JPPIPA 10(12) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Optimizing Discovery Learning to Enhance HOTS: Why Use Argumentative Worksheets?

Neni Hasnunidah[1*], Endri Dwiyanti[1], Berti Yolida[1], Nadya Meriza[1], Dina Maulina[1]

[1] Biology Education Program, University of Lampung, Bandar Lampung, Indonesia.

Received: August 15, 2024
Revised: October 12, 2024
Accepted: December 25, 2024
Published: December 31, 2024

Corresponding Author:
Neni Hasnunidah
neni.hasnunidah@fkip.unila.ac.id

DOI: 10.29303/jppipa.v10i12.9412

Abstract: Higher Order Thinking Skills (HOTS) is very important for learners to master because they can develop the critical, analytical, and creative thinking skills needed to face complex challenges in daily life This study aims to examine the HOTS of students on the use of the Argumentative LiveWorksheet of Plant Tissue Structure through the Discovery Learning model. This type of research is a quasi-experiment using a pretest-posttest non-equivalent control group design. The subject of this study is 60 students of grade VIII of junior high school in Metro City which are divided into experimental classes and control classes. The research instrument is in the form of a HOTS essay test that measures the ability to analyze (C4), evaluate (C5), and create (C6) according to Bloom's taxonomy. In addition, questionnaire instruments are also used to find out students' responses to the learning carried out. The results showed that the experimental group that used the LiveWorksheet argumentative with the Discovery Learning model had a significantly higher HOTS score when compared to the control group. The argumentative LiveWorksheets with Discovery Learning creates a more dynamic learning environment by encouraging active student involvement in discussions, arguments, discovery, and reflective practices.

Keywords: Argumentative; Discovery learning; HOTS; LiveWorksheet

Introduction

The paradigm of science education in the 21st century includes developing skills oriented to Higher Order Thinking Skills (HOTS) in learning (Kwangmuang et al., 2021; Sepriyanti et al., 2022; Jihannita et al., 2023). HOTS is very important for learners to master because they can develop the critical, analytical, and creative thinking skills needed to face complex challenges in daily life (Hadiati et al., 2023; Karuru et al., 2023; Laksana et al., 2024; Lee et al., 2024). HOTS also encourages students to understand concepts more deeply, not just memorize information (Lu et al., 2021; Antonio & Prudente, 2023; Putri et al., 2023). It helps them in connecting concepts and applying them in various contexts (Ibrahim et al., 2024). Furthermore, HOTS involves the ability to critically evaluate information and develop new ideas (Misrom et al., 2020; Nadia et al., 2023). This is important in an increasingly complex world where innovation and adaptation are urgently needed.

Results of the study PISA in 2018 which was released in 2019 is one of the references to measure HOTS. The study showed that Indonesian students obtained an average score of 396 from the average score PISA 489 in science (Totok, 2019). According to the survey results TIMSS In 2015, Indonesian students were ranked 44th out of 49 countries in terms of science skills (Lestari & Widodo, 2021). From these results, it indicates that HOTS Students are still relatively low. This is in line with the results of the UN in 2018 which shows that students are still weak in HOTS such as reasoning, analyzing, and evaluating (Ariyana et al., 2018). The low HOTS of students is also experienced by junior high school students in Metro City, Lampung Province, Indonesia they are less able to connect, manipulate, and

How to Cite:
Hasnunidah, N., Fadhila, S., Yolida, B., Nadya, M., & Maulina, D. (2024). Optimizing Discovery Learning to Enhance HOTS: Why Use Argumentative Worksheets?. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10348–10358. https://doi.org/10.29303/jppipa.v10i12.9412

change the knowledge and experience they already have critically and creatively in making decisions to solve problems in a new situation. As a result, they are unable to come up with ideas or ideas concretely, are unable to argue to construct explanations with reasonable reasons and are unable to solve problems creatively.

HOTS Low learners are caused by several factors. First, it is caused by low-level thinking habits or LOTS taught to students. If the learning method places more emphasis on memorization or factual knowledge, students may be less trained to think critically, analyze, or solve complex problems. Should HOTS are also accustomed to solving problems creatively, and innovatively (Rochman & Hartoyo, 2018; Suherman et al., 2020; Wahyudi et al., 2022; Ali & Zaini, 2023). Second, students are not trained in completing tests or questions that require analysis, evaluation, and creativity (Ichsan et al., 2020; Widana, 2020; Hidayatullah et al., 2022). If the evaluations and exercises provided are mostly low-level questions (memorization or basic understanding), students are not used to higher thinking challenges, such as analysis, synthesis, and evaluation (Istiyono et al., 2020). Third, students are rarely involved in open discussions or collaborate on collaborative projects that integrates real-world problem (Hikmawati et al., 2021; Jacinda et al., 2024). Thus, students are not motivated or feel that there is no relevance between lessons and daily life, they may not be interested in thinking more deeply.

Serious efforts are needed to improve students' HOTS through science learning (Fauziah & Sukmawati, 2023; Rahmawati et al., 2023; Purwanti et al., 2023; Suhartini et al., 2023; Zulhelmi et al., 2023) One of the main objectives of science learning is that students must know scientific explanations of natural phenomena and use arguments to solve problems (Hasnunidah, 2020). HOTS has a close relationship with argumentation because the argumentation process requires high-level thinking skills. Nature builds an argument, one needs to analyze information, facts, and evidence. Analytical skills are one of the components of HOTS, where students must be able to identify important parts of a problem or idea and understand the relationships between those elements. Then, good arguments require a critical evaluation of different evidences and opinions. Evaluation is one aspect of HOTS that requires students to assess the validity of arguments, consider various points of view, and evaluate the appropriateness and strength of the evidence used. Furthermore, forming a logical and coherent argument involves synthesis, which is the ability to combine ideas from various sources into a single view or a complete argument. This is a high-level thinking ability that requires creativity and innovation in assembling ideas.

