The Effect of Using HOTS-Based Student Worksheets on Student Learning Outcomes and Activities at MA Mannilingi Bulo-Bulo Jeneponto

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ABSTRACT

This study aims to determine the effect of using HETS-based Student Worksheets (LKS) on student learning outcomes and activities. This study used a quasi-experimental design with a non-equivalent control group and involved 60 students from two classes at Madrasah Aliyah Mannilingi, Jeneponto. The experimental group was given HOTS-based LKPD, while the control group used conventional LKPD. Data were collected through pre-test and post-test assessments, student activity observation sheets, and student response questionnaires. The results showed that the experimental group experienced a significant increase in learning outcomes with an average score of 69.63 for the control class and 90.60 for the experimental class. In addition, student activity in the experimental group was higher with an average score of 4.2 (very active), while the control group obtained a score of 2.8 (quite active). The N-Gain value for the experimental group was 0.72 (high category), indicating a substantial increase in " ". The independent t-test showed a highly significant difference between the two groups of the importance of implementing HOTS-based LKPD in the learning process, which can help improve students' higher-order thinking skills and problem-solving abilities. This study provides a significant contribution to educators and curriculum developers, by showing that implementing a HOTS-based approach in learning materials not only improves learning outcomes, but also prepares students to face real-world challenges. Therefore, it is important for educators and curriculum developers to consider integrating HOTS-based LKPD in their learning designs to achieve better academic outcomes and more optimal critical skill development.

Keywords: Student Worksheets, Higher Order Thinking Skills, Learning Outcomes, Student Activities

INTRODUCTION

Education is the primary foundation for developing quality human resources ready to face increasingly complex global challenges. In Indonesia, efforts to improve the quality of education continue to be encouraged, one of which is through an emphasis on the development of Higher-Order Thinking Skills (HOTS). HOTS is one of the aspects highlighted in producing high-quality human resources. However, improving students' HOTS is a challenge. Meanwhile, data analysis skills have become a superior qualification for employers (Nguyen & Hsu, 2022). The concept of higher-order thinking skills involves analysis, evaluation, and synthesis, as well as the ability to think critically and solve problems (Hart et al., 2021; Ismail et al., 2017). Higher Order Thinking Skills (HOTS) are crucial in education because they help students develop the

ability to deal with complex problems, enabling them to adapt quickly and appropriately in unfamiliar situations (Liu & Pásztor, 2022; Maxnun et al., 2024).

Research emphasizes that HOTS (Higher Order Thinking Skills) are crucial not only for academic purposes but also for personal and professional development (Aston, 2023), providing students with the tools necessary to succeed in the dynamic and often unpredictable environments of the future, as well as fostering adaptability (Utomo et al., 2023). For example, integrating methodologies that encourage metacognitive and critical reflection helps students understand their cognitive processes and improve their analytical skills (Afrilyasanti et al., 2025). Furthermore, the implementation of innovative educational tools, such as gamification and project-based learning, has shown potential in increasing student engagement and motivation, which directly correlates with better HOTS outcomes (Riwayatiningsih et al., 2025). Students with strong adaptability skills are better able to analyze and solve real-life phenomena (Amaningsih Jumhur et al., 2021).

Implementing different strategies in educational settings to enhance HOTS can significantly improve students' cognitive abilities. Dynamic problem-solving strategies have been shown to significantly enhance HOTS in science education, in line with Sustainable Development Goal 4, which promotes quality education (Haris et al., 2025). However, the reality on the ground shows that learning centered on developing KBT is still suboptimal. Teachers are often trapped in conventional methods that emphasize memorization and lower-level thinking skills, thus under-stimulating students to analyze, evaluate, and generate new ideas (Ramdiah et al., 2019; Sidiq et al., 2021).. This has a significant impact on student learning outcomes, which tend to stagnate at a low cognitive level, as well as a lack of student involvement in the constructive learning process.

