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ANALYSIS OF HOTS ABILITY IN SCIENCE MATERIAL OF FIFTH GRADE ELEMENTARY SCHOOL STUDENTS

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ABSTRACT
The low ability of Higher Order Thinking Skills (HOTS) of students in ecosystem material is a crucial problem in science learning in elementary schools. This study aims to map in depth the profile of HOTS abilities of fifth grade students in ecosystem material reviewed from the cognitive domains of analyzing (C4) and evaluating (C5). The study used a descriptive qualitative approach with a case study type. The sample consisted of 30 fifth grade students of Kaligayam 1 Elementary School, Klaten Regency, who were selected through a purposive sampling technique. Data collection was carried out through a HOTS diagnostic test in the form of 10 essay questions and semi-structured interviews with 8 selected students. Data analysis followed the interactive model of Miles, Huberman, and Saldaña. The results showed that students' HOTS abilities were classified as low with an average score of 52.3 and 60% of students were in the Low to Very Low category. The main findings indicate a significant gap between C4 (55.8) and C5 (47.1) abilities, and the highest failure rate occurred in the subtopic of the impact of human activities (73.3%) caused by conceptual misconceptions, neglect of the role of decomposers, and weak systemic thinking. This study concludes that the root of the low HOTS lies in learning that is still LOTS-oriented. The contribution of this study is to provide a specific diagnostic map of student weaknesses in each HOTS cognitive indicator, which can be a basis for teachers in designing more focused and differentiated HOTS-based science learning.

INTRODUCTION
Learning in the 21st century has to be critically, creatively and analytically oriented, rather than just recalling facts. These skills are contained in Higher Order Thinking Skills (HOTS) which is one of the learning goals in the primary education curriculum of Indonesia, especially the Independent Curriculum. In elementary school, Natural and Social Sciences (IPAS) is an important course in fostering scientific and social literacy for students. It teaches students to observe and investigate the

natural and social phenomena in an integrated way. Mastering HOTS in IPAS is important because it enables students to solve problems (C4), analyze cause-and-effect relations (C4) and disseminate information (C5), rather than merely memorizing concepts (C1). Students who have excellent HOTS skills will have the ability to design an ecosystem of concepts and social behaviour – a key competency for future problem solvers (Shutaleva, 2023).

A sad fact obtained from observations and diagnostic assessments in several elementary schools is that the ability of the fifth grade students in learning science is still very low in terms of Higher Order Thinking Skills (HOTS). Most students are only able to answer questions at the recall (C1) and understanding (C2) levels, but experience significant difficulties when faced with higher cognitive demands. Science learning, which should train students to analyze natural and social phenomena in an integrated manner, is still dominated by lectures and rote memorization assignments oriented toward Lower Order Thinking Skills (LOTS).

Teachers also face challenges in designing evaluation instruments and learning activities that specifically stimulate analytical (C4) and evaluation (C5) skills in the context of science and science (Rahayu & Rosawati, 2023). This situation is exacerbated by the finding that most daily evaluation questions and exams in elementary schools still focus on the C1 and C2 levels, while the proportion of questions requiring higher-order reasoning is very minimal (Simanjuntak et al., 2023). A study by Ichsan et al., (2019) also confirmed that science learning at the elementary level in Indonesia rarely integrates activities that stimulate HOTS, such as environmental problem-solving and open inquiry. Furthermore, research Aditomo and Klieme, (2020) confirms that the quality of cognitive activities in science learning in Indonesia, especially at the elementary level, is still dominated by simple tasks that do not require complex reasoning, thus under-facilitating students' potential for critical development.

Students will grow into critical, creative individuals capable of solving problems contextually if they have a good mastery of HOTS, making it an essential competency that is the main objective of the Independent Curriculum (Arnellis et al., 2021). This is in accordance with the results of the research (Hugerat & Kortam, 2014) which proved that inquiry-based science learning could facilitate the improvement of students' HOTS skills, such as proposing hypotheses, analysing data and drawing scientific conclusions. In addition, developing HOTS in science should start early as skills like critical thinking and metacognition need long habituation, as noted by (Zohar & Dori, 2012).

This risk is further exacerbated by data from international studies such as the Programme for International Student Assessment (PISA), which consistently ranks Indonesian students' reasoning skills at the bottom, indicating that the crisis in higher-order thinking skills poses a serious threat to the future competitiveness of Indonesia's human resources (Sukmayadi & Rofii, 2025). Furthermore, research by Shalikhah and Nugroho (2023), revealed that low HOTS skills at the elementary school level negatively impact students' readiness for project-based and inquiry-based learning at higher levels. Meanwhile Quinn et al., (2020) found that failure to develop HOTS from elementary school contributes to low reflective thinking and complex problem-solving skills later in life, ultimately weakening the nation's productivity and innovation.

Although the urgency of HOTS development has been widely voiced, a literature review reveals a significant research gap. Most HOTS research in Indonesia remains focused on secondary education (junior/high school) or on exact science subjects such as Mathematics (Santosa et al., 2025). Research specifically examining HOTS abilities in fifth-grade elementary school IPAS subjects as a result of the integration of the *Merdeka* Curriculum remains very scarce. Furthermore, previous studies have been more oriented toward general HOTS instrument development Sarwanto et al., (2021), or descriptive analysis without delving specifically into students' error profiles per cognitive indicator. International research Woolley et al., (2018) also emphasizes the importance of analyzing specific cognitive levels to accurately understand student difficulties; however, no study has diagnostically mapped the C4 and C5 levels in elementary school IPAS ecosystem materials with a focus on specific subtopics such as food chains, food webs, the role of decomposers, and the impact of human activities. Thus, the novelty of this study lies in providing an in-depth diagnostic map of students' weaknesses in each ecosystem subtopic, which can serve as a concrete foundation for designing differentiated, HOTS-based instruction—a contribution not yet offered by previous studies.

