The influence of Jigsaw-based Cooperative learning model on students' critical thinking skills of light wave concepts

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Abstract

This study aims to examine the influence of the Jigsaw-based cooperative learning model on students' critical thinking skills in the concept of light waves. The background of this study is based on the low levels of students' active participation and the underdeveloped critical thinking skills in physics learning, which have been traditionally dominated by conventional approaches. The Jigsaw model was chosen because it can promote active student engagement in group learning, enhance scientific communication, and foster a deeper conceptual understanding. This study employed a quantitative approach with a quasi-experimental method using a one-group pretest-posttest design. The research sample consisted of 20 students from Grade XI-1 at MAN 6 Tasikmalaya. The instrument used was a written test of critical thinking skills based on Ennis's indicators. Data analysis using the paired sample t-test revealed a significant difference between pretest and posttest scores, with a significance value of $0.000 < 0.05$. Additionally, the N-Gain calculation showed an average improvement categorized as medium (0.35). Therefore, it can be concluded that the Jigsaw-type cooperative learning model has a positive effect on enhancing students' critical thinking skills in the topic of light waves.

Keywords: Jigsaw Model, Critical Thinking, Light Waves, Cooperative Learning

1. Introduction

The education plays a crucial role in enhancing the quality of human resources to realize the aspirations of the Indonesian nation, namely to educate the nation's youth and improve public welfare. According to Law Number 20 of 2003 concerning the National Education System, education functions to develop students' potential to become individuals who are faithful, pious, morally upright, knowledgeable, creative, and responsible. Therefore, human resource development through education requires serious attention to ensure that the learning process is effective and oriented toward the optimal development of students' potential.

In practice, the classroom learning process still faces various challenges, such as the dominance of one-way lecturing methods, low student participation, and limited group collaboration. These conditions result in underdeveloped critical thinking skills among students. Critical thinking, however, is an essential ability that encompasses analyzing information, providing logical reasoning, evaluating others' opinions, and making appropriate decisions. The lack of discussion

activities and active participation indicates that students' critical thinking skills have not been optimally facilitated in the learning process.

One strategy that can promote the development of critical thinking skills while fostering positive social interactions is group learning. Through collaborative work, students can exchange ideas, engage in discussions, and gain a deeper understanding of the material from multiple perspectives. Such interactions not only enhance conceptual understanding but also develop social skills, including empathy, tolerance, and responsibility. Therefore, group learning plays a crucial role in nurturing critical thinking abilities while simultaneously shaping students' collaborative character.

The Jigsaw-type cooperative learning model is a practical approach for developing critical thinking skills through group collaboration. This model emphasizes both individual and collective responsibility, where each student studies a specific portion of the material and then shares their knowledge with other group members. According to Slavin (2005) and Arends (2012), the Jigsaw model can enhance communication skills, critical thinking, and a sense of accountability for group learning outcomes. Through these activities, students are trained to analyze information, evaluate different perspectives, and present arguments in a logical and systematic manner.

Several previous studies have demonstrated the effectiveness of the Jigsaw model in improving learning outcomes and critical thinking skills. Research by Huda (2016) and Nurkholis and Fitriyani (2020) demonstrated that implementing the Jigsaw model in science and physics instruction enhanced students' conceptual understanding, active participation, and critical thinking abilities. Similarly, Lestari and Rahayu (2021) reported that this model can train scientific communication skills and collaboration. These findings confirm that the Jigsaw model holds significant potential for enhancing 21st-century learning, which emphasizes higher-order thinking skills and collaborative competencies.

In the context of physics learning, the Jigsaw-type cooperative learning model is highly relevant, particularly for conceptual and complex topics such as light waves. This material can be divided into several interrelated subtopics, making it ideal for expert group–based learning. Through this strategy, students are encouraged to actively understand, discuss, and explain concepts to their peers, which ultimately strengthens their critical thinking skills.

2. Research method

This study employed a quasi-experimental method with a one-group pretest-posttest design. The research subjects consisted of 20 students from Grade XI-1 at MAN 6 Tasikmalaya, selected using a saturated sampling technique. The research instruments included a 10-item essay test on critical thinking skills based on Robert H. Ennis's indicators, as well as an observation sheet to assess the implementation of learning. Data analysis was conducted through N-Gain calculation, normality testing using the Shapiro-Wilk test, and hypothesis testing using the paired sample t-test with the assistance of SPSS Statistics 25.0.

