Journal of Mathematics Education
Website: http://usnsj.id/index.php/JME
Email: pengelolajme@gmail.com
p-ISSN 2528-2468; e–ISSN 2528-2026

DOI: https://doi.org/10.31327/jme.v8i2.2048

THE EFFECTIVENESS OF HOTS-ORIENTED LEARNING ON ACHIEVEMENT OF STUDENT HOTS

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Article Info

Article history:

Received Sept 03, 2023
Revised Nov 30, 2023
Accepted Dec 22, 2023

Keywords:

Combinatorial;
higher order thinking skills;
HOTS-oriented learning;
Problem solving, creative thinking, critical thinking.

ABSTRACT

This research is motivated by the findings regarding the difficulties experienced by students in solving combinatorial problems as an indication of weak High Order Thinking Skills (HOTS) students. The reason is that the lecture process has not facilitated active and interactive student involvement, where the lecture process is dominated by lecturers through the lecture method. Lecturers' formative and summative assessments are mostly because they only access understanding and mastery of material, are not contextual, and have not facilitated student HOTS achievement. This study aims to improve student HOTS through the application of HOTS-oriented learning. The HOTS-oriented learning components in this study include HOTS-based strategies and models, media, and assessments. The type of research used is a quasi-experimental study with a one group pretest-posttest design. The sample for this research was 17 students taking discrete mathematics courses for the 2022/2023 Academic Year. The data obtained were analyzed descriptively in the form of mean, standard deviation, and n-gain and inferential analysis using the one-way Multivariate Analysis of Variance (MANOVA) test. The results showed that students' HOTS experienced an increase after applying HOTS-oriented learning in the four aspects of the skills assessed, namely the skills of analyzing, evaluating, and creating; problem solving skills; creative thinking skills, and critical thinking skills, with an average increase in the medium criteria. Learning that is applied effectively to student HOTS achievement.

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How to Cite:

Sirad, La Ode., Arbain. (2023). The effectiveness of hots-oriented learning on achievement of student hots. *JME: Journal of Mathematics Education*, ***8***(2), 260-271.

1. INTRODUCTION

As individuals who are projected to become educators or teachers of mathematics subjects, mathematics education students need to be equipped with various competencies that are qualified and in line with the needs of the times. One of the important competencies that must be provided to mathematics education students is professional competence. By having professional competence, students will later become teachers who are competent in building and developing good and effective learning processes so that they can produce smart and skilled students and quality education (Borg, 2018; Retnawati et al., 2018; Zeng, 2023).

It is not enough for prospective mathematics teachers to just master the material and mathematical concepts that will be taught to students, it is also necessary to master thinking skills and mathematical skills in studying and solving mathematical problems that are non-routine and complex in nature which must be passed on to students. . The thinking skills in question are thinking skills that are aligned with the needs of the 21st century, namely High Order Thinking Skills (HOTS) (Hobri et al., 2018; Zohar & Cohen, 2016). By having HOTS, students can learn better, are able to develop more perfect performance, can reduce weaknesses in their learning, and can control information and solve problems in everyday life (Ahmad et al., 2018).

Several literatures identify various student skills that are categorized as higher-order thinking. Following are some of the HOTS skills, namely critical thinking, creative thinking, problem solving, and decision making (Singh et al., 2017), logical, reflective thinking, and metacognition (Zohar & Barzilai, 2015), science process skills (Afolabi & Akinbobola, 2010), argument skills (Kathpalia & See, 2016) as well as the skills to analyze, evaluate, and create (Watson, 2019). In this paper, HOTS is limited to (1) revised Bloom's taxonomy, namely analyzing, evaluating, and creating; (2) problem solving; (3) creative thinking; and (4) critical thinking.

Each course offered in the Mathematics Education Study Program at the Nineteen November Kolaka University (USN Kolaka) is basically structured in such a way that it is relevant for training student HOTS. However, what is of particular concern in this study is the combinatorial content of discrete mathematics courses. Combinatorial material is one of the vehicles to train students in HOTS (Lockwood, 2013). Combinatorial mathematics includes essential material for students to master because it trains students to reason, think critically and creatively, and solve problems (Salavatinejad et al., 2021).