In an effort to address the problem of low HOTS and fill this research gap, this article offers a solution in the form of a comprehensive and detailed diagnostic analysis of HOTS abilities in fifth-grade science materials. This solution is designed through three concrete steps. First, developing and validating HOTS diagnostic test instruments specifically designed for fifth-grade science essential materials, such as ecosystems, changes in state of matter, and the water cycle, using contextual stimuli close to students' lives. Second, conducting an in-depth analysis of students' responses to qualitatively map their thinking error profiles—whether failures occur in the aspects of analyzing cause-and-effect relationships (C4), organizing information from graphs or diagrams (C4), or evaluating arguments based on scientific evidence (C5). Third, formulating recommendations for differentiated learning strategies based on the weakness map, including scaffolding design, selection of learning models (e.g., Problem-Based Learning or Inquiry-Based Learning), and developing teaching materials that stimulate students' weak cognitive levels.

This approach is supported by research results Cantona et al., (2023) which proves that Problem-Based Learning is effective in improving problem-solving and HOTS skills in elementary school students. In addition, research (Sayekti & Anggriani, 2026) shows that the use of standardized HOTS diagnostic instruments helps teachers identify students' specific weaknesses so that learning interventions can be carried out precisely. Thus, the results of this analysis will be a solid foundation for teachers to design HOTS learning in science that is no longer generic, but truly directed according to the specific needs of each student. Based on the description of the problem, urgency, and research gaps above, the research question posed in this article is: "What is the profile of Higher Order Thinking Skills (HOTS) abilities in science material for fifth-grade elementary school students in terms of cognitive levels of analysis (C4) and evaluation (C5), and what are the recommendations for appropriate learning strategies based on the results of the diagnostic analysis?"

METHOD

This descriptive qualitative case study aims to deeply map the HOTS profile (C4 and C5) of fifth-grade students in Ecosystem Science. A qualitative approach allows for in-depth exploration without statistical generalizations Sugiyono, (2022), while the case study design intensively examines students' abilities in a real context Creswell and Poth (2018), to holistically reveal their thinking processes and difficulties beyond mere quantitative scores (Yin, 2018). Using purposive sampling based on specific research criteria (Arikunto, 2019), the study selected 30 fifth-grade students from Kaligayam 1 Public Elementary School out of the Klaten District population. Ecosystem material was chosen as the focus because its complex concepts are highly suitable for assessing students' analytical (C4) and evaluation (C5) abilities (Anderson & Krathwohl, 2010). Using purposive sampling based on specific research criteria Arikunto (2019), the study selected 30 fifth-grade students from Kaligayam 1 Public Elementary School out of the Klaten District population. Ecosystem material was chosen as the focus because its complex concepts are highly suitable for assessing students' analytical (C4) and evaluation (C5) abilities (Anderson & Krathwohl, 2010).

The main instrument is a 10-question HOTS essay test (6 C4 and 4 C5 questions) focused on ecosystem concepts. The essay format was chosen because it requires students to actively organize and analyze their own ideas, making it highly effective for assessing higher-order thinking Odanova et al., (2022) at the C4 (Analyze) and C5 (Evaluate) cognitive levels (Anderson & Krathwohl, 2010). The instrument demonstrated strong psychometric properties: it was deemed "very valid" by experts with an average score of 3.82 out of 4.00, and it achieved a 92% inter-rater reliability agreement, ensuring consistent measurement. To ensure scoring objectivity, student answers were evaluated using a 0-3 rubric: C4 (Analyzing) scored the logical connection of concepts, while C5 (Evaluating) assessed evidence-based critiques and arguments. Additionally, semi-structured interviews were conducted with eight selected students (varying skill levels) to deeply explore their thinking processes, a method chosen because it provides flexibility while maintaining focus on the research topi (Kvale & Brinkmann, 2015).

Data was collected through a HOTS diagnostic test and individual student interviews, utilizing triangulation to ensure the data was credible and complementary Moleong (2017). The analysis followed an interactive model (Miles et al., 2014) consisting of four stages: data collection, condensation (scoring C4 and C5 abilities into categories based on (Arikunto, 2019), and coding interview themes), data presentation, and conclusion drawing. Finally, data validity was strictly maintained through technical and source triangulation (Moleong, 2017), as well as member checking with teachers to ensure interpretation accuracy (Creswell & Poth, 2018).

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RESULT AND DISCUSSION

Overview of HOTS Capabilities

The results of the diagnostic test showed that the average overall score of 30 fifth-grade students at Gatak 1 Public Elementary School only reached 52.3 out of a scale of 100. This figure places the students' HOTS ability on ecosystem material in the Low category. Not a single student managed to reach the Very High category (0%). Only 4 students (13.3%) were in the High category, 8 students (26.7%) were in the Medium category, while the majority of students, namely 12 people (40%), were in the Low category, and 6 people (20%) were in the Very Low category. Thus, as many as 18 students or 60% of the total sample were still stuck at an inadequate level of ability. The distribution of students in the five ability categories is presented in Figure 1 below.