2.1 Population

According to Sugiyono (2016), a population is a generalization area consisting of objects/subjects that possess certain qualities and characteristics determined by the researcher to be studied and subsequently drawn conclusions from. The population in this study comprised all Grade XI students at MAN 6 Tasikmalaya.

2.2 Sample

The sample in this study consisted of 20 students from Grade XI-1 at MAN 6 Tasikmalaya. The sampling technique employed was saturated sampling, in which all members of the population were included as the sample, given the relatively small number, making it feasible to study them comprehensively.

2.3 Research Instruments

Research instruments are tools used to collect data or measure variables in a study. The instruments in this research included both test and non-test instruments. The test instrument was used to measure students' critical thinking skills on the topic of light waves. The test consisted of 10 essay questions. The development of the test items referred to the critical thinking indicators proposed by Robert H. Ennis, namely, providing simple explanations, building basic skills, making inferences, offering further explanations, and arranging strategies and tactics (**Table.1**):

Table 1

Specifications of Critical Thinking Skills Instrument (Source: Ennis, 2016)

No.	Critical Thinking Aspect	Item Indicators
1.	Providing simple explanations	Focusing questions
		Analyzing arguments
		Asking and answering questions about an explanation or challenge
2.	Building basic skills	Considering the credibility of a source

		Observing and evaluating the results of observation
3.	Making inferences	Making deductions and evaluating the results
		Making inductions and evaluating the results
		Making decisions and considering the outcomes
4.	Providing further explanations	Defining terms and considering definitions
		Identifying assumptions
5.	Arranging strategies and tactics	Deciding on an action
		Interacting with others

Meanwhile, the non-test instrument was used to obtain supporting data related to the learning process, namely an observation sheet. The observation sheet was employed to monitor the implementation of the applied learning model, specifically the Jigsaw-type cooperative learning model. The assessment categories for learning implementation in this observation referred to Zainuddin (2017), who stated that the percentage range of implementation can be divided into five categories (**Table.2**):

Table 2.
Assessment Categories for Learning Implementation

Percentage Range	Category
81 - 100 %	Very Good
61 - 80 %	Good
41 - 60 %	Fairly Good
21 - 40 %	Poor
0 - 20 %	Very Poor

2.4 Data Collection Techniques

The data collection techniques employed in this study included both test and non-test instruments. The test instrument was a written essay used to compare students' critical thinking skills before and after the learning process. The non-test instrument was used to obtain supporting data related to the learning process and students' responses to instruction. The non-test data were collected using an observation sheet to assess the implementation of learning.

2.5 Data Processing and Analysis Techniques

After the research data were collected, they were analyzed using Statistical Product and Service Solutions (SPSS) Statistics 25.0 and Microsoft Excel through the following procedures:

a. N-Gain Calculation

The Normalized Gain (N-Gain) calculation was used to determine the extent of improvement in students' learning outcomes after receiving treatment through the implementation of the learning model. N-Gain is calculated based on the comparison between pretest and posttest scores relative to the maximum possible score.

$$N - Gain = \frac{Posttest\ score - Pretest\ score}{Ideal\ score - \ Pretest\ score}$$

To determine the improvement in students' critical thinking skills, an analysis of the pretest and posttest results was conducted based on the critical thinking indicators proposed by Ennis (1996). The gain was calculated using the following formula:

$$Gain = \frac{Posttest\ score\ _{indicator} - Pretest\ score_{indicator}}{maximum\ score_{indicator} - \ Pretest\ score_{indicator}}$$

The N-Gain interpretation criteria according to Hake's categories, as cited in recent studies and explained by Prastowo and Wicaksono (2020), are as follows (**Table.3**):

Table 3.
N-Gain Interpretation

N-Gain Range	Improvement Category	Effectiveness Indicator
$g \geq 0{,}70$	High	Very Effective
$0{,}30 \leq g < 0{,}70$	Medium	Moderately Effective
$g < 0{,}30$	Low	Less Effective

Thus, the N-Gain calculation was used to measure the effectiveness of the implemented learning model in enhancing students' critical thinking skills in this study.

b. Normality and Hypotesis Test

The normality test was conducted to determine whether the pretest and posttest data were normally distributed, a prerequisite for selecting the appropriate statistical test. In this study, the Shapiro-Wilk test was applied because the sample size was less than 50. Following the normality assessment, a hypothesis test was conducted to determine whether there was a statistically significant difference between pretest and posttest scores after implementing the learning model. If the data were normally distributed, the paired sample t-test was used; otherwise, the non-parametric Wilcoxon Signed-Rank Test was applied. The results were interpreted based on the significance value ($p < 0.05$). < 0.05 indicated a significant difference and Sig. ≥ 0.05 indicated no significant difference between pretest and posttest scores.