The current curriculum explicitly encourages the implementation of deep learning. Deep learning is not simply memorizing facts, but the ability to comprehensively understand concepts, connect ideas, and apply them in various contexts. Unfortunately, the implementation of this approach is often hampered by limited teaching materials and strategies that support the development of critical and creative thinking (Basheer et al., 2016; Mohammed & Kora, 2023; Yousef & Allmer, 2023). The gap between curriculum expectations and practice in the field is a crucial issue that hinders the achievement of educational goals oriented towards developing 21st-century competencies.

One of the root causes of low HOTS and student activity is the lack of challenging learning tools to stimulate higher-order thinking. Student Worksheets (LKPD) used so far often only contain routine questions that do not encourage students to think critically, creatively, and innovatively (Aisah, 2020; Nadifatinisa & Sari, 2021). As a result, students tend to be passive, waiting for instructions, and lack motivation to explore knowledge independently. This creates a monotonous and meaningless learning cycle, which fails to facilitate the development of students' maximum potential. In response to this challenge, the development of HOTS-based LKPD emerged as an innovative solution to address this problem (Maghfirah, 2020; Puspita, 2020).This HOTS-based worksheet is specifically designed to facilitate students in applying analytical, evaluative, and creative skills, in accordance with the revised Bloom's taxonomy at a higher level. By presenting contextual problems, provocative questions, and tasks that require complex problem solving, HOTS-based worksheets are expected to trigger active student engagement in the learning process (Rejeki et al., 2022).This design also allows students to construct their own knowledge through exploration and collaboration, which is the essence of deep learning.

Higher-Order Thinking Skills (HOTS) are higher-order thinking skills that encompass complex cognitive processes such as analysis, evaluation, and synthesis. These skills are crucial for problem-solving and critical thinking in educational contexts (Asok et al., 2017; Nguyen & Hsu, 2022). HOTS-based Student Worksheets (LKPD) are designed to enhance these skills by engaging students in activities that require deeper and more critical thinking. Through HOTS-based LKPD, students are expected to be more engaged in challenging learning activities and improve their ability to solve problems effectively (Fitriyah et al., 2020; Kahar et al., 2021).

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The integration of HOTS-based student worksheets (LKPD) into the learning process is expected to not only improve the quality of instruction but also directly correlate positively with student learning outcomes. When students are accustomed to analyzing information, evaluating arguments, and creating solutions, their conceptual understanding will be deeper and more lasting (Firdiana et al., 2023; Salsabila & Tambunan, 2022). This contrasts with rote learning, which tends to be easily forgotten. Furthermore, the active process required by HOTS-based LKPD will automatically increase student engagement, transforming them from passive recipients into active participants responsible for their own learning (Noviati et al., 2022; Puspita, 2020).. The implications of using HOTS-based student worksheets (LKPD) are far-reaching. From a pedagogical perspective, this approach will encourage teachers to shift their role from being primarily information providers to facilitators and motivators. Teachers will be required to design more interactive and challenging learning scenarios and provide constructive feedback to develop students' critical thinking skills (Khotimah & Ahmadi, 2022; Numa et al., 2023; Suarni, 2022).. Practically, this worksheet provides clear guidance for students to master the subject matter while honing higher-order thinking skills, making learning more meaningful and relevant to future needs. This worksheet is designed to increase student engagement and motivation in the learning process and support the development of their higher-order thinking skills (Kahar et al., 2021).

Therefore, this study aims to determine the effect of using HOTS-based student worksheets (LKPD) on student learning outcomes and activities. Using a quantitative approach, this study will analyze the extent to which the implementation of this innovative LKPD can improve students' academic achievement and encourage their active participation in learning. The results of this study are expected to make a significant contribution to the development of effective and sustainable learning practices and serve as a basis for more progressive education policies in realizing deep learning in Indonesia.

METHOD

This study will employ a quantitative approach with a quasi-experimental design with a non-equivalent control group (Abraham & Supriyati, 2022). This design was chosen based on practical considerations in the field, where perfect randomization of subjects is often impossible, but it still allows for comparison of existing experimental and control groups (Arib et al., 2024; Sugiyono, 2019). This design is considered relevant for testing the effectiveness of the intervention (the use of HOTS-based worksheets) on the dependent variables (student learning outcomes and activities) by minimizing bias and increasing the study's internal validity.