The expected benefits of learning combinatorial mathematics are HOTS achievements for students. However, expectations have not matched reality. From the results of the assessments and interviews, it was found that students had difficulties in solving combinatorial problems that required high-order thinking. Similar findings were also reported by several previous researchers, namely students' ability to solve combinatorial problems was lower than the level of complexity of the questions given due to students' low HOTS (Rahayuningsih, 2016; Uripno & Rosyidi, 2019; Dwinata, 2019).

Given the importance of HOTS, the problem of weak HOTS for students is a serious problem that must be addressed. Notes from lecture reflection, namely the lecture process has not facilitated active and interactive student involvement, where the lecture process is dominated by lecturers through the lecture method. Most of the lecturers' formative and summative assessments are because they only access understanding and mastery of the material, are not contextual, and have not facilitated student HOTS achievement. These findings are thought to be the main cause of students' low HOTS.

Based on this description, HOTS-oriented learning transformation is deemed necessary to be carried out. The use of strategies, models, assessments, and other tools in learning needs to be focused on achieving HOTS without forgetting lower-level thinking skills. Some relevant research results, namely: (1) the average HOTS score of students increases after experiencing HOTS-based learning on four skills namely problem solving, critical thinking, creative thinking, and analytical thinking (Kwangmuang et al., 2021); (2) HOTS learning can make students think systematically, learn to analyze a problem from various aspects, educate students to be confident, and improve critical and creative thinking skills (Hidayati, 2017); and (3) Several innovative active and constructive learning models and strategies have been proven to increase student HOTS (Hwang et al., 2018; Mahanal, 2019; Prahani et al., 2020; Zubaidah et al., 2015).

From previous research, no one has examined the effectiveness of HOTS-oriented learning that integrates strategies, models, media, and assessments at the higher education level, especially in combinatorial content. Therefore this study focuses on the application of HOTS-oriented combinatorial learning and then measures its effect on student HOTS achievement. HOTS-oriented learning in question is learning that integrates the concepts of blended learning and problem-based learning, media in the form of student activity sheets, and HOTS-based assessment sheets. The aim is to determine the effectiveness of learning on increasing student HOTS.

2. METHOD

This research is included in the type of quantitative research. To find out the effectiveness of HOTS-oriented combinatorial learning on student HOTS achievement, a one group pretest-posttest design was applied. This research was carried out at the Mathematics Education Study Program, Faculty of Teacher Training and Education USN Kolaka. The sample for this research was students who took the Discrete Mathematics course for the 2022/2023 Academic Year, consisting of 17 people. An initial test (pretest) was given to participants before applying HOTS-oriented learning. The aim is to access students' initial HOTS before treatment on the four thinking skills, namely (1) analyze, evaluate, and create; (2) problem solving; (3) creative thinking; and (4) critical thinking.

Next, HOTS-oriented learning is carried out with the learning concept presented in Figure 1. Learning activities are divided into three main parts, namely input, process, and output. Activities in the input section are pre-learning activities, namely (1) determining the roles of lecturers and students by paying attention to aspects of student involvement; (2) preparing and incorporating content into PPT by paying attention to aspects of differentiation, designing LKM, compiling HOTS-based instruments, as well as defining and preparing other tools that will support the face-to-face learning process such as manila paper, origami paper, markers, scissors, and etc; and (3) setting up an online learning management system using a combination of the Google Classroom and WA group applications.

In the process section, learning activities are carried out that integrate the concepts of blended learning and problem-based learning. Before entering class, students first access and study the material that has been prepared on Google Classroom and discuss with colleagues to build their initial knowledge and thinking skills. Learning is then continued face-to-face using a problem-based learning model with 13 phases as shown in Figure 1. The learning activities take place over four meetings with the scope of material: the basics of counting, permutations and combinations, the pigeonhole principle, and discrete probability. After the learning activities ended, in the fifth meeting a posttest was carried out.