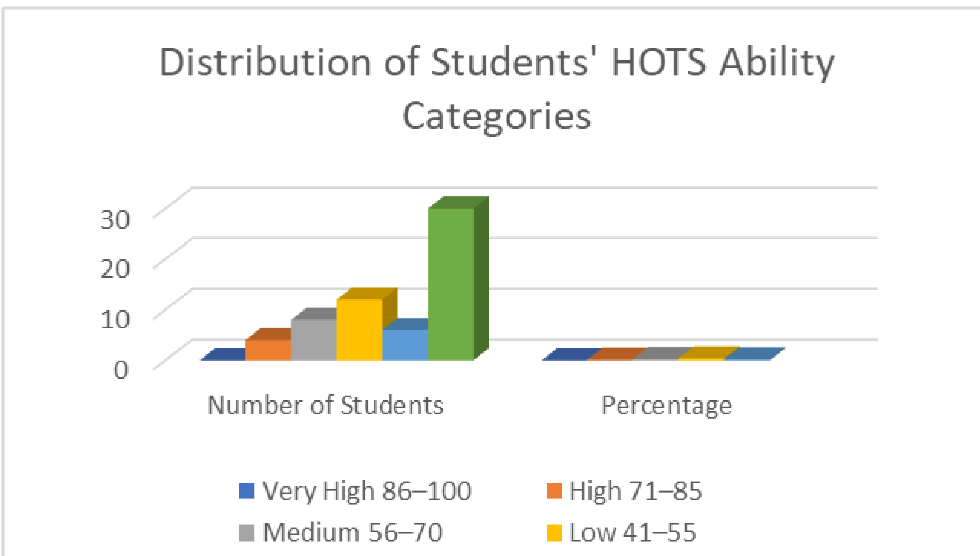

Figure 1. Distribution of Students' HOTS Ability Categories
Source: Processed primary data, 2026

The quantitative results were substantiated by the qualitative findings in the interviews when it was found that students' low test scores did not only stem from their not being familiar with the material, but also from not being used to answering questions that demand complex reasoning. One pupil from the low group said ‘Ma'am, the questions are confusing, usually I'm just told to state them but this time I'm supposed to explain them long. This statement indicates that the learning students have received so far has been more oriented towards memorization and restating information, rather than analysis and evaluation.

More deeply, this low achievement is not an incidental phenomenon, but rather a reflection of learning designs that systematically do not target HOTS development. The main contributing factor is the assessment culture in schools that is still dominated by multiple-choice and short answer questions at the C1 and C2 levels, so that students are never trained to build long and structured reasoning. The implication is, when students are faced with HOTS essay questions, they experience cognitive shock because their thinking schemes lack experience in processing information analytically and evaluatively.

C4 and C5 Level Gap

The achievement gaps at each cognitive level were calculated and there was a significant gap. The mean pupil score for level C4 (Analyzing) was 55.8 and for level C5 (Evaluating) was just 47.1. The 8.7-point gap shows that students had significantly fewer points in the Evaluate scale than in the Analysis scale.

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Interview data provides in-depth explanations of this gap. A medium student responded to the question that asks for evidence-based judgment: "When I have to make a judgment about whether something is right or wrong and tell why, I hesitate to answer that one. But when I have to find the relationship between A and B, I can do that, ma'am. Another High category student freely acknowledged, "I know the answer, but I don't know how to explain it properly. These two quotations make it clear that the first difficulty that students have is not in having a good grasp of basic knowledge but in being able to make judgments and judgments and argue them logically.

This C4-C5 gap is not simply a difference in scores, but rather an indication of a deep-rooted metacognitive gap. The ability to evaluate (C5) requires students to examine and critique based on specific criteria, which fundamentally requires metacognitive awareness—the ability to monitor and regulate one's own thinking processes. Students who are not accustomed to reflecting on the reasoning behind their answers will struggle to reach the evaluative level.

Sub-Material Food Chains and Food Webs

For food chain, 14 students (46.7%) were able to sequence the food chain properly. This success rate was quite low in the food web sub-topic, however, as 20 students (66.7%) were unable to analyse the interrelationships between food chains and predicted nothing would happen if one of the species in the food web went extinct.

The results of the interviews showed that the problem lay in the fact that the students had a concept of food chains and food webs confused. 6/8 students interviewed thought the two terms were synonymous. A young student in the class who was in the middle of a thoroughgoing mental breakdown said to his teacher, "The pictures both have arrows, ma'am. So I thought they were just different pictures. Even an admitting the high student said, "I'm a little bit confused about the difference ma'am because in the book they were both the same. This confusion caused students to use food webs as a straight line. Thus, when asked to describe the effects of the snake's extinction in a rice paddy ecosystem, most could only respond with a single effect, for example that there would be more mice, but were unable to explain the knock-on effects on other species, such as the rise in species of insects that were formerly controlled by frogs and the fall in species of eagles that also feed on mice. The inability of 66.7% of the students to analyze food webs suggests that they did not possess systemic thinking skills, which is a vital competence in comprehending ecosystems as a whole.

Causally, this conceptual error stems from two main factors. First, the presentation of material in science textbooks often presents food chains and food webs as static diagrams without adequate narrative explanation of the fundamental difference between the two that a food chain is a single pathway, while a food web is a collection of interconnected chains. Second, teachers tend to teach the two concepts separately without providing systemic thinking exercises that connect them. However, according to Piaget's theory of cognitive development, fifth-grade students (aged 10–11) should begin entering the formal operational stage, which is characterized by the ability to think logically, abstractly, and systematically about complex cause-and-effect relationships. However, this transition does not occur automatically; it requires stimulation in the form of challenging and meaningful learning experiences. If learning relies solely on lectures and static images in textbooks, students' systemic thinking potential will not develop. The implication is that teachers need to adopt interactive inquiry and simulation approaches for example, through digital food web diagrams or ecosystem role-plays so that students can actively construct an understanding of the interconnectedness of species.

