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RESEARCH ARTICLE

Reinforcement analyze and evaluate of higher-order thinking skills using problem-based learning in ecosystem material

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Abstract: Higher-order thinking skills (HOTS) is one of the skills needed for 21st century challenges, especially for students. The aim of this study was to describe HOTS in students, especially the cognitive domain of analyzing and evaluating. This is a descriptive quantitative study employing a Pretest-Posttest One Group research design. The experiment was limited to 34 students heterogeneously from class X-C SMAN 1 Nglames. The research instruments used include learning observation sheets and posttests for student academic score also analyze and evaluate skills. The findings revealed that the average of analyze and evaluate of HOTS Completeness was 79.40% with a good category. The classical completeness of students in learning was 82.35% with a very complete category. Thus, the problem-based learning model can reinforce students' analysis(C4) and evaluate(C5) in higher order thinking skills of ecosystem material.

Keywords: ecosystem; higher-order thinking skills; problem-based learning

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Introduction

Globalization makes education nowadays an important matter of concern as a form of preparing the society for 21st century challenges. The challenge is particularly essential for dealing with new and uncertain situations that are required have problem solving ability. Bayley (2022) stated that worldwide concerns that are complicated in recent years, there has been a growing emphasis on the importance of learning for both personal and societal adaptation. As stated by (Dini et al., 2018) that education may transform someone's mentality and inspire them to make changes and improvements in their lives with excellent quality of education. Education can make people more creative in thinking and students' mental health should be improved (Carson, 2019; Forgeard, 2021). Education in the future requires students to be more skilled and qualified by exploring and developing their knowledge to a high level. This opinion is affirmed by Yusmanto & Herman, (2016) who stated that students are more actively memorizing than understanding the concept so student's thinking ability or thinking skill is less involved in constructing their knowledge.

Thinking skills have become one of the metrics for boosting learning quality (Lukitasari et al., 2018). Thinking skills has several levels, ranging from Low Order Thinking Skill (LOTS), Medium Order Thinking (MOTS), to Higher-Order Thinking Skill (HOTS). High order thinking skills (HOTS) belong to critical thinking, creative thinking, problem solving, and decision making (Apino & Retnawati, 2017). HOTS are also not possessed by all people because these skills are included in the C4, C5, and C6 domains of Bloom's revised taxonomy. So, HOTS is a higher level of process-based reasoning capacity (Ichsan et al., 2019; Jaenudin et al., 2020).

HOTS is an essential component in education according to Ahmad et al., (2018) because of its advantages in improving students' learning accomplishment, lowering weakness, construing, integrating, issues solving, controlling information, concepts, and daily activities. Learning HOTS of students can be measured by using assessments. Appropriate assessment that was carried out by

the teacher needed to quantify the ability, namely tests in the form of HOTS questions. Other than as an assessment tool, this question also can help teachers to enhance the question's quality in subsequent learning sessions. Then, HOTS questions can reinforce the ability to work on national or international standard questions. HOTS involve the capacity to think more creatively and critically in order to solve difficulties (Yulianto et al., 2019).

Analysis (C4) by Wilson, (2016) is the process of dividing resources or ideas into pieces and determining how the components connect to one another or interrelate, or how the parts relate to an overarching structure or objective. Level analysis questions highlight learners' capacity by Birgili, (2015); Mullis et al., (2017) to explain concepts or concerns that indicate their capacity to compare components using logical reasons. Analytical abilities are also required and essential for students (Setiawaty et al., 2019; Somatanaya & Nugraha, 2018). Meanwhile, evaluate (C5) is reviewing and criticizing results based on criteria and standards. Deliverables that may be developed to reflect the evaluation methods include critiques, recommendations, and reports. In the revised taxonomy, evaluate comes before create because it is typically a necessary step before generating something. Evaluating as C5 is a systematic procedure for determining merit, worth, value, or relevance answer (McMurry et al., 2016). A literary criticism inquiry is one example of a form that necessitates evaluating skill. The question that is given to indicate evaluation must encourage students to respond to the situations critically. So, the higher-order processes' abilities or HOTS were represented by the categories of applying and analyzing (Jensen et al., 2014).