One of the efforts that can be made to improve HOTS Students through the empowerment of argumentation in science learning are through Discovery Learning. Discovery Learning encourage students to learn in a critical way of thinking, self-discovering new information and skills (Watson & Galser, 2012). With Discovery Learning Students can carry out problem formulation activities, preparation and proof of provisional answers, conclusion formulation, and conclusion (Maysara et al., 2023). In this case, argumentation helps them structure, evaluate, and question their own thoughts as well as those of others. Students are trained to make logical, clear, and evidence-based arguments, which deepen their understanding of the subject matter. Overall, argumentation is an integral part of Discovery Learning because it supports the formation of knowledge through dialogue, critical discussion, and testing of new ideas (Osborne et al., 2004; Sampson & Clark, 2008). Students can use argumentation to reflect on what they have learned. By presenting their arguments, students evaluate the extent to which they understand the material and whether their findings are truly logically and factually acceptable. However, there is a risk of misunderstandings or conceptual errors if students fail to find the correct answer. Therefore, interactive argumentative worksheets are needed in the use of Discovery Learning, where educators can guide, evaluate and advise on arguments made by students.

Learn about science, especially the structure of plant tissues by Discovery Learning can improve HOTS if you use an interactive and visual method. Limitations of technology utilization in the model Discovery Learning It can be seen from the fact that although this model has been widely applied in various science learning, only a few interactive Student Worksheets are used (Febrianti et al., 2022; Niswah & Dewi, 2024; Noviana et al., 2024). Therefore, researchers are interested in using electronic LiveWorksheet. LiveWorksheet be platform in the form of a website that provides services to educators to develop student worksheet to be interactive online (Hasnunidah et al., 2023; Ha Le & Prabjandee, 2023). This worksheet can be filled out digitally, educators can display simple plant tissue images and diagrams with different colors for each tissue so that it can help students understand the function and position of each tissue. Then, LiveWorksheet can provide more interesting and dynamic exercises in the form of cases, for example about how plant tissues adapt to their environment. Thus, students can argue in it online so that this can encourage students' activeness in learning and provide them with convenience (Prastika & Masniladevi, 2021). Furthermore, educators can correct students' answers

and then give suggestions on their arguments through the comment column feature in it. Thus, Students can interact with the material directly and also get feedback directly from educators. This will help students to deepen their understanding of concepts and increase their motivation to learn (Boaler et al., 2022).

Research on the use of Discovery Learning-integrated Liveworksheet argumentative has never been found in current research. Therefore, the researcher considers it necessary to conduct related research. This study aims to investigate the effectiveness of using argumentative LiveWorksheets with the Discovery Learning model in improving the HOTS of junior high school grade VII students on plant tissue structure material. This study seeks to answer the following research questions: (1) What is the effect of the use of argumentative LiveWorksheets on students' HOTS compared to learning with the Discovery Learning model without the worksheet?; (2) Which HOTS indicator increased most significantly in the use of LiveWorksheets argumentative with the Discovery Learning model?

Method

This study is a quasi-experiment with pretest-posttest non-equivalent control group design to investigate the effect of LiveWorksheet argumentative on students' HOTS. A total of 60 junior high school students in Metro City were used as research subjects. This research started from an educator survey to identify problems, determine the population and sample. Furthermore, experiments were carried out in class VIII A (n=30) as the experimental group and class VIII C (n=30) as the control group. The argumentative LiveWorksheets used includes various activities and instructions designed to guide students through the modified Discovery Learning model syntax from the Ministry of Education and Culture (2013) as shown in Table 1. In the data verification syntax, there is a preparation of the Toulmin Argumentation Pattern (TAP) argumentation scheme as shown in Figure 1. The expected learning outcomes are that students are able to analyze the relationship between plant tissue structure and its function, as well as technology inspired by plant structure. In this study, students were divided into 6 groups with different task topics, namely: roots, stems, leaves, flowers, fruits, and seeds.

Table 1. Syntax of Discovery Learning Model with Argumentative Liveworksheets (Kemendikbud, 2013)

Syntax	Information
Stimulation	Students are given questions that arouse their curiosity. Teachers provide initial stimuli to motivate them to seek answers and solutions.
Problem statement	Students are invited to formulate research problems or questions based on the situation or case presented. This helps them determine the direction of exploration.
Data Collection	Students conduct exploration to collect relevant data or information by reading literature, observing objects, interviewing sources, conducting their own experiments and others.
Data Processing	The data that has been collected is processed and analyzed. In this phase, students try to find patterns or relationships in the information they get. This relationship is arranged in the form of an argumentation scheme containing claims, data, warrants, and backing.
Verification	Students check whether the results are consistent with existing data or with relevant theories.
Generalization	The last stage is the process of drawing conclusions that can be used as general principles and apply to all the same events or problems, taking into account the results of verification. Based on the results of the verification, the principles underlying the generalization are formulated

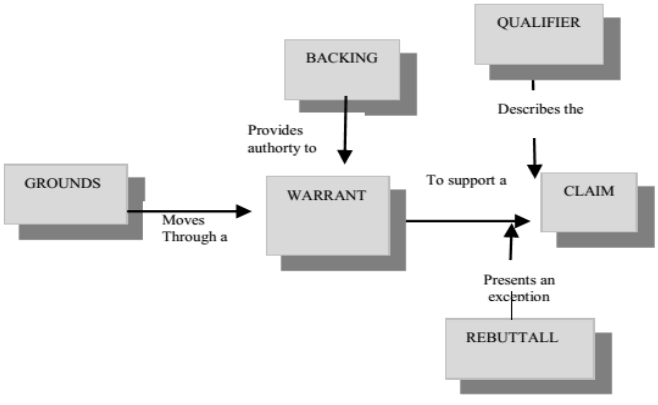

Figure 1. Toulmin argumentation pattern (TAP) (Toulmin, 2003)

