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Abductive Reasoning Skills: The Impact of Cooperative Learning Type Number Head Together (NHT) Assisted by Lumi Education in Science Learning

Dania Yuliyati[1], Azzah Rohadatul Aisy[2], Sisilia Eka Maulidiah[3], Laily Rosdiana[4]

[1,2,3,4] Department of Science Education, Universitas Negeri Surabaya, Jawa Timur, Indonesia
*Email: dania.22115@mhs.unesa.ac.id

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ABSTRACT

Purpose – This study aims to determine the effectiveness of NHT Cooperative Learning assisted by Lumi Education in improving the abductive reasoning skills of junior high school students in science lessons on substance pressure material.

Methodology – The research used a pre-experimental pretest with a replication across two schools. The effectiveness of learning in improving abductive reasoning skills was analyzed using pretest and posttest results. Data collection uses test and questionnaire methods. The test data were analyzed using the n-Gain score and the average difference test, while the response questionnaire data were analyzed using the Likert scale.

Findings – The results of this study showed an n-Gain score of 0.71, indicating a high category. The results of the paired t-test showed a p-value of <0.001 (<0.05), indicating a significant difference in ability before and after the learning application. The results of the response questionnaire showed that 100% of students responded positively to learning. Thus, the implementation of NHT Cooperative Learning, assisted by Lumi Education, has proven effective in improving abductive thinking skills in science learning.

Contribution – Abductive reasoning in science learning supports the scientific process so that students are able to design innovative solutions based on incomplete data. This research can serve as a basis for improving higher-order thinking skills so that students gain a deep, meaningful understanding and, in addition, can create an active classroom atmosphere and integrate technology into learning.

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INTRODUCTION

Along with the development of science and technology, countries around the world are strengthening education by integrating 21st-century skills such as critical thinking, collaboration, communication, and creativity (Wangguway et al., 2020). The 21st century presents students with complex global challenges, so life skills are needed to help them face problems and formulate solutions (Hutabarat et al., 2023; Wrahatnolo & Munoto, 2018). High-level thinking skills, such as critical thinking, are key to preparing students to become human resources with analytical and critical skills to face complex and dynamic scientific and technological developments (Saputra, 2024; Purnawati & Yakin, 2025). One important component of critical thinking is abductive reasoning, the ability to form initial conjectures based on evidence that is then further tested (Zahroh et al., 2025).

Abductive reasoning skills are the initial and key process in developing a temporary hypothesis of the observed phenomenon (Upmeier zu Belzen et al., 2021). This tentative hypothesis is based on information characterized as statements that may be "true" or "false" (Shodikin et al., 2021). This skill requires students to formulate the most plausible hypotheses supported by evidence. Magnani (2023) stated that the skill of abductive reasoning encourages students to use all available information to arrive at the best solutions. This allows students to be more successful in solving problems. In science learning, mastery of abductive reasoning skills is essential for improving scientific reasoning, enabling students to be more active in the critical thinking process and to design innovative solutions based on data interpretation (Oh & Ha, 2025).

Abductive reasoning skills play a crucial role in science learning, as the scientific process essentially requires students to form initial assumptions before conducting experiments. This reasoning method serves to construct hypotheses, support the inductive process, enhance reasoning skills, and generate new, creative ideas (Shodikin et al., 2021). Abductive reasoning requires students to formulate a hypothesis or tentative explanation for a phenomenon based on limited information. Science learning, particularly the concept of pressure, presents many contextual phenomena that are readily observable but cannot always be explained directly without reasoning (Nikat et al., 2021). This concept requires in-depth understanding and analytical skills to connect the various factors that influence pressure. This material has great potential to develop abductive thinking skills, as students are confronted with real-world phenomena that require initial reasoning before obtaining a complete conceptual explanation. This environment strongly supports the development of abductive thinking, particularly during the stage of formulating hypotheses before formally proving the concept.