Neglect of the Role of Decomposers

In the ecosystem components sub-topic, most students had a good knowledge of identifying biotic and abiotic components in an ecosystem. But 60% (18 students) of those who were asked to analyse interdependence gave an incoherent response. The interviews revealed that one of the primary causes of students' misconceptions was the lack of consideration for decomposers when teaching them about the ecosystem.

Five of the eight students interviewed did not mention or know what decomposers were. One of the students in the Moderate category responded, "Well, dead animals just die, ma'am. They'll disappear on their own. The researcher then asked the student where the animals "disappeared" and the student shrugs. One other student in the Low category was unaware that there was a term at all, let alone decomposer. Ma'am, what is a decomposer? We didn't teach you," said he. This is why 60% of students were unable to analyze interdependent relationships--they would not be able to explain about the energy cycle and the material cycle in an ecosystem without knowing about the role of decomposers. They knew of no way to return the nutrients to the soil to be used again by the producers in the food chain. This leaves a big gap in students' learning of ecology.

The neglect of the role of decomposers is not an isolated error; it reflects the fragmented presentation of ecosystem concepts in curricula and textbooks. Misconceptions about decomposers are among the most common in elementary school ecosystem instruction, as textbooks and teacher explanations often overemphasize producers and consumers, while decomposers are only briefly mentioned or even ignored altogether. Students' understanding of energy transformation remains low if concepts are presented fragmentarily, without a complete integration. In the context of the Independent Curriculum (IPS) science and science, which demands holistic and integrated learning, the neglect of decomposers is ironic, as they are key to understanding the continuous cycle of matter. Consequently, teachers must revise the order in which they present the material: not only mentioning decomposers as part of the biotic component, but also explicitly demonstrating their role through simple observational activities for example, observing the decay of leaves or organic waste in the surrounding environment so that students realize that the ecosystem is a cycle, not simply a straight line from producers to top consumers.

Ecosystem Balance and the Impact of Human Activities

The sub-topic pertaining to the effect of human activity on ecosystems had the highest failure rate of 22 students (73.3%). Likewise, with regard to sub-topic on ecosystem balance, 19 students (63.3%) could not explain how population changes can lead to disruption of ecosystem. These two figures are interconnected and substantiated with the results of interviews.

The students interviewed all responded in the same manner when asked to assess the practice of deforestation, which they all deemed as bad. However, none were able to provide a thorough argument. One pupil in the High category responded, 'It's not okay to take trees down, it will leave the forest bare, and the animals will lose their homes. This was a good response but the student was not able to build on it, e.g. connect it with soil erosion, flooding, microclimate changes etc. or with disruption of water cycle. A student in the LOW category may only respond, "I don't know, ma'am. It's just bad.

Of the students who failed the sub-topic on the impacts of human activity, these responses indicate that 73.3% of them had shallow factual knowledge. They understood that an action is destructive, but they didn't know how. Their assessment of skills was still at an emotional level ("bad" or "not allowed") and not yet at a cognitive level where they need to provide evidence to back up their assessment and use logical arguments. The result is consistent with the results obtained by Ichsan et al., (2019) that elementary science education is rarely able to provide students with skills to critically analyze environmental issues.

Overall, the findings from the quantitative and qualitative data in this study corroborated and are consistent. 60% of students in the Low and Very Low categories is not only a statistic but also a reflection of four root problems confirmed in interviews: (1) shallow conceptual understanding, which makes it difficult to differentiate between food chains and food webs; (2) lack of concept of decomposers resulting in incomplete understanding of ecosystems; (3) limited systemic thinking, which makes it difficult to predict the effects of population changes; and (4) limited evaluating skills, as a lack of habituation in constructing an evidence-based argument.

The interview excerpts offered here are used to show that the problem of low test scores is not entirely due to outside influences, but is due to less than optimum learning that does not stimulate HOTS. Pupils require additional practice questions but not just more questions but a shift in their approach to learning that explicitly and systematically developed their abilities to analyse, evaluate and express their reasoning in logical ways.

Discussion

The achievement in HOTS of fifth grade students at Public Elementary School 1 Kaligayam in ecosystems is a concern, and can also be used as a medium for deep reflection on the learning process of science in elementary schools. The diagnostic test scores, which yielded a 60% average of students in the low and very low performers' groups and an average overall score of 52.3, are not an isolated indication. This discovery is indicative of a learning process that does not optimally deal with the dimensions of higher-order thinking. Students are accustomed to questions that require the re-expression of information, so when faced with HOTS instruments that require analysis and evaluation, they experience cognitive shock.

The statement of a student in an interview who admitted to being confused because the questions "asked for long explanations" is concrete evidence that their learning experience is still dominated by LOTS activities.

This condition aligns with findings Nur'ariyani et al., (2023) which confirm that science learning in elementary schools still focuses on memorization and basic understanding, with teachers often using lecture methods and mechanical assignments. Furthermore, research Aditomo and Klieme (2020), confirms that the quality of cognitive activities in science learning in Indonesia is still dominated by simple tasks that do not require complex reasoning. In the light of these two studies, it can be concluded that low HOTS is not an instant issue but a result of all the years of learning designs that have not been deliberately oriented towards higher order thinking skills.

However, most teachers' assessment tools in elementary schools are still in the level C1 and C2, which are not able to prepare students to answer questions that require reasoning, added (Febrianti et al., 2021). This is why students get confused and confused when solving HOTS questions because they do not have enough cognitive schemas to cope with the HOTS questions. Based on Piaget's schema theory, students need to have the necessary cognitive structures or schemata to accommodate new knowledge (Santrock, 2018). If they do not have higher order thinking experiences in the learning process, then they will not develop cognitive structures for HOTS.