Data collection was carried out using research instruments in the form of pretest and posttest questions, as well as response questionnaires. This test in the form of an essay is used to measure students' HOTS on plant tissue structure material. The HOTS question rubric in this study has a score interval of 0-1. Score 1 if the answer is correct and the reason is correct. Score 0 if the answer is incorrect or does not answer. The development of the rubric prioritizes answers regarding declarative and conceptual knowledge. In this case, the test demands answers that can demonstrate the ability to analyze, evaluate, and create based on aspects of Bloom's cognitive domain (Anderson & Krathwohl, 2001) as shown in Table 2. Before the test is used, a

validity and reliability analysis is first carried out to ensure the quality of the test after it is developed. The validity of the question item is calculated by the product moment correlation formula with if the p value < 0.05 then the question item is said to be valid, on the other hand, if p > 0.05 then the question item is said to be invalid. The reliability of the test questions is calculated with the Alpha Cronbach formula, then the value is compared with the table. If the count is > r table, then the test instrument can be said to be reliable, on the other hand, if the count < r table, then the test instrument is not reliable.

Table 2. HOTS Indicator by Bloom's Cognitive Level (Anderson & Krathwohl, 2001)

Process Category	Cognitive Process	Description
Analyzing: Breaking down matter into its constituent parts, determining how the parts relate to each other and to construct an overall structure or purpose	Differenting	Distinguish irrelevant parts from relevant or unimportant parts of a material.
	Organizing	Determine how elements fit or function within the structure.
	Attributing	Determining the viewpoints, biases, values or intentions underlying a material
Evaluating: Make assessments based on criteria and standards	Checking	Detecting inconsistencies of errors in processes or products; determining whether a process or product has internal consistency; detect the effectiveness of a procedure.
	Critiquing	Detecting inconsistencies between products and external criteria; determine whether a product has external consistency; detect the suitability of procedures for a given problem.
Creating: Placing elements together to form a coherent/functional whole; Reorganization of elements into new patterns or structures	Generating	Building a hypothesis based on criteria
	Planning	Designing procedures to complete multiple tasks
	Producing	Creating products

After the posttest was carried out, students were given a questionnaire responding to learning. This questionnaire contains statements aimed at capturing students' attitudes towards learning with the LiveWorksheet argumentative through the Discovery Learning model. The statements in the questionnaire are made in a structured manner with a Likert scale, each student is asked to answer the questions by marking a checklist (√) on the statement that matches the answer choice Yes or No. The question aspects in the questionnaire concern the quality of the worksheet, high-level thinking skills, students' interests, and argumentation skills.

Analysis of the data of the students' pretest and HOTS postest results was carried out sequentially by calculating the N-gain value, testing the normality and homogeneity of the data, and conducting an independent sample t-test. N-gain is a measure used to evaluate the improvement of understanding or learning outcomes before and after learning. N-gain measures how much of the increase is relative to the maximum possible increase. The N-Gain value is calculated using the Hake formula (1999), then interpreted based on the criteria of Meltzer et al. (2002), namely: High (N-gain ≥ 0.7); Medium (0.3 ≤ N-gain < 0.7); Low (N-gain < 0.3). Furthermore, the N-gain data obtained was tested for normality and homogeneity as a prerequisite for an independent sample t-test. The normality test used the One Sample Kolmogorov-Smirnov Test, while the homogeneity test used the Levene Test of Equality of Error Variances. In the end, the hypothesis was tested by an independent sample t-test on N-gain data with a real level of 5%. The test criteria are that if Sig is > α then the hypothesis is accepted and if Sig is < α then the hypothesis is rejected.

Analysis of the student response questionnaire data is in the form of qualitative descriptive analysis in the form of percentages. The steps taken are: 1) Counting the number of "yes" and "no" answers filled in by respondents. Each indicator in the yes answer is given a score of 1 and if it is not given a score of 0; 2) The determination of student responses is made in the form of a percentage based on the frequency of the answers; 3) Furthermore, the results of the percentage data are summarized in written form, with the following categories: all disagree (P = 0%), a small part agree (0% < P < 25%), half agree (25% ≤ P < 50%), most agree (50% ≤ P < 75%), almost all agree (75% ≤ P< 100%) and all agree (100%).

Result and Discussion

Implementation of Discovery Learning with Argumentative LiveWorksheet

In this study, the learning steps used by students to master the basic competition analyzed the relationship between plant tissue structure and its function, as well as technologies inspired by plant structure including: stimulation, problem statement, data collection, data processing, verification, generalization. In the

stimulation syntax, students are faced with phenomena regarding the structure of plant tissues (roots, stems, leaves, flowers, fruits and seeds) as seen in Figure 3. The stimulation provided aims to provide stimulation or encouragement to trigger higher-level thinking activities such as analysis, evaluation, and creation. The result is that students can identify problems that arise through this phenomenon (Figure 2a). Problem identification is also closely related to higher-order thinking. Problem identification requires the ability to look at the problem from multiple perspectives, understand the root cause, and separate the relevant factors from the irrelevant (Dörner & Güss, 2022). This is a form of critical thinking. Furthermore, in identifying problems, learners must be able to thoroughly evaluate the data or situation to determine where the real problem lies. Based on the students' answers, it can be seen that after being given pictures and discourses containing an event about the roots of bamboo trees, they are able to find a well-formulated problem (Figure 2b).

Figure 2. a. Simulations given; b. Problem formulations prepared by students

After students know what problems will be solved, then in the data collection syntax they collect information in the form of networks contained in plants, network structures and their functions according to their respective groups. On the worksheet, educators provide reading sources for students to use in searching for appropriate information (Figure 3a). After students synthesize and evaluate the information, a number of data obtained are entered into the table that has been available on the LiveWorksheet (Figure 4b). Thinking at a higher level demands the ability to integrate information from multiple sources (Khoiriah & Jalmo, 2020). Good data collection allows individuals to compile and combine various pieces of information to form new conclusions or solutions. In this case, learners need analytical skills and critical thinking to ensure the data or facts collected are relevant to the problem at hand because incorrect or incomplete information can lead to wrong conclusions. In high-level thinking, one must be able to analyze information carefully, looking for relevant patterns, trends, and relationships (Alem, 2020).