But in reality, the skill to reason abductively in Indonesia is still relatively low. Not all students have strong abductive reasoning skills, as research by Amalia & Hadi (2020) shows that some students do not understand reasoning questions well, which continues to pose difficulties when developing problem-solving strategies. This is reinforced by the findings of pre-research conducted at one of the junior high schools in Surabaya. Using questions with abductive indicators, only 37.24% of students answered them correctly. This suggests that students tend to simply memorize concepts without understanding the meaning of the learning carried out (Ansya & Salsabilla, 2024). Other results of the researcher's observation show that learning activities are still dominated by conventional models that focus on delivering material and discussing practice questions. Students still often use the provided package books. Student learning activities tend to be passive and limited to following procedures determined by the teacher, so the opportunity to conduct independent scientific exploration remains minimal. Syafiqah & Arsyad (2024) state that passive learning activities and a tendency to follow the teacher's directions indicate that students do little independent exploration. As a result, abductive reasoning skills, such as formulating problems, proposing hypotheses, and developing solutions, remain low. Therefore, a suitable approach is needed to train these abductive thinking skills in science learning.

This condition indicates a need for a learning model that stimulates active student engagement in discovering concepts through the scientific process (Yuana et al., 2025). In this case, the learning model must encourage students' active involvement in observing phenomena, discussing, putting forward assumptions, and defending arguments scientifically. The learning model is expected to emphasize student activities in seeking, managing, and reporting information from various sources. One learning model relevant to developing abductive reasoning skills is the Numbered Heads Together (NHT) cooperative learning model. NHT provides a clear discussion structure through the steps of numbering, questioning, head together, and answering. The NHT learning steps include students being assigned numbers in each group (numbering), students being given questions through Lumi Education that contain abductive indicators (questioning), students discussing with their groups to make the best decision/answer (heads together), and then randomly calling a student's number and being asked to convey the group's answer responsibly (answering). Especially during the heads-together stage, students will put forward their guesses, compare possible explanations, correct discrepancies, and ultimately choose the most reasonable hypothesis, a process of abductive reasoning. Then, during the answering stage, the activity is combined with the Lumi Education feature, which checks the accuracy of the hypothesis through quizzes with instant feedback. (Yuana et al., 2025).

Lumi Education is a free application that creates and manages interactive H5P content, such as interactive videos, course presentations, and memory games. This platform offers features like multiple-choice, drag-and-drop, true-or-false, fill-in-the-blank, and more (Ilhami et al., 2025). Lumi Education presents visual phenomena, poses open-ended questions, and provides automated feedback to help students build reasoning (Mutawa et al., 2023). When using abductive indicators, students can develop their reasoning gradually and in a structured manner. The virtual laboratory provides direct evidence for students to test their hypotheses and deepen their understanding of the material. When teachers use the NHT cooperative learning model, Lumi Education content fosters discussion and stimulates the exchange of ideas and scientific arguments among group members. Lumi Education also provides students with information, encouraging them to explore the material independently. Therefore, in this study, Lumi Education does not stand alone as a digital medium but functions as an integrated part of the NHT cooperative learning process to develop students' abductive reasoning skills (Akuba et al., 2025).

Previous research on students' abductive reasoning skills has been limited to science learning. Much of this research has focused on mathematics learning, specifically on abductive-deductive strategies for solving mathematical problems (Dasmina et al., 2022), effective in solving algebraic problems (Rambe et al., 2023), and representing mathematically (Mufridah, 2023). In science learning, Suktomansyah's (2021) research found differences in concept comprehension and general science skills in physics between the experimental class using abductive cycle learning and the control class using conventional learning. The limitations of previous research in elaborating abductive strategies with innovative learning models and interactive media integration include research gaps and serve as the basis for this research. Considering the increasingly modern era that demands digital-based learning but also involves student activity. Therefore, this research is essential for offering an innovative NHT learning model, assisted by Lumi Education, to improve students' abductive reasoning skills.