According to the findings of PISA (Program for International Student Assessment) 2018 study, Indonesia was rated 10th out of 15 countries. In terms of education, the students in Indonesian were still at the level of Lower Order Thinking Skill (LOTS) or low thinking skills (Avvisati et al., 2018). Furthermore, the findings of the most recent TIMSS assessment that was performed in 2015, revealed that students in Indonesia had not demonstrated adequate achievement. Indonesia received a score of 397 in the subject of Science, placing it 45th out of 48 countries (Mullis et al., 2017; Ulger, 2018). This is in accordance with the results of pre-observation that made by the researcher towards assessment in X-C class of SMAN 1 Nglames shows that high order thinking skills ability who cover the cognitive area namely C4 and C5 domain on average still achieve a value of ≤ 68 or less than the Minimum Mastery Criteria (MMC) that set by school, which is quite low. Students' HOTS in the cognitive domain analyzing (C4) were only 45,86% and 23.52% in evaluating (C5). Furthermore, according to the findings of interviews with biology educators, learning biology in the classroom still lacks the activity of students, students tend to be less active, have not been able to learn independently, less constructive knowledge and reflecting on the problem situation and thinking process. As stated by (Saputri & Febriani (2017) learning nowadays focuses solely on idea mastery. As a result, students just remember things in order to attain high exam results, and this circumstance causes students to not think critically while addressing issues or problems. In addition Lu et al., (2021) research shows that HOTS have an effect on student learning, which includes of the learning achievements.

Problem-based learning (PBL) is one of the educational models for biology that can help students to solve real problems and think deeply about what is the solution for the case, especially ecosystem material. PBL is an educational methodology that enables facilitators and learners to foster critical thinking and improves standard teaching techniques (Fink & Benedek, 2021). The degree to which students collaborate in small groups is crucial to the PBL method. This strategy stimulates learners' interest and improves their comprehension of the subject. The advantages of the PBL model are that it is applicable to students' lives, that the idea is relevant to students' needs, that it promotes the nature of student inquiry, concept memory improves, and it encourages problem solving abilities. In addition, for cognitive aspects it also can enhance students' high order thinking skills (Birgili, 2015; Ulger, 2018). Therefore, PBL is one of the most often suggested learning approaches models for the 21st century (Phang et al., 2018). As a result, students are expected to be critical problem solvers in their surroundings. Regarding the phenomenon, this research aimed to reinforce the analysis (C4) and evaluation (C5) domain of HOTS using critical questions in ecosystem material which combined with the PBL.

Method

This is a descriptive quantitative study employing Pretest-Posttest One Group research design. The participants in this study were students from SMA Negeri 1 Nglames class X-C with 34 students heterogeneously. This research was conducted in May 2023. An explanation of the research design is as follows as Table 1.

Table 1. One Shot Case Study Design

Group	Pre-test	Process	Post-test
G	O1	X	O2
	HOTS (analyze and evaluate category) test	Treatment using PBL model	HOTS (analyze and evaluate category) test

(Sugiyono, 2013).

Research instrument that was used is Student Worksheet (SW) where students are required to

solve difficulties through the PBL phase such as 1) orienting students to the topic; 2) arranging students to conduct research; 3) helping solo and group investigations; 4) producing and presenting work; and 5) assessing and evaluating the problem-solving process, which involves critical thinking in offering answers to the questions. Research instrument that used in this study based on expert adjustment including two related lecturers and one biology teacher. Almanasreh et al. (2019), describe content validation by expert judgment as an educated opinion from an individual with a track record in the subject who is recognized by others to be a competent expert and who can give knowledge, proof, and evaluation. Evaluation by expert judgment is asking numerous people to evaluate an instrument or express their view on a certain element (Leite et al., 2022). The expert's participation is critical in clarifying, adding, and/or amending the required components (Nurrohmah et al., 2018). Questions used to reinforce students' mastery of the HOTS while in this case are focused on analyze(C4) and evaluate(C5) categories in ecosystem material. The form of the test applied is an essay examination, which is carried out during group discussions with the indicators as shown at Table 2.

Table 2. Indicators of Analyze (C4) and Evaluate (C5) in Ecosystem Material

No	Indicator	Cognitive Level	Number of questions
1	Analyze the connection between energy fluxes and food chain	C4	5
2	Consider behavior to solve ecosystem issues	C5	5

The result of student scores in this research used to determine whether students have or have not mastered learning indicators related to the ecosystem material in accordance with the basic competencies. Student' HOTS (analyze and evaluate category) are said to be well trained if the completeness of the students test scores is achieved. The questions take form of essay questions, with the cognitive domains of analyzing (C4) and evaluating (C5) relating to the new Bloom's taxonomy levels (Wilson, 2016). The score of student HOTS category can be counted using the Formula 1 (Purbaningrum, 2017).

$$HOTS\ Score\ (H) = \frac{score\ obtained}{total\ score}\ x\ 100\% \quad (1)$$

Furthermore, students' analysis and evaluation abilities were calculated as a percentage and then interpreted into the scoring criteria as (Purbaningrum, 2017) shown in Table 3.