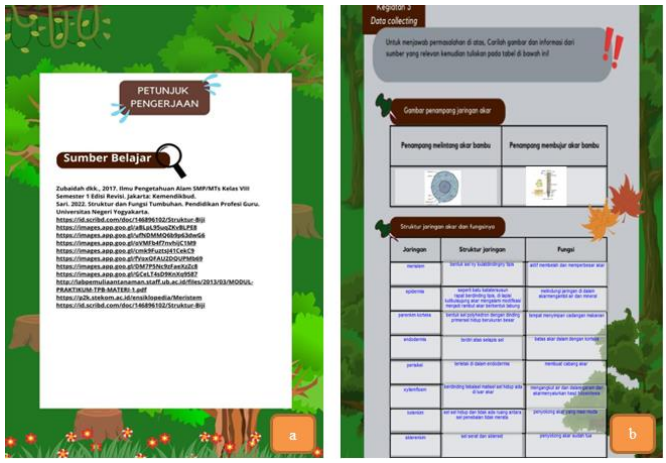

Figure 3. a. Learning resources provided by educators for students to search for information; b. Data that students have successfully collected in the data collection syntax

The next stage of Discovery Leaning in this study is the syntax of data processing. Through the LiveWorksheet, students process data by evaluating the quality of the data, verifying the validity of the source, and distinguishing relevant information from irrelevant information. An example of a student's answer in the LiveWorksheet argumentative worksheet is presented in Figure 4a. Here, students provide information about the main and only supporting root networks and how they play a role in absorbing water and nutrients from the soil. Thus, learners need analytical thinking skills to break down complex information into simpler parts, understand the relationships between data elements, and draw conclusions (Ningsih & Kamaludin, 2023).

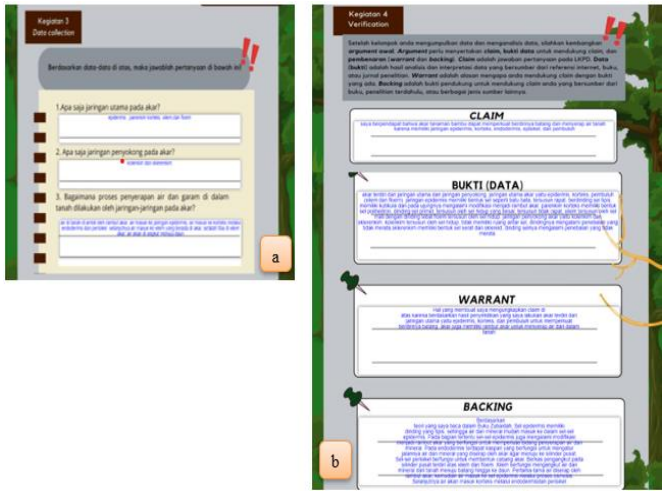

Figure 4. a. Students' answers to the syntax of data processing; b. Learners' arguments developed on the verification syntax

In the verification syntax, students compile arguments and write them in an argumentation scheme consisting of claims, data, warrants, and backing (Figure 4b). This is the characteristic of the argumentative worksheets in this study that are different from the Discovery Learning worksheets that are commonly used by other researchers. Through argumentation, students can support claims with appropriate evidence and reasoning. They make ideas, evidence, and reasoning seem to relate to each other, then test their ideas through discussions with friends or teachers, and defend their views based on strong evidence. Ultimately learners can receive feedback, improve their understanding, and form stronger arguments. Therefore, argumentation demands the use of HOTS because it requires the ability to analyze, evaluate, and create coherent and logic-based ideas in support or against an idea (Torregoza et al., 2024).

The last stage of Discovery Learning in this study is generalization. Students develop a conceptual understanding to reach a conclusion to answer the problem. An example of a student's answer in the LiveWorksheet argumentative worksheet at the generalization stage can be seen in Fig 5. In this answer, it can be seen that the conclusion that "the roots of bamboo plants can strengthen the establishment of the stem and absorb water from the soil because it has a network of epidermis, cortex, endodermis, and vessels" is the result of thinking highly. This is because learners can summarize concrete facts and see the broad implications or general concepts behind the phenomena they have investigated. This generalization becomes a tool for understanding the world in a more complex way (Kojiri & Yamada, 2020). High-level thinking, including critical thinking, involves the ability to evaluate the generalizations made. Is the generalization widely applicable? Are there any exceptions?

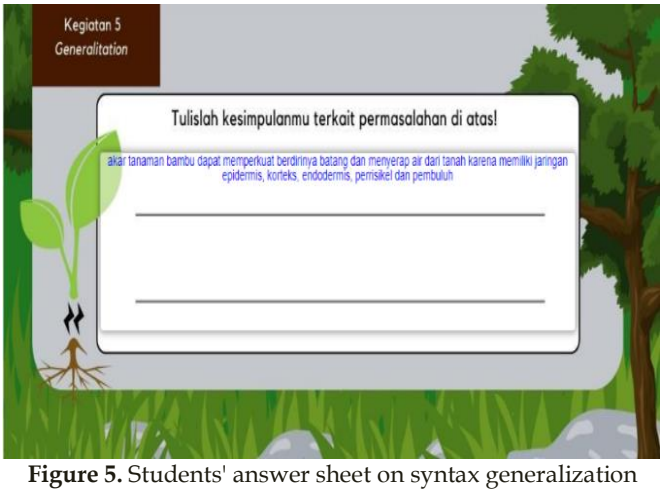

Figure 5. Students' answer sheet on syntax generalization

Students' HOTS Scores

This study produced data on the N-Gain HOTS scores of students who used the LiveWorksheet argumentative compared to the Discovery Learning model alone. The results of the study are shown in Table 2. Initially, the pretest values between both sample groups were categorized as low (= 26.00 & = 24.67). However, after the implementation of learning, the postes score obtained by the experimental group was categorized as good (= 69.33) while the control group was only categorized as sufficient (= 42.33). Thus, the HOTS scores of students increased more in the experimental group compared to the control group.