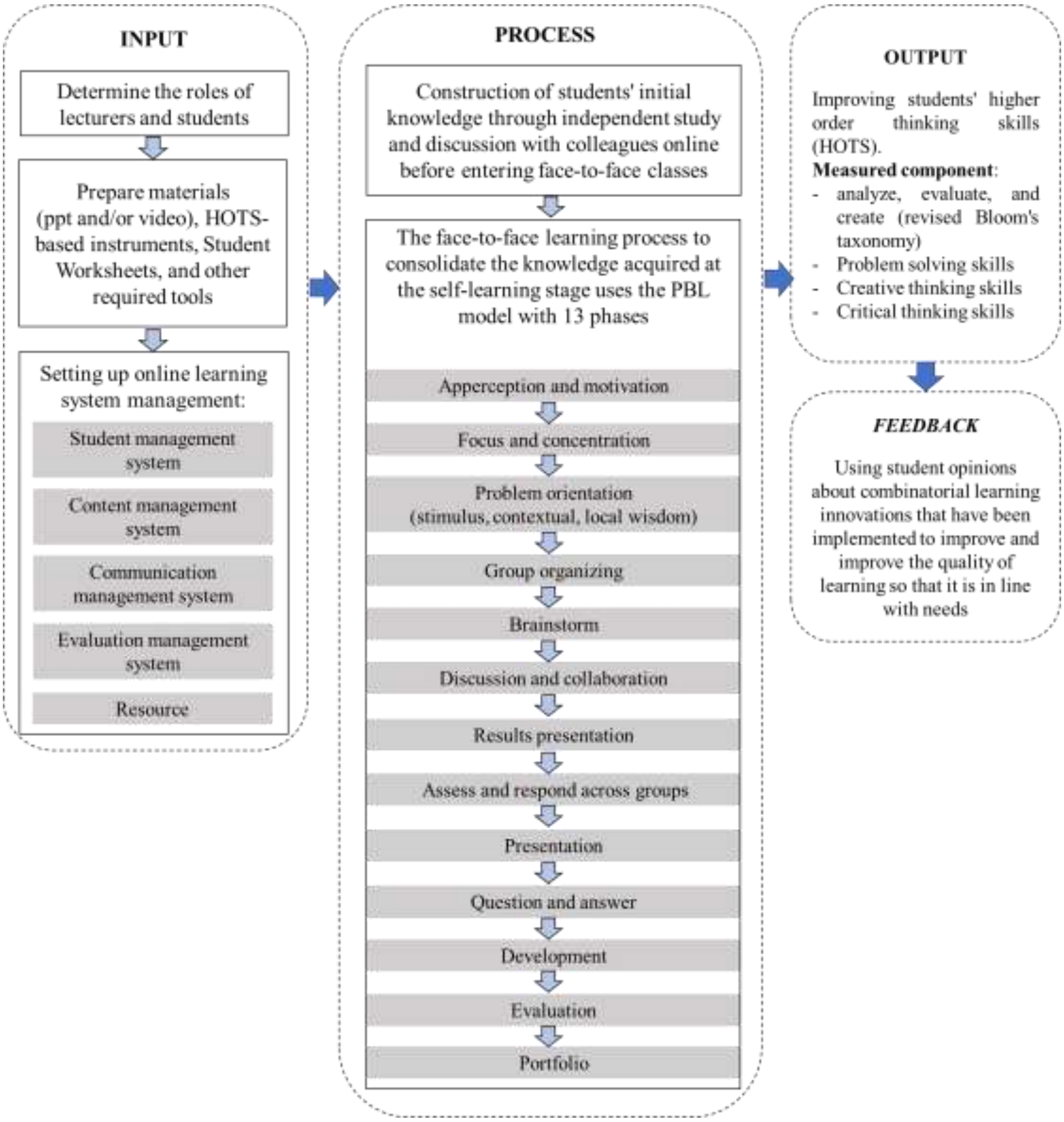


Figure 1. HOTS-oriented learning framework

The instruments in this study consisted of lecturer activity observation sheets, student activity observation sheets, and the HOTS test (pretest and posttest). For the observation sheet using a Likert scale (five criteria). For the HOTS test, there are four components of thinking skills that are measured by each assessment rubric, namely: (1) analyze, evaluate, and create; (2) problem solving; (3) think creatively; and (4) critical thinking (Mahanal, 2019).