The population in this study is all grade X students at Madrasah Aliyah Mannilingi, Jeneponto Regency, South Sulawesi, in the 2024/2025 academic year. This population was determined based on the consideration that grade XI students are at the early stage of learning at the senior high school level, where adaptation to new learning methods and the development of higher-order thinking skills are very important. The sampling method that will be used is purposive sampling with criteria including (1) schools that have implemented the Independent Curriculum, (2) classes with relatively homogeneous characteristics in terms of students' initial abilities (based on the average grades in relevant subjects from the previous semester), and (3) adequate facilities to implement the intervention. From this population, two classes will be selected as research samples, one class as an experimental group that will be taught using HOTS-based LKPD, and one class as a control group that will be taught using conventional LKPD commonly used by teachers. The number of students in each group will be balanced to ensure the validity of the comparison.

Data in this study will be collected using several instruments that have been tested for validity and reliability. The learning outcome test to measure student learning outcomes will use objective tests in the form of multiple-choice questions and/or essays that have been validated by subject matter experts and evaluation experts (Prasetyo & Anitra, 2020). The test questions will be designed to measure students' cognitive abilities at the HOTS (analysis, evaluation, and creation) level according to the subject competency achievement indicators (Choirunnisa & Pahlevi, 2021; Sahlan et al., 2020). The test will be administered in the form of a

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pre-test before the intervention begins and a post-test after the intervention is completed in both groups (experimental and control). Student Activity Observation Sheet: To measure student activity during the learning process, a structured observation sheet will be used. This observation sheet will include a list of student activity indicators that reflect active engagement, discussion, collaboration, and problem-solving (e.g., asking questions, providing ideas, participating in groups, and presenting results) (Facione, 2015). Observations will be conducted by two independent observers (observer reliability) throughout the learning process at several meetings, in both the experimental and control groups, to minimize bias. A student response questionnaire will be used as supporting data to explore students' perceptions of the use of HOTS-based worksheets, their level of difficulty, and their perceived benefits in improving their understanding and thinking skills. This questionnaire uses a Likert scale and is administered at the end of the intervention only to the experimental group.

The collected data will be analyzed using inferential statistical techniques with the aid of statistical software (SPSS version 26). Before conducting the hypothesis testing, the pre-test and post-test data from both groups will be tested for normality using the Shapiro-Wilk test and for homogeneity of variance using the Levene test (Mann, 2010). This test is important to determine whether parametric assumptions are met or whether non-parametric tests are necessary (Arib et al., 2024; Asrin, 2022).. Next, a descriptive analysis will be conducted to provide an overview of the initial and final conditions of both groups. Then, an independent t-test will be conducted to test for significant differences between the average learning outcomes of the experimental and control groups after the intervention. A pre-test comparison between the two groups will also be conducted to ensure that both groups are relatively equal before the intervention. The N-Gain Score test will be conducted to measure the effectiveness of using HOTS-based LKPD in improving learning outcomes, and an N-Gain score will be calculated for each group. According to Meltzer (2002) The N-Gain Score will indicate the level of improvement in learning outcomes after the intervention, which will then be compared between the experimental and control groups. Observational data on student activity, which tends to be ordinal or interval in nature, will be analyzed using the Mann-Whitney Test to compare the average differences in activity between the experimental and control groups.

RESULTS AND DISCUSSION

In parametric analysis, assumption testing is required as an absolute requirement in parametric statistical tests (Sedgwick, 2015). The normality test for parametric experimental and control class data is a method for determining whether the data is normally distributed or not. The normality test uses *Shapiro-Wilk* because the data is less than 50 for each class if the sig value > 0.05 the data is normally distributed (D'Agostino & Stephens, 1986; Hasmawaty et al., 2023).

Table 1 Pretest Normality Test for Experimental and Control Classes

	Statistic	df	Say.
Experimental Class Pretest	0,956	30	0,240
Control Class Pretest	0,956	30	0,248

The results of the normality test for the Experimental Class Pretest and the Control Class Pretest showed a Statistic value of 0.956 for both groups with df 30. The Sig. values for both groups were 0.240 for the Experimental Class and 0.248 for the Control Class, both of which were greater than 0.05. Based on these results, it can be concluded that the data in both groups were normally distributed, and therefore, parametric tests such as the t-test can be used for further analysis.