Table 3. N-Gain HOTS Scores of Students

Value	Class	Average± Sd	Category
Pretest	Experiment	26.00 ± 14.04	Less
	Control	24.67 ± 14.79	Less
Posttest	Experiment	69.33 ± 13.37	Good
	Control	42.33 ± 13.56	Enough
N-Gain	Experiment	0.56 ± 21.06	Moderate
	Control	0.20 ± 20.28	Low

Based on the average data of pretest and postest scores in each HOTS indicator, namely: analyzing (C4), evaluating (C5), and creating (C6) in Table 4, several different results were obtained. Students in the experimental group obtained higher pretest scores on the analyzing and evaluating indicators but obtained lower scores than the control group on the creating indicators. Then, the average postest scores of students in the experimental group in all indicators were higher than those in the control group. Thus, students in the experimental group experienced an increase in all three indicators, namely: analyzing and evaluating higher compared to the control group.

Table 4. Average Pretest-Postest Score on Each HOTS Indicator

HOTS Indicator	Class	Pretest	Posttest
Analyze (C4)	Experiment	38.33	74.17
	Control	31.67	47.50
Evaluate (C5)	Experiment	18.89	68.89
	Control	17.78	37.78
Create (C6)	Experiment	16.67	63.33
	Control	22.22	43.33

The Effect of the Use of Argumentative LiveWorksheet on HOTS

This study examines the effect of the use of argumentative worksheets on students' HOTS. The results of the influence test using an independent sample t-test along with prerequisite tests in the form of normality test and data homogeneity test are presented in Table 5.

Table 5. Prerequisite and Hypothesis Test Results

Class	N-Gain	Category	Normality Test	Homogeneity Test	Independent Sample T-Test
Experiment	0. 56	Keep	Sig. 0.09 > 0.05	Sig. 0.70 > 0.05	Sig. (2tailed) 0.00 < 0.05
Control	0. 20	Low	Sig. 0.13 > 0.05		

Based on Table 5, it can be seen that the N-Gain data of the experimental group and the control group are normally distributed (sig = 0.086 > 0.05; sig =) and have a homogeneous variance (sig = 0.66 >0.05). Then, the results of the independent sample t-test showed that there was a significant influence of the use of LiveWorksheet argumentative on the Discovery Learning model. The effect is categorized as large when viewed based on the results of the effect size test (ES=1.3) as seen in Table 6. With the average N-Gain value of the experimental group higher than that of the control group, the LiveWorksheet argumentative is effective in increasing the HOTS of students.

Table 6. Effect Size Test Results

Class	N-Gain Average ± Sd	Effect Size	Interpretation of effectiveness
Experiment	43.33 ± 21.06		Big
Control	17.66 ± 20.28	1.3	

Effective use argumentative LiveWorksheet in this study, as the results have shown above, it has been proven to have succeeded in overcoming the limitations of the model Discovery Learning in the use of technology. Especially on how educators are able to empower argumentation skills through digital worksheets to improve higher-order thinking skills. Students worksheet which is digitally packaged with various features that can be accessed by students makes the learning atmosphere more attractive so that students become more motivated and more active in the learning process. This is stated by students through the questionnaire given and the results can be seen in Table 7. In the table, it is known that almost all students agree that the use of argumentative worksheets LiveWorksheet It doesn't bore them because it looks attractive and makes them active in their opinions because it's easily accessible. At LiveWorksheet Students can work on assignments by typing, selecting answers, matching, or even filling in answers directly on online worksheets (Maharani & Hamid, 2024).

Table 7. Students Response

Statement	Percentage	Category
Attractive display	86.66	Almost everyone agrees
Easy to access	53.33	Most agree
Can train high-level thinking skills	90.00	Almost everyone agrees
Be able to cultivate new ideas to create solutions to problems	80.00	Almost everyone agrees
Facilitates problem analysis	90.0.	Almost everyone agrees
Makes it easier to understand the material	86.66	Almost everyone agrees
Doesn't bore me	83.33	Almost All Agree
Facilitate the process of positive interaction between students and students and students with educators	83.33	Almost everyone agrees
Making active in opinion	83.33	Almost everyone agrees
Makes it easier to conduct group discussions	86.66	Almost everyone agrees

Students also gave positive responses to the use of LiveWorksheet argumentative through the Discovery Learning model applied by the researcher, with almost all categories agreeing on the aspect of practicing higher-level thinking skills (Table 6). This is possible because the worksheet makes it easier for them to analyze the problem and grow new ideas to create solutions to the problem. Higher-order thinking involves the ability to see a problem from multiple perspectives (Al Aliyawinata et al., 2021). The analysis process involves breaking the problem into small elements to understand the relationships between parts, as well as identifying their causes and consequences. These include complex information evaluation, critical thinking, and the ability to draw conclusions based on evidence (Nursiamti et al., 2022).

Argumentative worksheets LiveWorksheet In this study, it is considered that students are easy to use for discussion so that there is a positive interaction between educators and students as well as between one student and another (Table 7). LiveWorksheets It is very useful in remote learning situations because it can be accessed from anywhere and at any time, facilitating interaction between teachers and students (Ha Le & Prabjandee, 2023). Then, teachers can monitor students' progress and see their work results in real time, allowing for more personalized and responsive teaching (Maysara et al., 2023). Next LiveWorksheets has an automatic scoring feature. After students complete the worksheet, the

system will provide an automatic score, saving teachers time in checking assignments (Faidah et al., 2023).