METHODOLOGY

Research Design

This study used an experimental method with a pre-experimental one-group pretest–posttest design replicated in two settings. A one-group pretest–posttest design has only one group, without a control group. It is given a pretest before treatment and a posttest after treatment to assess changes resulting from the learning intervention (Ary et al., 2018). Replication across these two settings can be conducted in two classrooms, two schools, or two environments. The purpose of replication in research is to increase external validity and provide an overview of the stability of the findings (Nurmawan et al., 2023).

This design applied Lumi Education media in two experimental classes at different schools. The experimental classes were given a pretest, then treated with cooperative learning using NHT assisted by Lumi Education and finally given a posttest. This design was chosen to measure and compare test results (pretest and posttest) of abductive reasoning skills in two different schools in the Surabaya area. Selecting subjects from these two schools aimed to examine the consistency of NHT cooperative learning with Lumi Education in improving junior high school students' abductive reasoning skills. Additionally, giving the same treatment at two schools also aimed to strengthen the reliability of the research findings. This design illustrates the relationship between variable X (treatment) and variable Y (measurement), which is presented in the following framework:

Table 1. Research Design Framework

Setting 1	O_1	X	O_2
Setting 2	O_1	X	O_2

Details:

O_1 = Pretest

X = treatment in the form of NHT learning assisted by Lumi Education

O_2 = Posttest

Participant

The population in this study was all eighth-grade students at SMP Negeri 1 Surabaya (358 students) and SMP Negeri 46 Surabaya (273 students) in the odd semester of the 2025/2026 academic year. The sample in this study comprised 23 students from class VIII-B at SMP Negeri 1 Surabaya (8 boys and 15 girls) and 23 students from class VIII-A at SMP Negeri 46 Surabaya (12 boys and 11 girls). The sample in this study ranged in age from 13 to 14 years. The selection of research subjects was not random (non-random assignment); participants were conveniently or naturally selected, as the classes had already been established and determined by the school. The selection of eighth-grade students as participants was based on the assumption that they had already received materials on force, mass, and acceleration as prerequisites for learning about the pressure of substances.

Data Collection and Instrument

The data collection in this study used the method of testing abductive reasoning skills on the material of pressure substances in the science subject. The research instrument was a sheet of abductive reasoning skill tests containing 25 multiple-choice questions on the topic of substance pressure, including solid, liquid, and gas substance pressure. The questions were independently developed by the research team, tailored to the learning objectives on substance pressure and referring to indicators of abductive thinking ability, namely observation and inference, problem formulation, hypothesis comparison, making analogies, and concluding and evaluating (Williamson, 2017). The test instrument was validated before use using Aiken's V formula, yielding a validity coefficient of 0.92, which is categorized as valid. Reliability testing was also conducted to determine the consistency of the abductive reasoning skill test instrument. The reliability test used Cronbach's Alpha, yielding a coefficient of 0.75, which is considered reliable. Based on these validity and reliability tests, the abductive reasoning skill test instrument is deemed suitable for use in the research.

The test instruments were designed using indicators of abductive reasoning skills aligned with the learning objectives. The alignment of the abductive reasoning skills indicators with the learning objectives is presented in the Table 2.

Questions designed in this way will provide an overview of students' abductive reasoning skills in understanding, connecting, and applying the concept of pressure of substances, particularly in everyday life.

Student response sheet instruments were provided to understand students' reactions after participating in cooperative NHT learning assisted by Lumi Education. This instrument is a 10-question Likert-scale questionnaire assessing the use of models, media, and teaching systems. Student responses are useful for evaluating and determining the extent to which media-based interactive learning can improve students' reasoning skills and learning motivation. All instruments in this study have undergone validation by 3 validators: media expert lecturers, subject-matter expert lecturers, and science teachers in the educational unit.