The general overview is followed by more specific results which show a wide difference between analytical (C4) and evaluation (C5) skills. The gap between the average C4 (55.8) and C5 (47.1) scores is 8.7 points, showing that pupils are more likely to have more serious difficulties when making judgments and giving reasons based on evidence. This gap can be explained through the revised Bloom's taxonomy hierarchy developed by (Anderson & Krathwohl, 2010) where the evaluation level (C5) demands more complex cognitive processes because it involves checking and critiquing activities based on specific criteria.

Interviews confirmed this: students admitted to still being able to find relationships between two things (C4), but became hesitant when having to judge whether something was right or wrong and provide reasons (C5). Another equally honest statement came from a High category student who admitted to knowing the answer but was unable to explain it correctly. This condition indicates that the students' weaknesses are not in the aspect of factual knowledge, but rather in metacognitive abilities and argument articulation. Zohar and Dori (2012), emphasize that the ability to evaluate is closely related to metacognition, namely the awareness to monitor and regulate one's own thought processes. Students who have good metacognition will be able to reflect on the reasons behind their answer choices, while students with low metacognition are only able to provide answers without being able to explain their thought processes.

In line with this, (Woolley et al., 2018) through their research on secondary school students in science learning found that explicit teaching of critical thinking strategies, including how to identify evidence, evaluate arguments, and draw conclusions, is a key factor that differentiates students who are able to evaluate well from those who are not. This research is relevant to explaining why elementary school students experience similar difficulties; if at higher levels even explicit teaching is needed, then at the elementary level the need is even more urgent. (Arifin et al., 2025) also revealed that low HOTS in elementary school negatively impacts student readiness to face project-based and inquiry-based learning in junior high school, indicating that the gap between C4 and C5, if left unchecked, will become a persistent problem.

Students' difficulties in evaluating are closely related to their weak mastery of basic ecosystem concepts, particularly in the sub-topics of food chains and food webs. Data shows that 66.7% of students failed to analyze food webs and predict the impact of species extinction. This failure does not occur in isolation, but is a direct consequence of the conceptual confusion experienced by students (Richey et al., 2019). Interviews revealed that 6 out of 8 students considered food chains and food webs to be the same term. This confusion causes students to only see a simple linear relationship. So when asked to analyze the impact of snake extinction, they were only able to answer "there will be more rats" without being able to trace the chain impacts on other species, such as a decline in eagle populations or an increase in insect pests.

According to Piaget's cognitive development theory, fifth-grade students aged 10–11 should begin entering the formal operational stage, characterized by the ability to think logically, abstractly, and systematically about complex cause-and-effect relationships (Babakr et al., 2019). However, the transition from the concrete operational stage to the formal operational stage does not occur automatically but requires stimulation in the form of challenging and meaningful learning

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experiences. If learning relies solely on lectures and static images in textbooks, students' systemic thinking potential will not develop. Vygotsky, through the concept of the Zone of Proximal Development (ZPD), emphasized that students can achieve higher abilities if provided with appropriate scaffolding by teachers or more competent peers (Margolis, 2020).

In the context of food webs, scaffolding can take the form of guiding questions, group discussions, or interactive simulations that help students gradually see the relationships between ecosystem components. Hugerat and Kortam (2014), demonstrated that an inquiry approach can encourage students to build a more comprehensive ecological understanding because they are invited to directly investigate the relationships between ecosystem components through questions, observations, and simple experiments. A similar finding was confirmed by Wati et al., (2026) who found that integrating HOTS into science learning through interactive media such as digital food web simulations significantly improved elementary school students' analytical skills and scientific literacy.

Furthermore, Ichsan et al., (2019) through the HOTS-AEP (Higher Order Thinking Skills from Elementary School Students in Environmental Problem Based Learning) model showed that when elementary school students were invited to solve real environmental problems, their analytical skills on ecosystem dynamics, including food webs, increased significantly. These three studies collectively confirm that conceptual confusion in food webs can be overcome by changing the learning approach from passive-receptive to active-exploratory.

The confusion surrounding food webs is intertwined with another, equally fundamental problem: neglecting the role of decomposers. As many as 60% of students failed to analyze the interdependence between ecosystem components, and 5 out of 8 students interviewed did not understand the function of decomposers. For them, the food chain ends with the death of the top consumer; the animal remains are considered to "disappear on their own" without further processing. In ecology, however, the role of decomposers is of great importance in the material cycle. If there was no decomposers, the nutrients would remain in the dead organisms and would not be able to be reused by the producers (Nisha et al., 2023).

Such an omission of the decomposers' role leads to an important conceptual gap in students' learning about ecology. They do not realize that an ecosystem is a cycle and not just a line of producers to top consumers. This lack of understanding of decomposers also affects students' understanding of how an ecosystem is sustainable: If there were no decomposers, the planet would be covered with un-decayed dead bodies, and new living would be impossible. This is in line with the research of Wennersten et al., (2023) who found that misconceptions about Decomposers were among the most commonly found in Ecosystems in primary schools. These misconceptions are further intensified by the myths found in textbooks and in teacher explanations where consumers and producers are stressed and the decomposers are not mentioned or even given attention.

The solution comes from Yeo et al., (2022) who developed a diagnostic instrument for HOTS which can assist teachers in identifying specific misconceptions in the ecosystems, among which developing the HOTS in decomposers. Teachers can use a diagnosis instrument that has been proven to be valid in order to know the weaknesses of a student and plan individual intervention. However, the critical thinking skills of elementary school children regarding the energy transformation concept are still low because only a part of the concept is understood, as in this study, the neglect of decomposers (Yee & Karpudewan, 2022). They both show that science education in elementary school is more likely to have a disorganized or fragmented presentation of concepts.