Table 2 Posttest Normality Test for Experimental and Control Classes

	Statistic	df	Say.
Experimental Class Pretest	0,948	30	0,146
Control Class Pretest	0,961	30	0,332

The results of the normality test for the Posttest of the Experimental Class and the Posttest of the Control Class showed a Statistic value of 0.948 for the Experimental Class and 0.961 for the Control Class, with df 30 in both groups. The Sig. value for the Experimental Class

was 0.146, and for the Control Class was 0.332, both greater than 0.05. It can be concluded that the data in both groups are normally distributed, which allows the use of parametric tests for further analysis.

To determine whether the variances in the two experimental and control groups were similar in improving HOTS learning outcomes, a homogeneity test was conducted on the pretest and posttest data (Sianturi, 2022). The homogeneity rule is determined based on the P value, where if sig. > 0.05 in Based on Mean, the data are considered to have the same variance (homogeneous). Conversely, if sig. < 0.05, the data do not have the same variance (Usman et al., 2023).

Table 3 Homogeneity Test of Experimental and Control Classes

Class			Levene Statistic	df1	df2	Say.
Experimental and Control Pretest	Based on		2,483	8	15	0,061
Experimental and Control Posttests	Mean		1,380	8	16	0,277

The homogeneity test results for the Experimental and Control Pretest showed a Levene Statistic value of 2.483 with df1 8 and df2 15, and a Sig. of 0.061. Since the Sig. value is greater than 0.05, this means that the variance between the two groups can be considered homogeneous. Meanwhile, in the Experimental and Control Posttest, the Levene Statistic value was 1.380 with df1 8 and df2 16, and a Sig. of 0.277. Since the Sig. value is also greater than 0.05, it can be concluded that the variance between the two groups in the posttest is also homogeneous. Thus, both pretest and posttest data have the same variance, which allows for the use of further parametric tests.

Table 4. Descriptive Data of Experimental and Control Classes

Item	Pretest		Postal	
	Control Class	Experimental Class	Control Class	Experimental Class
N	30	30	30	30
Mean	61,83	61,27	69,63	90,60
Std. Error of Mean	0,800	0,479	0,670	0,397
Median	61,50	61,00	70,00	91,00
Mode	59	61	70[a]	91
Std. Deviation	4,379	2,625	3,672	2,175
Variance	19,178	6,892	13,482	4,731
Range	17	11	13	9
Minimum	52	56	63	87
Maximum	69	67	76	96
Sum	1855	1838	2089	2718

In the pretest, both the Control and Experimental Classes showed nearly identical average scores, namely 61.83 for the Control Class and 61.27 for the Experimental Class. This indicates that both groups had comparable ability levels before the treatment, which is a good starting point for seeing differences after the treatment is implemented.

After the implementation of HOTS-based LKPD in the Experimental Class, there was a significant increase in the posttest, with an average score reaching 90.60, while the Control Class only obtained an average of 69.63. This much greater increase in the Experimental Class indicates that the use of HOTS-based LKPD has a positive impact on improving student learning outcomes, especially in terms of higher-order thinking skills.

This significant improvement was also seen in the standard deviation and variance, where the Experimental Class had lower scores on both the pretest (2.625 vs. 4.379) and posttest (2.175 vs. 3.672). This indicates that the Experimental Class data is more concentrated around

the mean, with smaller value variations, indicating that the HOTS-based LKPD treatment produced more uniform and homogeneous results among students.

Furthermore, the difference in median and mode between the Control and Experimental Classes in the posttest further clarifies the effect of using HOTS-based worksheets. The Experimental Class had a higher median and mode (91.00 and 91) compared to the Control Class (70.00 and 70). This indicates that most students in the Experimental Class achieved higher scores after using HOTS-based worksheets, with more centralized results.