Table 2. Assessment Framework for Abductive Reasoning Skills

Indicator	Learning Objectives	Item	Scoring
Observation and Inferential	Explain the meaning of pressure and the factors that affect it in daily life	1-5	Correct = 4 Incorrect = 0
Summarizing the problem	Analyze the relationship of variables that affect pressure	6-10	
Comparing different hypotheses	Using pressure formulas to calculate pressures on solids, liquids, and gases	11-15	
Make an analogy	Apply the concept of pressure in solving simple problems and case studies	16-20	
Evaluate and conclude	Improve students' scientific attitude towards the phenomenon of pressure of substances around	21-25	

Data Analysis

The improvement in students' abductive reasoning skills resulting from the treatment applied during learning is analyzed using n-Gain, as follows:

$$\text{n-Gain} = \frac{S\ posttest - S\ pretest}{Smax - S\ pretest} \qquad (1)$$

Based on the gain scores obtained, they will be analyzed using the criteria in the following table:

Table 3. n-Gain Score Criteria

n-Gain Score	Criteria
n-Gain > 0,7	High
0,7 ≥ n-Gain ≥ 0,3	Medium
n-Gain < 0,3	Low

The analysis continued by comparing the n-Gain results from the two schools. The comparison of n-Gain scores was conducted using an independent sample t-test. This analysis was conducted to assess the consistency of the learning intervention across two settings. If the independent-samples t-test result is greater than 0.05, then the improvement in students' abductive reasoning skills due to the treatment is consistent. However, before that, the data must meet the classical assumption test, namely Levene's test for homogeneity. The pretest homogeneity test is used to ensure that the sample groups are sufficiently homogeneous, even though they come from two different schools, making them suitable for comparison. The homogeneity posttest is required to continue the comparative test using the independent t-test.

The next analysis is hypothesis testing, to determine whether the applied treatment has a significant impact on the results. Before that, a classical normality test, the Shapiro-Wilk test, was conducted. If the normality test results show a p-value> 0.05, the data are normally distributed and will proceed to parametric tests (paired-samples t-test); if the data are not normal, they will proceed to nonparametric tests (Wilcoxon test). All quantitative data analyses were performed using Jamovi software version 2.6.44.

The student response questionnaire data, arranged using a Likert scale, will be analyzed using the following equation.

$$\text{Percentage } (\%) = \frac{\Sigma \text{Student response score obtained}}{\text{Maximum Score}} \times 100\% \qquad (2)$$

Then, after calculating the percentage, the results are categorized based on the category in the following table.

Table 4. Student Response Category

Student Response (%)	Category
75 < SR ≤ 100	Very Positive
50 < SR ≤ 75	Positive
25 < SR ≤ 50	Negative
0 < SR ≤ 25	Very Negatif

(Ahmad et al., 2021)

FINDINGS

Descriptive Results

The findings in this study indicate the results of junior high school students' abductive reasoning skills obtained from quantitative data analysis through a test method. A pre-test post-test was conducted to determine the students' abductive reasoning skills before and after the treatment. The results of the pre-test and post-test are then analyzed with the aim of determining the effectiveness of the NHT learning model with the help of Lumi Education in improving the abductive reasoning skills of junior high school students.

Table 5. Descriptive Statistics of Pre-test and Post-test

	SMPN 1 Surabaya		SMPN 46 Surabaya	
	Pre-test	Post-test	Pre-test	Post-test
N	23	23	23	23
Minimum	0	48	0	52
Maximum	56	100	60	100
Mean	29,04	77,57	27,65	79,65
Standard Deviation	14,18	17,04	15,35	13,69

Based on Table 4, the abductive reasoning skill test for students at SMPN 1 Surabaya yielded an average pretest score of 29,04, with the lowest score being 0 and the highest being 56. The average posttest score was 77,57, with the lowest score 48 and the highest score 100. Meanwhile, the test results for students' reasoning skills at SMPN 46 Surabaya showed an average pretest score of 27.65, with a minimum of 0 and a maximum of 60. Then, the average posttest score was 79,65, with the lowest score 52 and the highest score 100. The comparison of the average pretest and posttest scores at both schools shows an improvement. This indicates an increase in abductive reasoning skills after implementing NHT learning with Lumi Education.