This conceptual confusion, the neglect of decomposers and poor systemic thinking all led to a climactic climax: the students' inability to assess the effect of human activities on ecosystems. The percentage of failure rate of this sub topic was also very high at 73.3%, which is logical as the students' conceptualization is very weak. If students are not aware of the relationship among the parts of an ecosystem, how do they know how to critically appraise deforestation? Interviews confirmed this: all the students interviewed were aware that the cutting down of trees was wrong, but none were able to elaborate on arguments. However, they were unable to link their responses to the ideas of soil erosion, flooding, microclimate change, or disruption of the water cycle because their responses were emotional. One student was even able to say, "I don't know, ma'am. It's just bad."

It is critical to cultivate reflective thinking skills, such as thinking from several perspectives, recognising bias and making decisions based on evidence, early in life to assess environmental issues, as stated by (Quinn et al., 2020). However, students' evaluation skills will remain limited to ill-informed, polarized judgments if they do not have a firm understanding of concepts and a well-developed ability to reason. Sari et al., (2024) gave empirical evidence that the Problem Based Learning (PBL) model which introduces real environmental problems in the world is effective in enhancing the HOTS skills of elementary school students, especially in evaluating skills. The PBL learning model was found to improve problem solving and critical thinking skills of students, as evidenced by the significant difference in problem solving and critical thinking skills obtained by students who learned using PBL in the study compared to students who learned conventionally. This indicates that lack of assessment of impacts of human activities is not a problem that students cannot overcome, but it can be overcome by changing learning strategies. Students' exposure to real-life examples of issue scenarios is also important, as discussed by Research (Zimmerman & Weible, 2017) for example, river pollution, land conversion, or poaching to make them understand how concepts of ecosystem services are relevant to the issues they are experiencing in their everyday lives.

So all the results of the study in this research create a chain, or a red thread. Low achievement of the students from the HOTS is not associated with any one sub-topic or any one level of cognition, but rather several interrelated problems: LOTS-oriented learning results in shallow conceptual understanding; shallow understanding leads to confusion and incompletion of food chain and food web concepts and a neglect of the role of decomposers; the confusion and incompleteness of these concepts weakens students' ability to think systemically; and poor systemic thinking makes the students unable to critically evaluate ecological issues. This series of problems is due to one root, namely learning design that has not been intentionally and systematically directed towards developing the HOTS.

The authors of Pakkasjärvi et al., (2024) highlighted that HOTS is not a side product of learning, but rather a specific learning target that needs to be planned, taught and assessed. This means that HOTS is not expected to come out of the blue in the traditional learning process, but needs to be well planned, beginning with the formulation of learning objectives, model, media and evaluation instruments with a focus on HOTS. This finding is consistent with Anderson and Krathwohl (2010) framework which focuses on the alignment of curriculum goals, instructional goals, and assessment goals. Development will be effective if these three components converge to focus on HOTS. However, when learning objectives include HOTS and process or assessment are LOTS, the gap will continue to exist.

The implication is that teachers need to transform their ecosystem learning design. First, the choice of learning model must shift from a transmissive model to one that encourages inquiry and problem-solving, such as Problem-Based Learning (PBL) or Inquiry-Based Learning (IBL), which have been proven effective through various studies mentioned above. Second, the use of concrete and interactive media such as terrariums, mini aquariums, or digital simulations must be increased so that students can directly observe ecosystem dynamics. Third, teachers need to familiarize themselves with metacognitive questions in each learning session to train students to reflect on their thinking processes. Fourth, evaluation instruments should increasingly use descriptive formats that require argumentation, rather than simply factual multiple-choice questions.

Wiyaka et al., (2025) emphasized that standardized HOTS diagnostic instruments can be a tool for teachers to identify specific student weaknesses so that learning interventions can be carried out in a targeted and differentiated manner. With a targeted and evidence-based strategy, developing students' HOTS in ecosystems material is not just an ideal, but a goal that can be realized in the classroom. Ultimately, equipping students with HOTS skills is not only about improving academic performance, but also about preparing them to become citizens who are able to think critically, make decisions based on evidence, and contribute to maintaining ecosystem sustainability in the future.

CONCLUSION

This study concludes that fifth-grade students at Kaligayam 1 Elementary School's HOTS skills in ecosystems are relatively low (average 52.3; 60% of students fall into the Low–Very Low category), with a significant gap between analytical (C4=55.8) and evaluation (C5=47.1) skills. The primary root of the problem is the LOTS-oriented learning design, which leads to conceptual confusion between food chains and food webs, neglect of the role of decomposers, weak systemic thinking, and minimal evidence-based argumentation skills. The primary academic contribution of this study lies in providing a granular diagnostic map that maps students' weaknesses specifically per ecosystem subtopic and per cognitive level of precision (C4 vs. C5)—a level of specificity largely unavailable in previous elementary education studies. This offers a concrete, evidence-based foundation for teachers to design targeted and differentiated learning interventions.