Overall, the analysis results show that the Experimental Class given HOTS-based LKPD treatment showed a more significant increase in student learning outcomes and activities compared to the Control Class using conventional learning methods. The greater increase in the Experimental Class both in the average, value variation, and consistency of results, indicates that HOTS-based LKPD is more effective in improving students' learning outcomes and higher-order thinking skills.

Based on the research results, pretest and posttest scores were obtained from both research groups (experimental and control) before and after the intervention. Learning outcome data were obtained using a valid multiple-choice objective test. The test questions were designed to measure students' cognitive abilities at the HOTS level according to the subject competency achievement indicators.

Table 5. Results of Hypothesis Testing of the Use of HOTS-Based Student Worksheets on Student Learning Outcomes and Activities in the Experimental and Control Classes

Assessment Aspects	N	t_{count}	t_{table}	df	Say.	Conclusion
Student Learning Outcomes and Activities	60	26,909	1.671	58	0.00	Significant

Table 5 shows the results of the hypothesis test used to examine the effect of using HOTS-based Student Worksheets on student learning outcomes and activities in the experimental and control classes. From the results obtained, it can be seen that the calculated t-value of 26.909 is greater than the t-table of 1.671, with a significance value (Sig.) of 0.00, which is much smaller than the significance level usually used in research, which is 0.05. This indicates that the difference between the experimental and control classes is very statistically significant. Thus, it can be concluded that the application of HOTS-based Student Worksheets has a significant positive impact on student learning outcomes and activities, especially in the experimental class that uses the Student Worksheets. These findings indicate that HOTS-based learning methods can significantly improve the quality of learning and student activities compared to methods that do not use HOTS-based Student Worksheets.

The use of HOTS-based worksheets significantly improved the quality of student learning and activities, especially in the experimental class that implemented it. This method encourages students to develop higher-order thinking skills, such as analysis, synthesis, and problem-solving, making them more active and engaged in the learning process. Unlike the control group that used conventional methods, students in the experimental class not only memorized information but were also able to apply and evaluate their knowledge in more complex contexts, ultimately resulting in more significant improvements in their learning outcomes and activities.

In addition, student activity data was collected through observation sheets during the HOTS-based learning process. The average student activity scores for both groups are presented in the table.

Table 6 Student Activities

Group	N	Rate-rate	Std. Deviation	Category
Experimental	30	4,2	0,6	Very active
Control	30	2,8	0,5	Quite active

Table 6 shows the average student activity scores for both groups, the experimental and control groups, measured during the HOTS-based learning process. The experimental group

had an average activity score of 4.2 with a standard deviation of 0.6, indicating that students in this group were very active during learning and had a high level of participation. The relatively small standard deviation indicates that student activity in this group was quite consistent, with not too much variation between students. In contrast, the control group had an average activity score of 2.8 with a standard deviation of 0.5, indicating that students in this group had a lower level of activity and were only moderately active in the learning process. Although there was less variation among students in the control group, their level of participation was still lower than that of the experimental group, indicating that the use of HOTS-based learning contributed to a significant increase in student activity.

differences in student activity levels between the Experimental group using HOTS-based learning and the Control group using conventional methods. The Experimental group demonstrated a very high level of participation, with students actively engaged in discussions, lab work, and assignments that encouraged critical thinking and independent problem-solving. Student activity in this group tended to be consistent, indicating that most students actively contributed to the learning process. In contrast, the Control group demonstrated a lower level of participation, with students tending to be more passive and only engaging in basic tasks that did not require high-level thinking skills. These findings suggest that HOTS-based learning successfully created a more dynamic and participatory environment, encouraging students to be more engaged in the learning process compared to traditional learning methods.

To measure the effectiveness of improving learning outcomes, the N-Gain score calculation was used in both groups, Experimental and Control. N-Gain measures the extent of improvement in learning outcomes after the intervention, with normalization based on the maximum achievable score. By comparing changes before and after learning, N-Gain provides an objective picture of the effectiveness of HOTS-based learning. A higher N-Gain score indicates a more significant improvement, indicating that the HOTS method is more effective than conventional learning in improving student learning outcomes.