Classical Assumption Test Results

The samples for this study came from two different schools, therefore a homogeneity test was conducted to ensure that their abilities were comparable and suitable for comparison.

Table 6. Homogeneity Test Result

	F	df	df2	p
Pretest SMPN 1 Surabaya– SMPN 46 Surabaya	0,064	1	44	0,800
Posttest SMPN 1 Surabaya– SMPN 46 Surabaya	2,317	1	44	0,135

The homogeneity test results showed a p-value of 0.800 (>0.05), meaning that the pretest scores indicating the students' initial abilities are homogeneous. Thus, even though they come from different schools, the initial abilities of students from both schools have equivalent uniformity. Furthermore, a normality test was conducted as a prerequisite for testing the hypothesis.

Table 7. Normality Test Result

		n	Statistic	Sig.	Decision
SMPN 1 Surabaya	Pre-test	23	0,969	0,671	Normal
	Post-test	23	0,931	0,114	Normal
SMPN 46 Surabaya	Pre-test	23	0,978	0,873	Normal
	Post-test	23	0,942	0,195	Normal

The pre-test and post-test scores each consist of 23 data points, which is less than 50, so the Shapiro-Wilk normality test was used. The decision criterion for normally distributed data is that it must have a p-value significance > 0,05. In Table 6, all significance values meet the requirement of > 0,05, so the data meets the prerequisite tests to proceed to parametric testing.

Paired Sampel t-Test Results

Subsequently, the data will be used for hypothesis testing. Hypothesis testing uses a paired t-test by comparing pretest-posttest scores in both schools and is presented in Table 7.

Table 8. Paired Sample t-test Result

		df	t	p
SMPN 1 Surabaya	Pretest-Posttest	22	-14,0	< 0,001
SMPN 46 Surabaya	Pretest-Posttest	22	-16,7	< 0,001

The results of the paired t-test analysis at SMPN 1 Surabaya showed a degree of freedom (df) of 22, a t-value of -14.0, and a p-value < 0.001. Meanwhile, the analysis at SMPN 46 Surabaya yielded df=22, a t-value of -16.7, and a p-value < 0.001. Based on the p-value, both met the requirement of being less than 0,05, thus the null hypothesis, which states that there is no difference after the learning treatment, was rejected, and the alternative hypothesis was accepted. These results indicate a significant difference between the before and after conditions in the cooperative NHT learning assisted by Lumi Education. In other words, the treatment provided was effective in enhancing junior high school students' abductive reasoning skills on the topic of substance pressure.

n-Gain Results

Pretest and posttest results were analyzed using n-Gain to assess improvement in students' abductive reasoning after treatment. Students' abilities were grouped into high, medium, and low categories. The following table shows N-gain scores for both schools.

Table 9. Student n-Gain Scores

Category	SMPN 1 Surabaya	SMPN 46 Surabaya
Low	1 (4,35%)	0 (0%)
Medium	11 (47,83%)	10 (43,48%)
High	11 (47,83%)	13 (56,52%)
Combined n-Gain	0,71 (High)	

The combined pretest and posttest scores in both schools obtained an n-Gain score of 0,71, which falls into the high category. The distribution of n-Gain scores for each student is represented in Figure 1. Most students' n-Gain scores are above 0.3. However, one student received an n-Gain in the low category, which does not mean there was no improvement. The n-Gain score is sensitive to the initial score, so students with very high initial scores will have small improvements (Guntara, 2021). Nevertheless, most students showed improvement in abductive reasoning skills, achieving a high category after NHT learning using Lumi Education.