Table 3. Analyze and Evaluate of HOTS Score Interpretation Criteria

Score	Category
81 < H≤ 100	Very Good
61 < H≤ 80	Good
41 < H≤ 60	Enough
21 < H≤ 40	Less
< 20	Very Less

According to the table, learners are said to have HOTS if students get a score of 61<H≤ 80 for each category which is analyzed and evaluated. Octoria et al., (2016) stated that implementing HOTS has an impact on students' academic score. Then, to know individual scores that must achieve the MMC established by SMA Negeri 1 Nglames which is 68 for considered competent in student academic scores. According to Widoyoko, (2014) the percentage of classical completeness (C) can be counted using the Formula 2.

$$C\ (\%) = \frac{number\ of\ complete\ student}{number\ of\ all\ students}\ x\ 100\% \quad (2)$$

Furthermore, the percentage of students who completed classical learning was calculated as shown in Table 4.

Table 4. The parameters for interpreting the indicator of learning completeness

Score (%)	Category
0-20	Not completed
21-40	Less completed
41-60	Enough completed
61-80	Completed
81-100	Very Completed

According to the table, classical completion is defined as 61% of students receiving a completed indication.

Results and Discussion

This section is arranged on the study's objectives. First, we attempted to assess the completeness of analyze and evaluate of HOTS indicator only based on students test as limitation in this research. Secondly, we attempted to seeing classical academic score completeness of students in ecosystem material using PBL model. In this regard, we present the findings of the analyze and evaluate score, as well as their answer and classical academic score on ecosystem material. The findings of this research on the completeness of analyze (C4) and evaluation (C5) criteria on HOTS show gaps in outcomes. Learners' analysis and evaluation are said to be well reinforced if students individually score 61<H≤ 80 for each category. The results are shown in Table 5.

Table 5. Analyze and Evaluate of HOTS Completeness Recapitulation

No	Indicator	Score Percentage (%)	Category
1	Analyze (C4)	88,23	Very Good
2	Evaluate (C5)	70,58	Good
	Average score	79,40	Good

The smaller difference results show that evaluate has a low average among analyze, which is 70,58. This demonstrates the distinction between evaluation and analysis. This is evident from the findings of the analysis indicator, which has an average of 88.23, indicating that the average result of analysis is greater than the average result of evaluation. According to this, there are variances in achievement in the analysis and evaluate metrics.

Bloom's cognitive indicators were measured in this study, particularly analysis (C5) and evaluation (C6). Analysis, evaluation, and creation are among the HOTs-based learning outcome indicators based on Bloom's taxonomic hierarchy(Wilson, 2016). According to this statement Zohar & Cohen, (2016) also stated that create is the highest and most complicated level, requiring more time and detail; as a result, researchers do not examine the create category, instead focusing on the analyze and evaluate categories.

Based on the analysis and evaluation of HOTS indicator completeness recapitulation in Table 5, the results of the analyze (C4) and evaluate (C5) are produced by an average score of 79.40% with a good category. Based on two indicators that are reinforced, analyze indicators get very good categorized and evaluate indicators get good categorized. It shows that analyzing (C4) uses one of the phases in PBL which is a third phase guiding research where students have to analyze the problems or cases that were given by the teacher. This action supported by Dewi et al., (2018); Putra et al., (2020) who said that the chance to work in groups and have in-depth conversations reinforces the ideas they already understand so it will improve their thinking skills or HOTS. It is in line with Ellis & Boyd, (2014); Wilson, (2016) which reveals that PBL has five phases: (1) student orientation to issues, (2) student organization, (3) guiding investigation, (4) developing and displaying work, and (5) analyzing and assessing problem resolution. On the other hand, another indicator that has a good categorization with 70,58% score is the evaluate indicator (C5). Evaluate is defined as the action of studying or assessing the credibility of a statement or conclusion (Facione, 2020). The ability to assess the benefits and drawbacks of anything is often referred to as evaluation (Varenina et al., 2021).

According to the findings of the students' answers (SA), they are still not proficient at evaluation when compared to analysis. This is supported by SA-1 (analyze) and SA-2 (evaluate) based on question 1 (Q1) and 2 (Q2) as sample of the whole question.