Table 7. N-Gain Score of Student Learning Outcomes

Group	N-Gain rate	Category
Experimental	0,74	High
Control	0,20	Low

Table 7 shows the N-Gain scores for student learning outcomes for both groups, the Experimental and Control. The Experimental group had an average N-Gain of 0.74, which is considered high. This indicates that students in the Experimental group experienced a significant improvement in their learning outcomes after participating in HOTS-based learning. This significant improvement indicates that the learning method applied was effective in improving students' understanding and skills. In contrast, the Control group only recorded an average N-Gain of 0.20, which is considered low. This score reflects a smaller improvement in student learning outcomes in the Control group, which used conventional learning methods. This significant difference between the two groups indicates that HOTS-based learning was more effective in improving student learning outcomes compared to the traditional methods used in the Control group. To compare the average student activity between the two groups, the Mann-Whitney U test was used, because the observed student activity data tended to be ordinal and did not always strictly meet the normality assumption.

Table 8. Mann-Whitney U Test Results (Student Activities)

Group	N	Average Rank	U value	p value
Experimental	30	45,6	152	0,001
Control	30	15,4		

The Mann-Whitney U test results in Table 8 show a U value of 152.0 with a p-value of 0.001. This means there is a very significant difference in the level of student activity between the Experimental and Control groups. Students who used HOTS-based LKPD showed a significantly higher level of activity compared to students who used conventional LKPD. A p-value smaller than 0.05 indicates that this difference in student activity did not occur by chance,

but was influenced by the application of HOTS-based learning in the Experimental group. Overall, these test results confirm the finding that HOTS-based learning is more effective in increasing student activity compared to traditional learning methods applied to the Control group.

The use of HOTS-based student worksheets (LKPD) not only improves learning outcomes but also significantly contributes to increased student engagement in the learning process. By integrating higher-order thinking skills, such as analysis, synthesis, and problem-solving, HOTS-based LKPD encourages students to think more actively and participate in discussions and tasks that require in-depth understanding. This increased student activity demonstrates that HOTS-based learning creates a more dynamic environment, where students not only receive information but also actively engage in constructing their own knowledge. This approach demonstrates that challenging learning and encouraging students to think critically can increase their motivation and participation, which in turn can improve the overall quality of learning.

DISCUSSION

The results of the study indicate that the implementation of HOTS (Higher Order Thinking Skills)-based LKPD has a significant impact on improving student learning outcomes, especially in improving higher-order thinking skills. This can be seen from the results of the comparison between the Control Class and the Experimental Class before and after treatment. Although both groups had almost similar initial abilities, the Experimental Class that used HOTS-based LKPD experienced a significantly greater increase in the posttest, both in average scores, consistency of results, and reduction in value variation among students. This increase indicates that HOTS-based LKPD is able to encourage students to think more critically and analytically, so that they can develop better higher-order thinking skills, which is reflected in higher and more uniform test results.

The implementation of Student Worksheets (LKPD) based on Higher Order Thinking Skills (HOTS) has shown a significant impact on improving student learning outcomes, as seen in the comparison between the Control Class and the Experimental Class. Research conducted by Hujjatusnaini et al. (2022) shows that the integration of HOTS-based learning can improve higher-order thinking skills in prospective teachers in the context of science learning. Furthermore, research by Ariansyah et al. (2021) reveals the importance of changes in teaching strategies that focus on exploration and inquiry-based learning as a way to improve the quality of education, which is in line with HOTS learning principles.

In the context of HOTS-based student worksheets (LKPD), the posttest results of the Experimental Class showed significantly greater improvement compared to the Control Class. Research by Abdullah et al. indicates that the use of active learning tools, such as smartboards, contributes to improving students' higher-order thinking skills in data handling, which is relevant to the use of HOTS-based student worksheets that facilitate active student engagement (Abdullah et al., 2020). This explains that the observed improvements in the Experimental Class include consistency of results and reduced grade variation among students. The implementation of HOTS-based student worksheets provides students with a broader source of information, which serves to delve deeper into the material being taught. Kosasih et al. show that teacher awareness of the importance of learning reform significantly influences improvements in the quality of education (Kosasih et al., 2022).