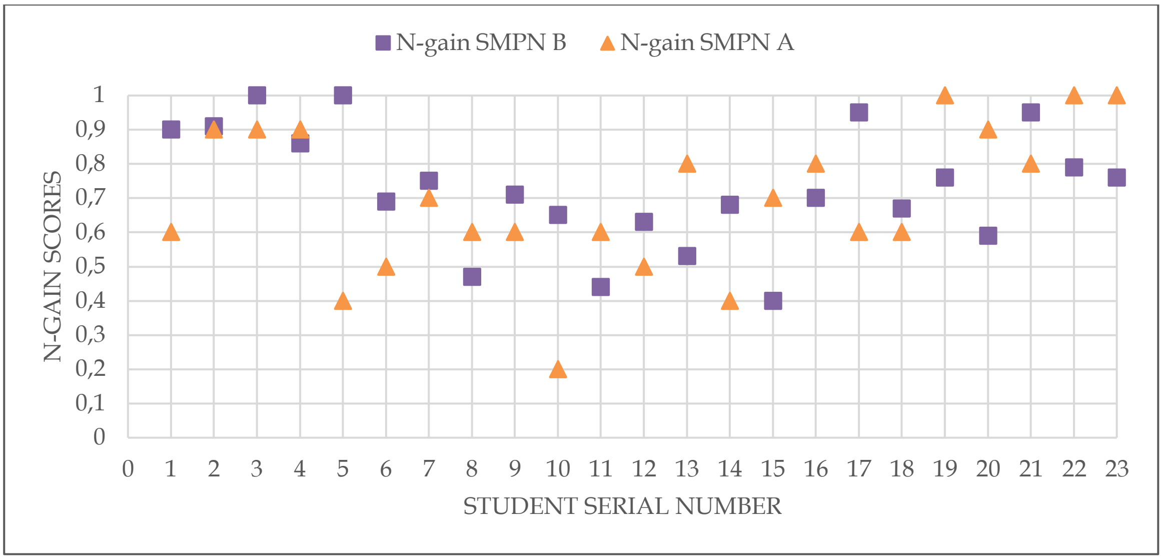

Figure 1. Comparison of N-gain Scores at SMPN 1 Surabaya and SMPN 46 Surabaya

The data were then analyzed based on the increase in n-Gain for each indicator of abductive reasoning skills. The results of the analysis of abductive reasoning skills on each indicator showed a good improvement, as presented in following table.

Table 10. n-Gain Test Based on Abductive Indicators

Abductive Reasoning Indicators	Pre-test	Post-test	n-Gain	Category
Observation and inference	32,17	82,17	0,74	High
Formulating the problem	27,83	75,65	0,66	Medium
Comparing different hypotheses	27,83	86,09	0,81	High
Making an analogy	25,22	72,17	0,63	Medium
Evaluate and conclude	28,70	76,96	0,68	Medium

The observation indicator increased from 32,17 to 82,17 with an n-Gain value of 0,74, which is in the high category. The comparison of different hypotheses indicators showed the highest increase from 27,83 to 86,09 with an n-Gain value of 0,81, also in the high category. Meanwhile, the indicator for formulating the problem increased from 27,83 to 75,65, with an n-gain of 0,66, categorized as medium. The making-an-analogy indicator increased from 25,22 to 72,17, with an n-gain of 0,63, also in the medium category. The evaluation and conclusion indicator also increased from 28,70 to 76,96, categorized as medium. Although all three categories fall into the medium range, they are all still above the minimum effectiveness threshold (> 0,3). All indicators of abductive reasoning skills showed significant improvement, and none are considered low.

Comparison of N-gain between the Two Schools

This study used two different school settings and then compared them. The comparison was based on the n-gain scores of students' abductive reasoning skills at the two schools. The results of this comparison are shown in the following table.

Table 11. n-Gain Results in Different Schools

	SMPN 1 Surabaya	SMPN 46 Surabaya
n-Gain	0,69 (Medium)	0,73 (High)

The n-Gain results in the two schools showed results of 0.69 and 0.73 where both showed good effectiveness in increasing abductive reasoning skills after the learning process. The difference in n-gain from the two schools showed a thin score of 0.04, however, this difference was able to place SMPN 1 Surabaya in the medium category and SMPN 46 Surabaya in the high category.