"We are aware that there are many different types of ecosystems in this world, and that each ecosystem has an energy flux and a food chain. Analyze whether there is a relationship between food chains and energy flux? Include explanatory evidence for your argument." (Q1)

"The food chain and energy flux are inextricably linked. This is due to the fact that the order of the food chain determines the trophic level, and the trophic level affects the quantity of energy flowing in an ecosystem. For example, if there is a food chain that is lost or extinct, it will cause the flux of energy to also decrease." (SA-1)

"At this point and based on the case that given before, industrial development is happening extremely quickly, and rising pollution levels follow. The mining sector, which contaminates the waterways, is one example. What are your thoughts on this issue, and what steps should the government and society as a whole take?" (Q2)

"In my opinion the government is less comprehensive and without further action in making rules for companies, especially mining which creates water pollution in this case." (SA-2)

According to this indication, students are still lacking in achievements in terms of deciding or evaluating something. It's shown by the answer that only criticism without a better workable solution, so they need to reflect and think more deeply about what they are considering. The process of developing conclusions is summarized by looking at students' abilities to convey reasons and facts that can reinforce their ideas, rather of merely providing a brief as meaningless answer. It can happen because Anderson & Krathwohl, (2001); Wilson, (2016) claimed that knowledge has levels or dimensions such as factual information, theoretical knowledge, practical

knowledge, and metacognitive expertise are all examples of knowledge where these knowledge dimensions signify the sequence of simple thinking challenges to complex thinking. This is one of the reasons why analysis scores higher than evaluation, because they are at different levels of knowledge. The analysis (C4) question in this study is at the factual knowledge level where students are required to order or sort, meanwhile the evaluation (C5) question is at the conceptual knowledge level where students are asked to assess an issue or case that is given in the student worksheet. According to Zohar & Cohen (2016), the capacity to analyze is connected to the ability to connect one knowledge to another methodically and problem solving abilities based on facts. In addition, essentially evaluation (C5) in HOTS question is more complex because not only reduce the ability to recall information knowledge but also increases the ability to; 1) change from one thought to another, 2) practice and drilling the data, 3) discover relationships between various forms of statistics, 4) using the facts to solve difficult problems, and 5) critically investigate and evaluate ideas (Herman et al., 2021).

Furthermore, classical academic score completeness show accomplishments. Student academic score completeness is said to be complete or achieved if the value obtained is while classical learning is more than 61% of students achieving scores more than MMC. Here the results are shown in Table 6.

Table 6. Classical Academic Score Completeness Recapitulation

Test Type	Number of Students		Classical Completeness	Category
	Complete	Not Complete		
Pretest	9	15	26,48	Less completed
Posttest	28	6	82,35	Very completed

There is an upsurge in the results of the pre-test and post-test achieved, when before only 9 students were complete with an average of 26.48% completion. Meanwhile, the posttest results reveal better outcomes, with a total of 28 students completing with average score of 82.35% in the very completed category as shown. Classical academic score in this study was also calculated to determine the effect of the questions or indicators of HOTS given. As stated by Octoria et al (2016) that implementing HOTS has an impact on students' academic score. Academic score completeness will be achieved if the percentage of learning completeness of some learners is achieved.

The questions that developed in this pretest and posttest use an analyze(C4) and evaluate(C5) domain to see the improvement of students' academic score by the problems that have been described previously using PBL models. Furthermore, it indicates there is a statistically significant change on posttest scores with high level questions which shows an increase in student academic score from 26,48 to 82,35. As stated by (Karmila et al., 2023) that high level questions will reinforce critical thinking that is interpreted in C4 and C5 which is part of HOTS, in order to improve students' academic score. In this research, students' academic scores were utilized as completeness in measuring student's completeness on ecosystem material. According to the findings, PBL model with high-level questions are helpful for reinforcing analysis(C4) and evaluation(C5) since they are achieved by student academic mastery. Furthermore, academic scores are used as a standard to measure achievement of the learning process, so it will be standardized for teachers to evaluate and identify students' progress. It also can be used for institutions to measure students' extent that the predetermined goals can be observed. The teacher's involvement is critical in motivating students prior to learning activities since it can increase excitement for studying, which affects academic score as the learning output (Andriani & Rasto, 2019).

Conclusion

Based on the study's findings, it is reasonable to conclude that PBL is beneficial to reinforce HOTS on ecosystem topics based on HOTS indicator questions and classical academic score completeness. From the result HOTS indicator (analyze and evaluate) completeness obtained an average score 79,40% with good categorization. Problem based learning that is integrated in form of posttest with high level questions to reinforce analyze and evaluate of HOTS at the end of learning shows classical completeness 82,35% with completed categorized for 28 out of 34 students can obtain score ≥68 as MMC of the school. This study is expected to help teachers regulate learning through the use of PBL models combined with HOTS questions in order to strengthen students' critical thinking abilities. For other researchers, it is projected that this study will serve as a new reference and broaden its scope to the C6 cognitive level (create).

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Conflicts of Interest

The paper's authors state that there actually are no conflicts of interest in the publication of this work

Author Contributions

A. D. Nanda: collecting data and authoring article; **R. Hasan:** review and editing article; **A. Sukri:** review and editing article; **M. Lukitasari:** research directing, reviewing and editing article; **A. T. Rivera:** review and editing article.

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