The practical implication is that teachers need to implement a paradigm shift in science learning through four steps: (1) shifting the model from transmissive to inquiry and problem-solving (PBL/IBL); (2) utilization of concrete and interactive media (terrarium, digital simulation); (3) habituation of metacognitive questions; and (4) consistent use of evaluation instruments in the form of argumentative descriptions. Research limitations include a limited sample (30 students from one school), a focus only on levels C4 and C5 (not including C6), a qualitative design that does not test the effectiveness of the intervention, and an instrument that only measures writing skills. Recommendations for further research include: (1) empirical testing of the effectiveness of differentiated learning models; (2) expansion of samples and geographic areas; (3) integration of level C6 in diagnostic instruments; (4) longitudinal studies; and (5) development of teacher guidebooks and teaching modules based on this diagnostic map.

REFERENCES

Aditomo, A., & Klieme, E. (2020). Forms of inquiry-based science instruction and their relations with learning outcomes: Evidence from high and low-performing education systems. *International Journal of Science Education*, *42*(4), 504–525. https://doi.org/10.1080/09500693.2020.1716093

Anderson, L. W., & Krathwohl, D. R. (2010). *Kerangka landasan untuk pembelajaran, pengajaran, dan asesmen: Revisi taksonomi pendidikan Bloom (A. Prihantoro, Penerj.)*.

Arifin, Z., Sukarmin, S., 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. https://doi.org/10.29333/ejmste/15988

Arikunto, S. (2019). *Prosedur Penelitian: Suatu Pendekatan Praktik*. Rineka Cipta.

Arnellis, Fauzan, A., Arnawa, I. M., & Yerizon. (2021). Analysis of High Order Thinking Skill of Students in Contextual Problems Solving. *Journal of Physics: Conference Series*, *1742*(1), 012021. https://doi.org/10.1088/1742-6596/1742/1/012021

Babakr, Z. H., Mohamedamin, P., & Kakamad, K. (2019). Piaget's Cognitive Developmental Theory: Critical Review. *Education Quarterly Reviews*, *2*(3). https://doi.org/10.31014/aior.1993.02.03.84

Cantona, I. G. E., Suastra, I. W., & Ardana, I. M. (2023). HOTS Oriented Problem-Based Learning Model: Improving Critical Thinking Skills and Learning Outcomes of Fifth Grade Students in Science Learning. *Thinking Skills and Creativity Journal*, *6*(1), 19–26. https://doi.org/10.23887/tscj.v6i1.61654

Creswell, J. W., & Poth, C. N. (2018). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches (4th ed.)*. SAGE Publications.

Febrianti, S. A. D., Widiana, I. W., & Ana, K. Y. (2021). Higher-Order Thinking Skill (HOTS) Instrument-Based Cognitive Evaluation in Grade V Elementary School Students. *Thinking Skills and Creativity Journal*, *4*(2), 48–56. https://doi.org/10.23887/tscj.v4i2.38570

Hugerat, M., & Kortam, N. (2014). Improving Higher Order Thinking Skills among freshmen by Teaching Science through Inquiry. *EURASIA Journal of Mathematics, Science and Technology Education*, *10*(5). https://doi.org/10.12973/eurasia.2014.1107a

Ichsan, I. Z., Sigit, D. V., Miarsyah, M., Ali, A., Arif, W. P., & Prayitno, T. A. (2019). HOTS-AEP: Higher Order Thinking Skills from Elementary to Master Students in Environmental Learning. *European Journal of Educational Research*, *volume–8–2019*(volume8-issue4.html), 935–942. https://doi.org/10.12973/eu-jer.8.4.935

Kvale, S., & Brinkmann, S. (2015). *InterViews: Learning the Craft of Qualitative Research Interviewing (3rd ed.)*. SAGE Publications.

Margolis, A. A. (2020). Zone of Proximal Development, Scaffolding and Teaching Practice. *Cultural-Historical Psychology*, *16*(3), 15–26. https://doi.org/10.17759/chp.2020160303

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook (3rd ed.)*. SAGE Publication.

Moleong, L. J. (2017). *Metodologi Penelitian Kualitatif (Edisi Revisi).* . *ISBN:* PT Remaja Rosdakarya.

Nisha, P., John, N., Rubeena, K. A., & Thangavel, M. (2023). Biomass from Terrestrial Environments. In S. Thomas, M. Hosur, D. Pasquini, & C. Jose Chirayil (Eds.), *Handbook of Biomass* (pp. 1–27). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-6772-6_3-1

Nur'ariyani, S., Jumyati, J., Yuliyanti, Y., Nulhakim, L., & Leksono, S. M. (2023). Scientific Approach to Learning Science in Elementary Schools. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6659–6666. https://doi.org/10.29303/jppipa.v9i8.3680

Odanova, S. A., Ermekova, T. N., & Moldabayeva, K. E. (2022). THE MAIN ISSUES OF ACADEMIC ESSAY WRITING. *Журнал Серии «Филологические Науки»*, *65*(2). https://doi.org/10.48371/phils.2022.65.2.019

Pakkasjärvi, N., Anttila, H., & Pyhältö, K. (2024). What are the learning objectives in surgical training – a systematic literature review of the surgical competence framework. *BMC Medical Education*, *24*(1), 119. https://doi.org/10.1186/s12909-024-05068-z

Quinn, S., Hogan, M., Dwyer, C., Finn, P., & Fogarty, E. (2020). Development and Validation of the Student-Educator Negotiated Critical Thinking Dispositions Scale (SENCTDS). *Thinking Skills and Creativity*, *38*, 100710. https://doi.org/10.1016/j.tsc.2020.100710

Rahayu, S., & Rosawati, E. E. (2023). *The development of higher-order thinking skills (HOTS) assessment instrument in chemistry using socioscientific issues context: A preliminary trial*. 030009. https://doi.org/10.1063/5.0118624

Richey, J. E., Andres-Bray, J. M. L., Mogessie, M., Scruggs, R., Andres, J. M. A. L., Star, J. R., Baker, R. S., & McLaren, B. M. (2019). More confusion and frustration, better learning: The impact of erroneous examples. *Computers & Education*, *139*, 173–190. https://doi.org/10.1016/j.compedu.2019.05.012

Santosa, A. B., Suyata, & Poerwanto, E. (2025). Cultivating Discipline and a Sense of Responsibility: An Integrated Approach to Character Education. *Journal of Nusantara Education*, *4*(2), 22–31. https://doi.org/10.57176/jn.v4i2.136

Santrock, J. W. (2018). *Educational Psychology (6th ed.)*. New York.