The n-gain results were then compared across two different school settings: SMPN 1 Surabaya and SMPN 46 Surabaya. The comparison used an independent t-test, the results of which can be seen in the following table.

Tabel 12. Independent Sample t-test Comparison of n-Gain between the Two Schools

	df	t	p
n-Gain SMPN 1 SBY – SMPN 46 SBY	44	0,592	0,557

The results of the independent t-test showed p>0.05, meaning there was no significant difference in test scores between the two schools. The learning implemented at both schools yielded relatively consistent results. This aligns with the research objectives. Despite the different schools, the learning models used in this study were found to be stable in their effectiveness.

Student Respons

This study also received positive responses from the students; the results of the response questionnaire are represented in the following figure.

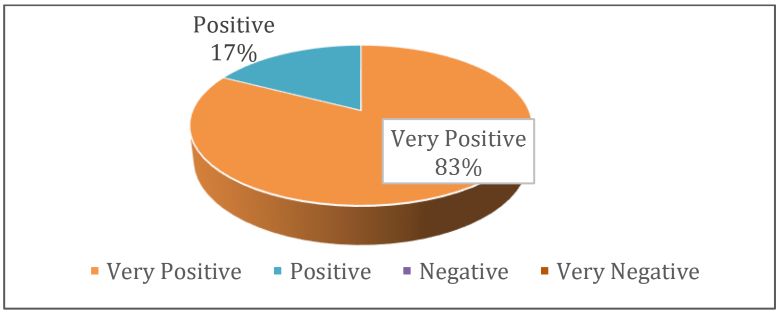

Figure 2. Student Response Survey Results

The student response questionnaire results showed 83% of students gave a very positive rating, while 17% gave a positive rating. No negative or very negative responses were recorded. These results indicate high student interest and engagement. Students reported liking and being interested in learning with a model that combines interactive digital media. The NHT learning model, when supported by Lumi Education media, was reported to boost student enthusiasm for learning.

DISCUSSION

The results of this study indicate that implementing the NHT cooperative learning model, supported by Lumi Education, significantly improved students' abductive thinking skills. This improvement was evident in the comparison of test scores before and after the learning. According to Creswell & David (2017), in conducting experiments, research subjects must experience changes in ideas or thought patterns after the researcher tests a particular idea or procedure. Improved abductive reasoning skills, as indicated by a paired t-test, show significant changes between pretest and posttest scores. In other words, the independent variable influences the dependent variable (Montgomery & Runger, 2019). According to the N-gain score results, the greatest improvement occurred in the moderate-to-high categories. This demonstrates that the NHT cooperative learning model, implemented with Lumi Education's support, is effective in improving students' abductive reasoning skills. This aligns with research by Akuba et al. (2025), who found that learning with the NHT model, supported by interactive media, led to higher problem-solving scores in the experimental group than in the control group.

The learning process in this study was conducted over three meetings. Each meeting began with group formation and the assignment of head numbers to each group member. Afterward, students were asked to explore the materials and exercises available on Lumi Education, which they could access together. Within the groups, students were trained to help each other, collaborate, provide explanations, and ask questions effectively (Lestari et al., 2023). Lumi Education provides materials and several quizzes with immediate feedback. Students can try to answer these interactive questions; if they answer incorrectly, they must repeat the question until they get it right. By trying various possibilities, they will discover recurring patterns in answering questions with specific indicators. For example, in questions with problem formulation indicators, they must identify independent and dependent variables that correspond to the presented phenomenon. When formulating a hypothesis, students must be able to make the most logical assumptions and relationships among the variables or brief data presented, based on sound scientific concepts.