The data obtained from the observation sheets were analyzed and presented in percentage form. Pretest and posttest data were analyzed descriptively and inferentially. Descriptive analysis was intended to describe HOTS students before and after treatment in the form of mean and standard deviation. To calculate the increase in HOTS between before and after treatment, a normalized gain (n-gain) analysis was performed. The improvement criteria based on the n-gain value are presented in Table 1.

Table 1. Criteria for improvement based on the n-gain value

Intervals	Criteria
$0.70 - 1.00$	Tall
$0.30 - 0.69$	Middle
$0.00 - 0.29$	Low

Source: (Arbain & Hali, 2021)

The inferential analysis is intended to provide statistical justification regarding the increase in student HOTS that occurs. The test that was carried out was the one-way Multivariate Analysis of Variance (MANOVA) test with the pretest and posttest data groups as fixed factors and four thinking skills: (1) analyze, evaluate, create; (2) problem solving; (3) creative thinking; and (4) critical thinking as the dependent variable. The assumption test as a preliminary test is included before the MANOVA test, namely the multivariate normality test with the Chi-Square Plot and the covariance matrix homogeneity test with Box's M test (Rusli et al., 2018). All analyzes were performed using SPSS software. The level of statistical significance was set at $\alpha = 0.05$. Learning is said to be effective towards achieving HOTS, if it meet two criteria: (1) the implementation of learning activities both from student activities and lecturer activities obtains a minimum percentage of 80%; and (2) Sig. the output of the MANOVA test is less than the significance level of $\alpha = 0.05$.

3. RESULTS AND DISCUSSION

3.1. Results

The learning activities were carried out in four meetings. The results of the analysis of the implementation of learning data, namely the observation sheet data of student activities and lecturer activities are presented in Table 2.

Table 2. Description of learning implementation data

Meeting	Student Activity (%)	Lecturer Activity (%)
I	81.33	82.67
II	85.33	84.00
III	90.67	88.00
IV	90.67	90.67
Average	87.00	86.33

Based on Table 2, it was found that the implementation of learning tended to increase student activity and lecturer activity at each meeting with an average student activity carried out of 87.00% and an average lecturer activity of 86.33%.

The results of the descriptive analysis of student HOTS data before experiencing learning innovation (pretest data) and after experiencing learning innovation (posttest data) are presented respectively in Table 3 and Table 4.

Table 3. Description of pretest data

Deskription	C4, C5, C6 (Revised Bloom's Taxonomy)	Problem Solving Skills	Creative Thingking Skills	Critical Thingking Skills
Respondents	17	17	17	17
Minimum	26.92	27.78	35.56	20.00

Maximum	69.23	69.44	71.11	66.67
Means	50.45	47.06	49.54	47.84
Standard deviation	10.17	12.32	10.91	12.96

Table 4. Description of posttest data

Deskription	C4, C5, C6 (Revised Bloom's Taxonomy)	Problrm Solving Skills	Creative Thingking Skills	Critical Thingking Skills
Respondents	17	17	17	17
Minimum	55.56	55.00	57.33	60.00
Maximum	91.11	81.67	85.33	92.00
Means	73.07	67.06	70.27	73.18
Standard deviation	10.88	8.05	8.90	9.36

Table 3 informs that before HOTS-oriented learning was implemented, students' HOTS achievements were not yet at an encouraging level. The average HOTS of students in the four skills assessed is only in the range of 50 on a scale of 100. The average score obtained by students on the four thinking skills, namely analyzing, evaluating, and creating is 50.45, problem-solving is 47.06, creative thinking at 49.54, and critical thinking at 47.84.