Cognitively, the application of HOTS in education trains students not only to memorize facts but also to think critically and analytically in various situations, as stated by Hoerudin, who emphasized the importance of improving analytical thinking skills through HOTS-based learning (Hoerudin, 2023). Another dimension of HOTS learning is the integration of computational thinking, which can increase student motivation and engagement in the learning process, as stated (Wu et al., 2025). The emphasis on exploration and inquiry-based learning is also related to different pedagogical approaches, as explained by Mustaffa et al., who emphasized the need for diversifying teaching methods to suit student diversity (Mustaffa et al., 2021).

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Research by Syafryadin et al. (2021) and Maryani et al. (2022) shows that classroom interactions focused on HOTS not only contribute to student motivation but also lead to significant improvements in higher-order thinking skills. Innovative learning specifically designed to stimulate higher-order thinking skills is now an urgent need, especially in modern education, which prioritizes 21st-century skills (Zainil et al., 2022).

Various research findings support the argument that HOTS-based student worksheets (LKPD) significantly encourage students to think more critically and analytically, resulting in deeper understanding and improved higher-order thinking skills, which are reflected in higher and more consistent learning outcomes. Further research in this area could examine how other models and strategies can further enhance HOTS achievement across various educational settings. A problem-based approach in biochemistry learning can encourage students to use additional resources effectively, which is also an indicator of improved higher-order thinking skills (Wikanta & Susilo, 2022).

The implementation of Student Worksheets (LKPD) based on Higher Order Thinking Skills (HOTS) has a significant impact on improving student learning outcomes at various levels of education. Research shows that learning strategies that prioritize HOTS can improve students' critical, analytical, and creative thinking skills, thus contributing to better academic achievement. The results of this study indicate that the use of HOTS-based worksheets has a positive impact on student learning outcomes and increases student activity during the learning process. Data analysis found that students who used HOTS-based worksheets showed significant improvements in critical, analytical, and creative thinking skills (Latifah et al., 2023; Ramadhan et al., 2020). They were able to analyze information more deeply, construct arguments more structuredly, and apply learned concepts in more complex situations (Widyawati & Sujatmika, 2020). This proves that HOTS-based worksheets can encourage students to think critically and develop the skills needed to solve problems innovatively.

Furthermore, this study also found that student activity in class increased after implementing HOTS-based worksheets (Ramadhan et al., 2020). These activities included student participation in group discussions, collaboration in problem-solving, and active involvement in exploring learning materials. Students given HOTS-based worksheets tended to be more engaged in learning because they felt the challenges stimulated their interest and curiosity (Nuniati et al., 2021). These activities are important indicators of effective and in-depth learning, which in turn contributed to improved student learning outcomes.

The use of HOTS-based worksheets (LKPD) has been shown to improve student learning outcomes. For example, research using the 7E Learning Cycle model showed a significant increase in students' HOTS skills (Fitriyah et al., 2020). Other research in the Informatics Engineering program also showed that the use of HOTS-based worksheets positively impacted learning outcomes and increased student motivation (Kahar et al., 2021). Furthermore, a HOTS-based learning tool oriented toward Realistic Mathematics Education (RME) showed an 85% increase in students' HOTS skills in the experimental group, compared to 56% in the control group (Dhoruri & Retnowati, 2025). These findings suggest that HOTS-focused learning not only improves students' cognitive abilities but also contributes to better learning outcomes.

HOTS-based student worksheets also play a significant role in enhancing student engagement in the classroom. For example, the use of the PDEODE model supported by PhET simulations on solubility equilibrium resulted in very high levels of student engagement, with an average engagement rate of 93% (Widyastuti et al., 2019). The integration of digital tools and active learning strategies, such as problem-based learning (PBL) and inductive reasoning, has been shown to increase student engagement and critical thinking skills (Abildinova et al., 2025; Misrom et al., 2020). By engaging students in a more active learning process, HOTS-based student worksheets motivate them to ask more questions, discuss more, and implement research-based decisions, which in turn strengthens their theoretical understanding.

The importance of HOTS-based classroom interactions for increasing student motivation and engagement, which contributes to better learning outcomes (Syafryadin et al., 2021). The use of student worksheets designed to encourage students to process information

and collaborate has also proven effective, as discussed in a study by Komala et al. (Komala et al., 2020) that examined the effectiveness of the group investigation model in environmental learning.