Then the lesson continues with questioning, where the teacher asks questions similar to the exercises students have studied in Lumi Education. However, at this stage, Lumi Education is only accessible to the teacher, and students can only view the projector screen. The teacher will ask the question and call out the head number that must answer. After the question is displayed, students are given the opportunity to discuss and choose the best answer. This answer is not just guesswork; it must include arguments that explain the phenomenon comprehensively and relate it to the material they have learned. This NHT learning model emphasizes student activities in deeper thinking, choosing the best group solution, and conveying responsible decisions (Sakban & Wahyudin, 2020). After the discussion time is up, the student with the chosen number can answer the question. The teacher, together with the students, checks whether the student's answer on Lumi Education is correct. If the group answers correctly, they will receive a point. If the group answers incorrectly, they will be retried, giving other groups the opportunity to answer until they get the answer correct. The points for the group with the correct answer will be accumulated, and a prize will be awarded. This kind of learning can create a fun atmosphere and increase learning motivation (Azryasalam et al., 2020), and abductive abilities increase because it includes abductive reasoning indicators embedded in Lumi Education.

Figure 3. Lumi Education Display

In independent group exploration, Lumi Education helps students gather clues by presenting material and phenomena as stimuli for thinking. Furthermore, Lumi Education will also help students develop their abductive thinking skills through the questions posed within. Lumi Education's features facilitate instant feedback on answers to questions. Students can determine whether their answers are correct or incorrect and repeat them if they feel they still lack confidence. When students answer incorrectly, they will receive feedback in the form of clues to help them reflect on their answers. There is also a "retry" menu for repeating the answer. If students have answered correctly, feedback will appear as a short discussion that supports and strengthens their understanding. This type of feedback has been proven to support self-evaluation and can improve students' perception and thinking. (Jacob & Centofanti, 2024). This automated feedback is a continuous review strategy that identifies deficiencies and gradually supports students' thinking (Salsabila et al., 2025; Wambsganss et al., 2022).

Numbered Head Together (NHT) or numbered thinking together is a type of cooperative learning designed to influence student interaction patterns (Hapsari, 2017). Cooperative learning requires students to work together to achieve a common goal. In this type of learning, differences in ideas and arguments among students are possible. Therefore, the process of exchanging arguments will become a group evaluation aimed at reaching agreement on the best, most logical hypothesis consistent with scientific principles. The NHT phase, "head together" and "questioning," facilitates discussion, selection of the best hypothesis, and reflection on the discussion results. In this phase, students will engage in abductive reasoning using evidence from available phenomena. Science learning through the development of abductive reasoning patterns will prompt students to engage in higher-order thinking. Higher-order thinking is defined as not simply memorizing or understanding material, but also involves the ability to make decisions, solve problems, and think critically (Aşkar & Altun, 2023).

Learning to improve abductive reasoning skills can be used as a starting point for developing other higher-order thinking skills. Abductive reasoning is important in learning because it offers more innovative solutions than conventional learning (Dasmina et al. 2022; Shodikin et al., 2021; Rambe et al., 2023). Teachers and educational practitioners can use the learning practices in this study as a reflection for developing students' thinking patterns beyond deductive-inductive thinking. However, abductive thinking also represents a new, rarely developed form of reasoning in drawing conclusions. Although this type of practice is rarely implemented in learning, students remain enthusiastic and respond positively. This is consistent with Yorganci's (2022) research, which suggests that interactive technology affects students' learning processes, motivation, and cognitive load (Bunari et al., 2024).

CONCLUSION

The implementation of the NHT cooperative learning model, supported by Lumi Education, is effective in improving middle school students' abductive reasoning skills in science learning. The integration of Lumi Education into learning serves as a source of information for argument formation, evaluation, and reflection, while NHT serves as a space for collaboration and the delivery of arguments. The results of this study show a significant improvement in students' abductive reasoning skills. The learning in this study not only strengthens conceptual understanding but also improves students' scientific reasoning skills. Students learn from phenomena that require further explanation, so logical hypotheses are developed through exploration and collaboration. Thus, students gain an in-depth understanding and go beyond mere information receipt. This research provides teachers with the foundation for incorporating abductive thinking patterns into technology-based science learning. This learning can also integrate further investigation to strengthen arguments, and abductive thinking is the initial step in compiling students' logistical arguments before their truth is proven in reality.

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