Table 4 provides information that after applying HOTS-oriented learning, there was an increase in students' HOTS scores in the four thinking skills assessed with an average score of analyzing, evaluating, and creating at 73.07, problem solving at 67.06, creative thinking at 70.27, and critical thinking of 73.18. The increase in the HOTS value is then analyzed by n-gain, then a grouping of improvement criteria is made based on the n-gain value. Description of n-gain values and grouping of improvement criteria based on n-gain values are presented in Table 5 and Table 6 respectively.

Table 5. Description of n-gain value

Deskription	n-gain value			
	C4, C5, C6 (Revised Bloom)	Problem Solving	Creative Thinking	Critical Thinking
Respondents	17	17	17	17
Minimum	0.29	0.18	0.30	0.23
Maximum	0.79	0.46	0.53	0.76
Means	0.47	0.38	0.42	0.49
Standard deviation	0.15	0.06	0.08	0.13

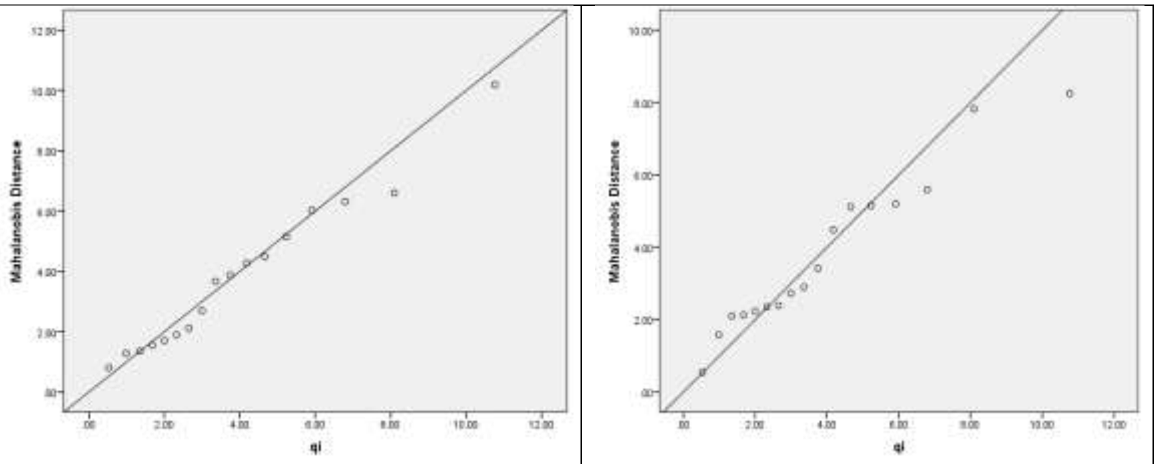
Table 6. The improvement criterion is based on the n-gain value

Intervals	Criteria	Number of Students			
		C4, C5, C6	Problem Solving	Creative Thinking	Critical Thinking
0.70 – 1.00	Tall	2	0	0	2
0.30 – 0.69	Middle	14	16	17	14
0.00 – 0.29	Low	1	1	0	1

By referring to the description of the n-gain value in Table 5 and the improvement criteria in Table 6, information is obtained that students experience an increase in the scores of the four thinking skills being assessed, with a description: (1) in the skills of analyzing, evaluating, and creating 2 people experienced an increase in the high category, 14 people in the medium category, and 1 person in the low category; (2) in problem solving skills the increase that occurred was only in the medium and low categories, namely as many as 16 people in the medium category and 1 person in the low category; (3) on creative thinking skills, all participants, namely as many as 17 people, experienced an increase in the moderate category; and (4) on critical thinking skills, students who experienced an increase in the high category were 2 people, 14 students in the medium category, and 1 person in the low category.