Use of argumentative LiveWorksheet This study has also provided great benefits to the empowerment of students' argumentative abilities so that they can improve their higher-level thinking skills. As stated by the students in the questionnaire (Table 7), they think that this worksheet makes them active in arguing or arguing. Argumentation has a close relationship with higher-order thinking (higher-order thinking). High-level thinking includes the ability to analyze, evaluate, and create new information or concepts, which involves some of the more complex cognitive skills compared to simply remembering or understanding information. The results of this study show that students who learn with the argumentative LiveWorksheet experienced a higher increase in analysis, evaluation, and creation skills compared to no such worksheet (Table 4). When arguing, one must be able to break down ideas or information into smaller pieces, explore the relationships between those parts, and critically examine the evidence or claims that support or reject an argument online (Hasnunidah et al., 2023). It involves the ability to think at a higher level in analyzing information in depth. Argumentation also requires individuals to judge the quality or validity of an argument. They must be able to evaluate strengths or weaknesses from a variety of points of view, evidence, and reasoning. This evaluation process is a key component of critical thinking, which is part of higher-order thinking. Furthermore, Higher-level thinking also includes the ability to combine information from different sources or viewpoints to create a strong and coherent argument. The synthesis of these ideas requires creativity and the ability to think to find new solutions or approaches that have not yet been considered.

Conclusion

Based on the results of the research and discussion, it can be concluded that the use of argumentative LiveWorksheets model Discovery Learning model is more effective in increasing students' HOTS compared to learning without the worksheet. In the experimental group, learning that combines the principles of argumentation in research can significantly improve the ability to analyze, evaluate, and create, with the most notable improvement being in the ability to evaluate. Meanwhile, in the control group, all HOTS indicators had lower values compared to the experimental group with the most notable improvement being the ability to analyze. The argumentative LiveWorksheets Discovery Learning model creates a more dynamic learning environment by encouraging active student involvement in discussions, arguments, experiments, and reflective practices. The significant improvement in higher-order thinking skills in the experimental group highlights the model's effectiveness in driving broader HOTS, demonstrating its potential as a powerful tool for improving thinking skills in educational settings.

Acknowledgments

On this occasion, the author would like to express his deepest gratitude to the parties who have provided assistance, guidance and support during the process of preparing this work. We extend our sincere gratitude to all the students, teachers, and schools who generously participated in this research. Their valuable contributions and cooperation were instrumental in the successful completion of this study.

Author Contributions

N. H.: conceptualized the research idea, research methods, and analyzed the data. E.D., B.Y., and D.M.: guided the review and editing authors, supervised and validated the instruments used in the research.

Funding

This research was funded by the 2024 DIPA FKIP grant.

Conflicts of Interest

The authors declare no conflict of interest

References

Al Aliyawinata, T. T., Utari, E., & Mahrawi, M. (2021). The Effect of Discovery Learning on Students' Higher-order Thinking Skills. *International Journal of Biology Education Towards Sustainable Development*, *1*(1), 1–9. https://doi.org/10.53889/ijbetsd.v1i1.47

Ali, L. U., & Zaini, M. (2023). Development of Interactive e-modules Based on Local Wisdom Using Android to Improve Students' Higher Order Thinking Skills (HOTS). *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10091–10100. https://doi.org/10.29303/jppipa.v9i11.4515

Antonio, R. P., & Prudente, M. S. (2023). Effects of Inquiry-Based Approaches on Students' Higher-Order Thinking Skills in Science: A Meta-Analysis. *International Journal of Education in Mathematics, Science and Technology*, *12*(1), 251–281. https://doi.org/10.46328/ijemst.3216

Ariyana, Y., Pudjiastuti, A., Bestary, R., & Zamroni. (2018). B*uku Pegangan Pembelajaran Berorientasi pada Keterampilan Berpikir Tingkat Tinggi*. Jakarta: Direktorat Jenderal Guru dan Tenaga Kependidikan.

Boaler, J., Brown, K., LaMar, T., Leshin, M., & Selbach-Allen, M. (2022). Infusing Mindset through Mathematical Problem Solving and Collaboration: Studying the Impact of a Short College

Intervention. *Education Sciences*, *12*(10). https://doi.org/10.3390/educsci12100694

Dermanis, A., Sansò, F., & Grün, A. (2007). An overview of data analysis methods in geomatics. *Geomatic Method for the Analysis of Data in the Earth Sciences*, *November*, 1–16. https://doi.org/10.1007/3-540-45597-3_1

Dörner, D., & Güss, C. D. (2022). Human error in complex problem solving and dynamic decision making: A taxonomy of 24 errors and a theory. *Computers in Human Behavior Reports*, *7*(July), 100222. https://doi.org/10.1016/j.chbr.2022.100222

Faidah, N. N., Hadiansah, Listiawati, M., & Yamin, I. M. (2023). Pengaruh Penggunaan Media Pembelajaran Liveworksheet Dalam Meningkatkan Hasil Belajar Kognitif Siswa Pada Materi Pemanasan Global. *Jurnal Kiprah Pendidikan*, *2*(2), 194–208. https://doi.org/10.33578/kpd.v2i2.182

Fauziah, N., & Sukmawati, W. (2023). Stacking Analysis of Higher Thinking Skills of Class V Elementary School Students on the Material of Movement Organs Using the RADEC Model. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5263–5270. https://doi.org/10.29303/jppipa.v9i7.3926

Febrianti, A. E., Mutmainna, A. S., Wulan, I., & Hadi, I. A. (2022). Efektivitas Penggunaan Media Liveworksheets dalam Model Pembelajaran Discovery Learning terhadap HOTS (High Order Thinking Skills) Peserta Didik SMP Negeri 6 Makassar pada Mata Pelajaran IPA The Effectiveness of Using Liveworksheets Media in the Discove. *Jurnal Sainsmat*, *XI*(2), 124–134. Retrieved from http://digilib.unila.ac.id/70379/