Innovative learning can improve students' HOTS achievement, encompassing a variety of methods known to be effective in the student's context (Saepuzaman et al., 2021). Furthermore, research by Takko et al. (2020) found that learning modules that adhere to cooperative learning principles significantly improve students' higher-order thinking skills in household subjects. The implementation of HOTS-based student worksheets (LKPD) has a significant positive impact on improving student learning outcomes by prioritizing critical, analytical, and creative thinking skills, as well as encouraging active student participation in the teaching and learning process. By integrating technology with student worksheets and AI-based learning media applications, students will be better able to analyze, evaluate, and create new understandings of the topics being studied (Kofahi & Husain, 2025).

However, despite significant improvements in student learning outcomes and activities, this study also found that not all students were able to fully utilize HOTS-based worksheets. Some students still experienced difficulty adapting to questions requiring higher-order thinking skills (Azizah et al., 2023; Lestari et al., 2023). This suggests that while HOTS-based worksheets have the potential to improve learning quality, their implementation must take into account the differences in abilities and readiness of each student. Therefore, it is important for teachers to provide more intensive guidance and allow students space to gradually develop higher-order thinking skills.

The implications of this research are highly relevant in the context of education in Indonesia, particularly in efforts to create more in-depth learning that is relevant to the needs of the 21st century. First, the results of this study indicate that the implementation of HOTS-based worksheets can help improve students' critical thinking skills, which are essential in facing increasingly complex global challenges (Sari et al., 2022). Active learning methods, such as project-based learning and discussions, can stimulate students to engage more deeply in the subject matter and improve their analytical skills (Blegur et al., 2023). Therefore, the development and implementation of HOTS-based worksheets should be an integral part of the learning process in Indonesian schools. Second, another implication is the importance of increasing student engagement in the learning process. Higher student activity can create a more dynamic learning environment, increase student motivation, and strengthen deeper conceptual understanding. Teachers need to design HOTS-based worksheets that not only focus on theory and concepts but also provide opportunities for students to collaborate, discuss, and solve problems together. By adopting methods that encourage exploration and problem-solving, students can learn to think critically in real-world contexts (Rahmi & Azrul, 2022). This can enrich students' learning experiences and better prepare them to face challenges. Furthermore, this research provides practical implications for teachers in developing and using HOTS-based worksheets more effectively. Teachers need to ensure that the questions in the worksheets not only test factual knowledge but also challenge students to think critically, analyze, and generate creative solutions. Therefore, training teachers in designing appropriate HOTS-based worksheets is crucial to optimally achieve learning objectives.

CONCLUSION

Based on the results of the research conducted, it can be concluded that the use of HOTS-based worksheets has a significant positive impact on student learning outcomes and activities. Students who use HOTS-based worksheets show improvements in higher-order thinking skills, such as critical, analytical, and creative thinking, which helps them understand the material more deeply and apply it in complex situations. In addition, student learning activities also increase, as seen from their involvement in discussions, collaboration, and exploration of the material, which are important factors in creating a more dynamic and effective learning process. However, the results of this study also show that not all students can utilize HOTS-based worksheets optimally. Some students still have difficulty adapting to questions that require higher-order thinking skills. Therefore, more intensive support from teachers is needed to help

students develop these thinking skills gradually. The implications of this study suggest that the implementation of HOTS-based worksheets can be an effective tool in improving the quality of learning, especially in developing students' critical thinking skills. Therefore, teachers need to design worksheets that not only focus on mastering knowledge but also encourage students to be actively involved in the learning process.

THANK-YOU NOTE

AUTHOR CONTRIBUTION STATEMENT

This research is a collaborative effort between several individuals, with each author making significant contributions at various stages. AFS conceived the research idea, designed the experimental methodology, and was solely responsible for the data analysis. LT actively participated in the development of the research instruments, assisted with data collection in the field, and provided crucial input in the discussion of the interpretation of the results and the refinement of the manuscript. He also participated in the final revision and editing of the article.

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