Based on the results of the descriptive analysis above, a descriptive conclusion was obtained that students' HOTS scores increased after learning activities were carried out by applying the HOTS-oriented learning concept. To get statistical justification and find out the significant increase in the HOTS value, a MANOVA test is carried out by first carrying out an assumption test in the form of (1) multivariate normality test using Chi-Square plots with the Mahalanobis distance, and (2) test the homogeneity of the covariance matrix using Box's M test.

Based on the calculation results according to the steps for determining the mahalonobis distance and the Chi-Square (qi) value of the data in this study, a scatter-plot was obtained between the mahalonobis distance and qi, which is presented in Figure 2.



(a) Pretest data (b) Posttest data

Figure 2. Chi-Square plots with the Mahalanobis distance for (a) pretest data, (b) posttest data

The scatter-plot results in Figure 2 shows that the Chi-Square plot and the Mahalonobis distance tend to form a straight line on both the pretest and posttest data, which means that the research data is normally multivariately distributed. This conclusion is strengthened by a very strong correlation between the Chi-Square value and the mahalanobis distance, which is 0.989 for the pretest data and 0.976 for the posttest data.

The results of the covariance matrix homogeneity test are presented in Table 7.
From Table 7, the value of Box's M = 26.285 and F = 2.270 is obtained with a value of Sig. = 0.012. Menurut Hahs-Vaughn, (2016), Box's M test has a high level of accuracy and also has a high sensitivity for small samples, so that the alpha (α) limit can be reduced to 0.001. So, to find out whether the results of the Box's M test are significant or not, that is by comparing the Sig. with a level of α=0.001. Because the value of Sig. = 0.012 is greater than 0.001, the results of the Box's M test are not significant, which means that the research data has a homogeneous covariance matrix.

Table 7. The statistical value of the covariance matrix homogeneity test

Statistics	**Statistical Value**
Box's M	26.285
F	2.270
df1	10
df2	4895.618
Sig.	0.012

Then a one-way MANOVA test was carried out with a recap of the test results shown in Table 8.

Table 8. The statistical value of the MANOVA test

Statistics	**F**	**Sig.**
Wilks' Lambda	10.318	0.000

From Table 8, the statistical value of Wilks' Lambda is obtained, namely $F = 10.318$ with a Sig. $= 0.000$ less than $\alpha = 0.05$. That is, the MANOVA test results are significant. Thus there is a significant difference in students' HOTS scores before and after applying HOTS-oriented learning, In this case, there is an increase in scores after applying HOTS-oriented learning to the four skills assessed, namely analyzing, evaluating, and creating; solution to problem; creative thinking; and think critically.

3.2. Discussion

The HOTS-oriented learning process that integrates the concepts of blended learning and problem-based learning has facilitated students to construct their initial knowledge and skills creatively. Through the learning strategies implemented, students are encouraged to explore content from various sources and discuss with colleagues to build their initial understanding before entering face-to-face classes. So that when entering face-to-face classes, students already have initial knowledge regarding content that is ready to be consolidated and developed in the form of group discussions, presenting work results, question and answer, mutual responses, and presentations. It was proven that starting from the first meeting of face-to-face learning, students were very active in discussing, asking, responding and expressing opinions with an active percentage of 81.33% and increasing in subsequent meetings to reach a percentage of 90.67% in the fourth meeting. Likewise, teaching activities experienced an increase from 82.67% implementation of learning in the first meeting up to 90.67% in the fourth meeting. This shows that the learning process has been carried out well and has exceeded the standards set, namely the minimum implementation of learning is 80%.

Relevant to the presentation of the results of this research, several previous studies stated: (1) blended learning is useful in helping students to develop better in the learning process, according to learning styles and learning preferences, providing realistic practical opportunities for educators and participants students for independent learning, as well as involving students in interactive experiences (Arifin & Abduh, 2021; Meilani et al., 2022); and (2) problem-based learning is useful in fostering enthusiasm for learning because students feel directly connected to real life, sparking student activity in working together to solve problems, and facilitating students to be communicative (Ramadhan, 2021; Aman, 2016; Maryati, 2018).

