schools.

This study recommends that in delivering the learning of science and science materials in elementary schools, teachers should systematically integrate environmental observation-oriented activities into learning planning, especially on themes related to nature and life. For further research, it is recommended to conduct research with a quasi-experiment design involving a control group to test the effectiveness of this strategy more rigorously with the experimental group. In addition, advanced research can explore strengthening other dimensions of critical thinking (such as analysis and drawing conclusions) through similar strategies, or test their application to other subjects and different grade levels.

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