Ha Le, V. H., & Prabjandee, D. (2023). A Review of the Website Liveworksheets.com. *Call-Ej*, *24*(1), 269–279. Retrieved from https://old.callej.org/journal/24-1/Le-Prabjandee2023.pdf

Hadiati, S., Pramuda, A., & Matsun, M. (2023). Musschenbroek Learning Media with Arduino Based with Relay and Max6675 Sensor to Increase HOTS and Creativity. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1006–1011. https://doi.org/10.29303/jppipa.v9i3.2634

Hasnunidah, N., Rosidin, U., Rakhmawati, I., & Maulina, D. (2023). Students' Argumentation Skills towards Using Biology e-Worksheet based on ProjectArgumentative Learning Model. *Eurasian Journal of Educational Research*, *2023*(103), 341–361. https://doi.org/10.14689/ejer.2023.103.020

Hidayatullah, A. R., Yamtinah, S., & Masykuri, M. (2022). Development of A Two-Tier Multiple-Choice Instrument Based on Higher Order Thinking Skills (HOTS) on Acids, Bases, and Salts. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 932–938. https://doi.org/10.29303/jppipa.v8i2.1423

Hikmawati, H., Suastra, I. W., Suma, K., Sudiatmika, A. A. I. A. R., & Rohani, R. (2021). Effect of Problem-Based Learning Integrated Local Wisdom on Student Hots and Scientific Attitude. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 233–239. https://doi.org/10.29303/jppipa.v7ispecialissue.1118

Ibrahim, N. M., Sanjaya, Y., & Nurjhani, M. (2024). Effectiveness of Biology Learning to Improve Digital Literacy and Higher Order Thinking Skills on the Concept of Digestive System. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 7131–7137. https://doi.org/10.29303/jppipa.v10i9.5018

Ichsan, I. Z., Sigit, D. V., Miarsyah, M., Ali, A., Suwandi, T., & Titin. (2020). Implementation supplementary book of green consumerism: Improving students hots in environmental learning. *European Journal of Educational Research*, *9*(1), 227–237. https://doi.org/10.12973/eu-jer.9.1.227

Istiyono, E., Dwandaru, W. S. B., Setiawan, R., & Megawati, I. (2020). Developing of computerized adaptive testing to measure physics higher order thinking skills of senior high school students and its feasibility of use. *European Journal of Educational Research*, *9*(1), 91–101. https://doi.org/10.12973/eu-jer.9.1.91

Jacinda, A. A., Sriyati, S., & Solihat, R. (2024). Integration of Local Potential of Way Kambas National Park in Developing HOTS-Based Assessment Content in Biological Conservation Courses. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4623–4633. https://doi.org/10.29303/jppipa.v10i8.8364

Jihannita, J., Prasetyo, Z. K., & Wilujeng, I. (2023). How to Prepare HOTS to Face the 21st Century? *Jurnal Penelitian Pendidikan IPA*, *9*(8), 486–492. https://doi.org/10.29303/jppipa.v9i8.2847

Karuru, P., Muta'allim, Suparjo, Setiawan, A. F., & Junaida, S. J. (2023). Improving Students' Higher Order Thinking Skills Through a Question and Answer Method. *RETORIKA: Jurnal Ilmu Bahasa*, *9*(3), 340–349. Retrieved from https://ejournal.warmadewa.ac.id/index.php/jret

Khoiriah, & Jalmo, T. (2020). Student Worksheets Based On Discovery Learning Combined With Assessment For Learning Higher Order Thinking Skills (AfL HOTS) to Fostering High Level Thinking Skills Of Students. *Journal of New Horizons in Education*, *10*(1), 69–77. Retrieved from https://www.tojsat.net/journals/tojned/articles

/v10i01/v10i01-07.pdf

Kojiri, T., & Yamada, T. (2020). Generalization support environment for understanding ways to use English words. *Research and Practice in Technology Enhanced Learning*, *15*(1). https://doi.org/10.1186/s41039-020-00142-8

Kwangmuang, P., Jarutkamolpong, S., Sangboonraung, W., & Daungtod, S. (2021). The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools. *Heliyon*, *7*(6), e07309. https://doi.org/10.1016/j.heliyon.2021.e07309

Lee, H. Y., Chen, P. H., Wang, W. S., Huang, Y. M., & Wu, T. T. (2024). Empowering ChatGPT with guidance mechanism in blended learning: effect of self-regulated learning, higher-order thinking skills, and knowledge construction. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-024-00447-4

Lestari, H., & Widodo, A. (2021). Peranan Model Pembelajaran Nature of Sains Terhadap Peningkatan Pemahaman Sains Siswa Di Sekolah Dasar. *Jurnal Cakrawala Pendas*, *7*(1), 1–10. https://doi.org/10.31949/jcp.v7i1.2425

Lu, K., Yang, H. H., Shi, Y., & Wang, X. (2021). Examining the key influencing factors on college students' higher-order thinking skills in the smart classroom environment. *International Journal of Educational Technology in Higher Education*, *18*(1), 1–13. https://doi.org/10.1186/s41239-020-00238-7

Maharani, P., & Hamid, M. A. (2024). Development of E-Student Worksheet Based Task-Based Learning Through LiveWorksheets.com for High School Students. *AL-ISHLAH: Jurnal Pendidikan*, *16*(2), 1205–1217. https://doi.org/10.35445/alishlah.v16i2.5183

Maysara, M., Ariana, D., Saefuddin, S., Haetami, A., & Habiddin, H. (2023). Implementation of Live Worksheets Assisted Interactive Student Worksheets Based on Discovery Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7628–7637. https://doi.org/10.29303/jppipa.v9i9.4029