The increase in student enthusiasm, activeness, collaboration, and communication as captured in the learning activity observation sheet was also followed by increased student achievement in high-level thinking skills. The results of descriptive and inferential analysis have shown that learning that focuses on achieving HOTS has had a significant impact on increasing student HOTS in the four aspects assessed, namely: (1) analyzing, evaluating, and creating; (2) problem solving; (3) creative thinking; and (4) critical thinking. This shows that the application of HOTS-oriented learning is effective for student HOTS achievement.

With HOTS-oriented learning, students are facilitated to practice their abilities in identifying problems, simulating problem situations, comparing problems, and designing problem-solving strategies as well as creating new hypotheses or adjusting the process to get other answers. The HOTS-oriented learning that is implemented provides opportunities for students to develop their abilities in analyzing and linking all existing information and connecting it with real problems, evaluating events in the problem to determine relevant solution strategies for each event, then creating models for each event and combining them to solve problems. Apart from that, students also become more critical and creative, where every solution to the problem given is accompanied by rational arguments and rich in ideas.

The findings in this research support the results of previous research which stated that HOTS-based learning is beneficial for the growth and development of students' skills in problem-solving, critical thinking, creative thinking and analytical thinking (Kwangmuang et al., 2021); make students think systematically, learn to analyze a problem from various aspects, educate students to be confident, and improve critical and creative thinking skills (Hidayati, 2017). Several innovative active and constructive learning models and strategies have been proven to increase student HOTS (Hwang et al., 2018; Mahanal, 2019; Prahani et al., 2020; Zubaidah et al., 2015).

The results of this research have theoretical implications that thinking skills are closely related to learning, where HOTS students can grow and develop through appropriate learning. HOTS can develop well if it is carried out deliberately and planned through the application of strategies and learning models that actively involve students (Yee et al., 2015). A similar opinion was expressed by Singh et al., (2017) that HOTS can be developed through appropriate learning models and learning environments that facilitate the development of students' thinking as well as persistence, self-monitoring, an open attitude, and a flexible attitude. In this case, the implementation of learning is not solely on the transfer of knowledge or information which ultimately results in low-order thinking but needs to be emphasized on achieving HOTS. In line with this opinion, Mahanal, (2019) suggested that HOTS was triggered by four situations, namely: (1) a certain learning condition that requires a special or specific learning scenario and cannot be used in other learning conditions; (2) thinking skills are no longer considered skills that cannot be changed, but rather a set of knowledge that can be promoted by various factors such as learning strategies, learning environment, and self-motivation; (3) a shift in understanding from a unidisciplinary and linear perspective to an interdisciplinary and interactive perspective; and (4) more specific HOTS such as reasoning, analytical skills, problem-solving, and critical and creative thinking skills.

In this study, in addition to using active learning models and strategies, namely combining the concepts of blended learning and problem-based learning, media integration in the form of student worksheets and HOTS-based assessments which are based on the core of important skills that apply to everyday academic situations, novelty, and includes various test items that require continuous reasoning and are also an important factor in increasing student HOTS. Regular and planned HOTS-oriented learning and assessments bring benefits to students. Students' thinking skills and overall performance improve with the implementation of the HOTS-oriented learning and assessment model. Students learn by constructing meaning and incorporating new content into their mental representations. Therefore, improving thinking skills, actually also increases knowledge and understanding of content.

4. CONCLUSION

The findings in this study indicate that learning strategies and models and their assessments that are managed intentionally and planned to support the interests of HOTS development bring benefits to increasing student enthusiasm, activeness, collaboration, and communication as well as improving thinking skills in four aspects, namely: (1) analytical skills, evaluate, and create; (2) problem solving skills; (3) creative thinking skills; and (4) critical thinking skills. This means that learning is applied effectively to student HOTS achievement. The HOTS-oriented learning components in this study include strategies and models that combine the concepts of blended learning and problem-based learning, student worksheets and other supporting media, as well as HOTS-based learning assessments. Learning activities run well and smoothly as planned.

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