Sari, N. K. D. A. S., Astawan, G. A., & Ni Ketut Desia Tristiantari. (2024). The Effectiveness of HOTS-Oriented Educational Game Media to Improve Students' Science Literacy on the Material of Weather Changes on Earth. *International Journal of Elementary Education*, *8*(4), 773–781. https://doi.org/10.23887/ijee.v8i4.89826

Sarwanto, S., Fajari, L. E. W., Faculty of Teacher Training and Education, Universitas Sebelas Maret, Indonesia, laksmievasufiwidifajari@student.uns.ac.id, & Chumdari, C. (2021). Open-Ended Questions to Assess Critical-Thinking Skills in Indonesian Elementary School. *International Journal of Instruction*, *14*(1), 615–630. https://doi.org/10.29333/iji.2021.14137a

Sayekti, P., & Anggriani, S. D. (2026). Enhancing 21st Century Teacher Competencies Through HOTS Integration and Diagnostic Assessment in Differentiated Instruction. *KnE Social Sciences*, *11*(2), 74–100. https://doi.org/10.18502/kss.v11i2.20730

Shalikhah, N. D., & Nugroho, I. (2023). Implementation of Higher-Order Thinking Skills in Elementary School Using Learning Model, Media, and Assessment. *AL-ISHLAH: Jurnal Pendidikan*, *15*(3). https://doi.org/10.35445/alishlah.v15i3.3091

Shutaleva, A. (2023). Ecological Culture and Critical Thinking: Building of a Sustainable Future. *Sustainability*, *15*(18), 13492. https://doi.org/10.3390/su151813492

Simanjuntak, M. P., Sihite, E. I., Science Education Study Program, State University of Medan, Indonesia, elvinairawatisihite@gmail.com, Suyanti, R. D., & Science Education Study Program, State University of Medan, Indonesia, retnosuyanti@unimed.ac.id. (2023). The Effect of Blended Learning with Edmodo-Assisted Scientific Approach on Independence and Science Learning Outcomes. *International Journal of Instruction*, *16*(4), 135–154. https://doi.org/10.29333/iji.2023.1649a

Sugiyono. (2022). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta.

Sukmayadi, A., & Rofii, M. S. (2025). Indonesia's Position in The Global War for Talent: A Study of Indonesian Talent Competitiveness Based on Global Talent Competitiveness Index (GTCI) in Year of 2020-2023. In I. K. Rohman, W. Zhaoyang, M. I. Muttaqin, I. S. Wekke, & I. S. Fitrinitia (Eds.), *Proceedings of the International Conference on Strategic and Global Studies (ICSGS 2024)* (Vol. 33, pp. 521–535). Atlantis Press International BV. https://doi.org/10.2991/978-94-6463-646-8_31

Wati, E. L., Lestari, I., & Wibowo, F. C. (2026). Systematic Analysis of the Use of Socio Scientific Issues-Oriented Mobile Learning as a Science Learning Media to Improve the Critical Thinking Skills of Elementary School Students. *Edunesia : Jurnal Ilmiah Pendidikan*, *7*(2), 837–854. https://doi.org/10.51276/edu.v7i2.1657

Wennersten, L., Wanselin, H., Wikman, S., & Lindahl, M. (2023). Interpreting students' ideas on the availability of energy and matter in food webs. *Journal of Biological Education*, *57*(1), 3–23. https://doi.org/10.1080/00219266.2020.1858935

Woolley, J. S., Deal, A. M., Green, J., Hathenbruck, F., Kurtz, S. A., Park, T. K. H., Pollock, S. V., Transtrum, M. B., & Jensen, J. L. (2018). Undergraduate students demonstrate common false scientific reasoning strategies. *Thinking Skills and Creativity*, *27*, 101–113. https://doi.org/10.1016/j.tsc.2017.12.004

Yee, Y. L., & Karpudewan, M. (2022). Science Writing Heuristics Improve Pre-University Students Understanding of Energy Transfer in an Ecosystem and Argumentation Ability. *Journal of Turkish Science Education*, 1. https://doi.org/10.36681/tused.2022.111

Yeo, J.-H., Yang, H.-H., & Cho, I.-H. (2022). Using A Three-Tier Multiple-Choice Diagnostic Instrument Toward Alternative Conceptions Among Lower-Secondary School Students in Taiwan: Taking Ecosystems Unit As An Example. *Journal of Baltic Science Education*, *21*(1), 69–83. https://doi.org/10.33225/jbse/22.21.69

Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods (6th ed.)*. SAGE Publications.

Zimmerman, H. T., & Weible, J. L. (2017). Learning in and about rural places: Connections and tensions between students' everyday experiences and environmental quality issues in their community. *Cultural Studies of Science Education*, *12*(1), 7–31. https://doi.org/10.1007/s11422-016-9757-1

Zohar, A., & Dori, Y. J. (Eds.). (2012). *Metacognition in Science Education* (Vol. 40). Springer Netherlands. https://doi.org/10.1007/978-94-007-2132-6