Misrom, N. S., Abdurrahman, M. S., Abdullah, A. H., Osman, S., Hamzah, M. H., & Fauzan, A. (2020). Enhancing students' higher-order thinking skills (HOTS) through an inductive reasoning strategy using geogebra. *International Journal of Emerging Technologies in Learning*, *15*(3), 156–179. https://doi.org/10.3991/ijet.v15i03.9839

Nadia, D. O., Solfema, S., Miaz, Y., & Ardipal, A. (2023). Effect of RADEC Learning Model on Student Learning Activities and HOTS on Science Learning in Elementary Schools. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 364–371. https://doi.org/10.29303/jppipa.v9ispecialissue.6702

Net, W. W. W. P., Ngurah, D., Laksana, L., Kua, M. Y., Sudatha, I. G. W., Qondias, D., & Dinatha, N. M. (2024). Higher Order Thinking Skill of Elementary Pupil wih Different Self Regulated in Learning using Printed and Electronic Learning Resources Based on Local Culture. *Pegem Journal of Education and Instruction*, *14*(2), 216–229. https://doi.org/10.47750/pegegog.14.02.26

Ningsih, N. R., & Kamaludin, A. (2023). Development of Higher Order Thinking Skills-Based Assessment Instrument on Acid-Base Materials in High School. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 13–19. https://doi.org/10.29303/jppipa.v9i1.1457

Niswah, P. U., & Dewi, N. R. (2024). Development of E-Worksheet with the TPACK Approach to Train Students' Digital Literacy and Higher Order Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3473–3485. https://doi.org/10.29303/jppipa.v10i6.4850

Noviana, I. V., Utami, W. S., & Widodo, B. S. (2024). Pengembangan E-LKPD Liveworksheets Berbasis Problem Based Learning pada Materi Perairan Darat. *Journal of Education Research*, *5*(3), 3902–3912. https://doi.org/10.37985/jer.v5i3.1518

Prastika, Y., & Masniladevi. (2021). Pengembangan E-LKPD Interaktif Segi Banyak Beraturan Dan Tidak Beraturan Berbasis Liveworksheets Terhadap Hasil Belajar Peserta Didik Kelas IV Sekolah Dasar. *Journal of Basic Education Studies*, *4*(1), 2601–2614. Retrieved from https://www.tracer.binahusada.ac.id/

Purwanti, D., Jalmo, T., Abdurrahman, A., & Diawati, C. (2023). Exploring Science Teacher's Perspective to Student Worksheets (Hard Scaffolding) to Improve Students' HOTS and Collaboration Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7302–7309. https://doi.org/10.29303/jppipa.v9i9.4035

Putri, D. P., Jalmo, T., & Suyatna, A. (2023). Scaffolding with Peer Tutoring in the Teacher's Perspective: Could Its Implementation in Learning Programs Improve Scientific Communication Skills and HOTS. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1902–1908. https://doi.org/10.29303/jppipa.v9i4.3004

Rahmawati, T., Wahyuningrum H, M. M., Bustari, M., Lestari, S., Ernawati, R. D., & Selviana, S. (2023). Science Learning Management Based on Higher Order Thinking Skills (HOTS). *Jurnal Penelitian Pendidikan IPA*, *9*(1), 533–541. https://doi.org/10.29303/jppipa.v9i1.3152

Rochman, S., & Hartoyo, Z. (2018). Analisis High Order Thinking Skills (HOTS) Taksonomi Menganalisis

Permasalahan Fisika. *Science and Physics Education Journal (SPEJ)*, *1*(2), 78–88. https://doi.org/10.31539/spej.v1i2.268

Sepriyanti, N., Nelwati, S., Kustati, M., & Afriadi, J. (2022). The Effect of 21St-Century Learning on Higher-Order Thinking Skills (Hots) and Numerical Literacy of Science Students in Indonesia Based on Gender. *Jurnal Pendidikan IPA Indonesia*, *11*(2), 314–321. https://doi.org/10.15294/jpii.v11i2.36384

Suhartini, K., Prasetyorini, P., & Rachman, I. (2023). E-Module of Science Development Based on Higher Order Thinking Skills on the Material of the Human Circulatory System for VIII Grade Students. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9278–9289. https://doi.org/10.29303/jppipa.v9i11.5229

Suherman, Prananda, M. R., Proboningrum, D. I., Pratama, E. R., Laksono, P., & Amiruddin. (2020). Improving Higher Order Thinking Skills (HOTS) with Project Based Learning (PjBL) Model Assisted by Geogebra. *Journal of Physics: Conference Series*, *1467*(1). https://doi.org/10.1088/1742-6596/1467/1/012027

Torregoza, M., Aliazas, J. V., Torregoza, M. A., Vincent, J., & Aliazas, C. (2024). Learning Through Argumentation In Elementary Science For Improved STEAM And Higher-Order thinking Skills. *Ijsart*, 143–155. https://doi.org/10.5281/zenodo.10595543

Totok, S. (2019). *Pendidikan di Indonesia Belajar dari Hasil PISA 2018*. Jakarta: Kemendikbud.

Wahyudi, W., Nurhayati, N., & Saputri, D. F. (2022). Effectiveness of Problem Solving-based Optics Module in Improving Higher Order Thinking Skills of Prospective Physics Teachers. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2285–2293. https://doi.org/10.29303/jppipa.v8i4.1860

Widana, I. W. (2020). The Effect of Digital Literacy on the Ability of Teachers to Develop HOTS-based Assessment. *Journal of Physics: Conference Series*, *1503*(1). https://doi.org/10.1088/1742-6596/1503/1/012045

Zulhelmi, Z., Fauza, N., Syaflita, D., Pratiwi, J., Wijaya, T. T., & Hermita, N. (2023). Development of Learning Media to Improve Students' Higher Order Thinking Skills in Circular Motion Material. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1734–1740. https://doi.org/10.29303/jppipa.v9i4.3536