3. Results and Discussion

The results of the study indicated an improvement in students' critical thinking skills following the implementation of the Jigsaw-type cooperative learning model.

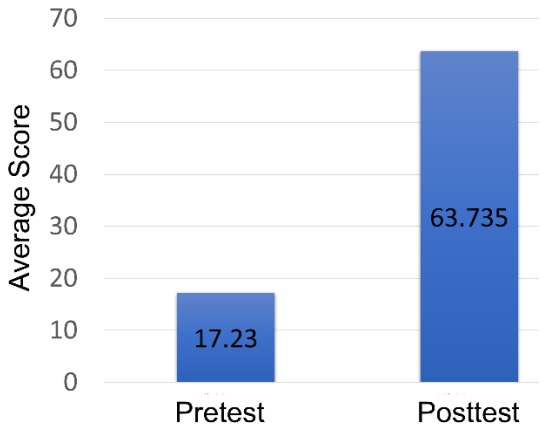

Figure 1. Average Pretest and Posttest Scores

Based on the pretest and posttest results, the average pretest score was 17.23, while the average posttest score was 63.735 (**Figure.1**). The improvement in critical thinking skills, as indicated by the difference between the two mean scores, was 46.50. This increase is considered quite significant, although each student exhibited varying levels of critical thinking ability. By comparing the pretest and posttest scores of individual students, the extent of improvement at the individual level can be determined.

The improvement in students' critical thinking learning outcomes was analyzed by calculating the N-Gain scores. The N-Gain calculation was used to determine the effectiveness of the implemented learning model in enhancing students' learning outcomes. Based on the overall Normalized Gain (N-Gain) results, the average N-Gain was 0.351. This value falls within the range of $0.3 \leq g < 0.7$, which, according to Hake's classification, is categorized as medium or moderately effective. From the data obtained, 17 students showed improvement within the N-Gain range of $0.3 \leq g < 0.7$ (medium category), while 3 students experienced improvement within the range of $g < 0.3$ (low category).

These findings are consistent with the study conducted by Huda (2016), which stated that the implementation of the Jigsaw learning model in physics significantly improved both learning outcomes and students' critical thinking skills. Similarly, the study by Anggraini (2019) reinforced that the Jigsaw-type cooperative learning model consistently has a positive impact on enhancing students' critical thinking abilities.

Thus, it can be concluded that, in general, the implementation of the Jigsaw-type cooperative learning model is moderately effective in enhancing students' critical thinking skills on the topic of light waves. This finding is consistent with the study by Nurkholis and Fitriyani (2020), which demonstrated that the Jigsaw model is effective in improving both conceptual understanding and students' critical thinking skills in science subjects. Furthermore, the research by Fadilah (2019) also showed that the use of critical thinking indicator–based instruments in Jigsaw-type cooperative learning significantly enhanced students' critical thinking abilities.

Based on the normality test results using SPSS Statistics 25.0, the significance value (Sig.) for the pretest data was 0.100, which is greater than 0.05 ($0.100 > 0.05$), indicating that the pretest data were normally distributed. Meanwhile, the significance value (Sig.) for the posttest data was 0.103, which is also greater than 0.05 ($0.103 > 0.05$), indicating that the posttest data were normally distributed as well. Thus, these results indicate that all data obtained in this study are normally distributed.

Based on the hypothesis test using the Paired Sample t-Test in SPSS Statistics 25.0, the significance value (Sig. 2-tailed) was 0.000, which is less than the significance threshold of 0.05 ($0.000 < 0.05$). This indicates that the null hypothesis (H_0) was rejected and the alternative hypothesis (H_1) was accepted. Therefore, it can be concluded that the implementation of the Jigsaw-type cooperative learning model has a significant effect on students' critical thinking skills in the concept of light waves.

When examined based on the critical thinking indicators used, the implementation of the Jigsaw-type cooperative learning model showed varying effects across each indicator. Based on the pretest and posttest scores obtained, there was an observable improvement (gain) in students' critical thinking skills after the application of the learning model, with different gain scores for each indicator **(Figure.2**).

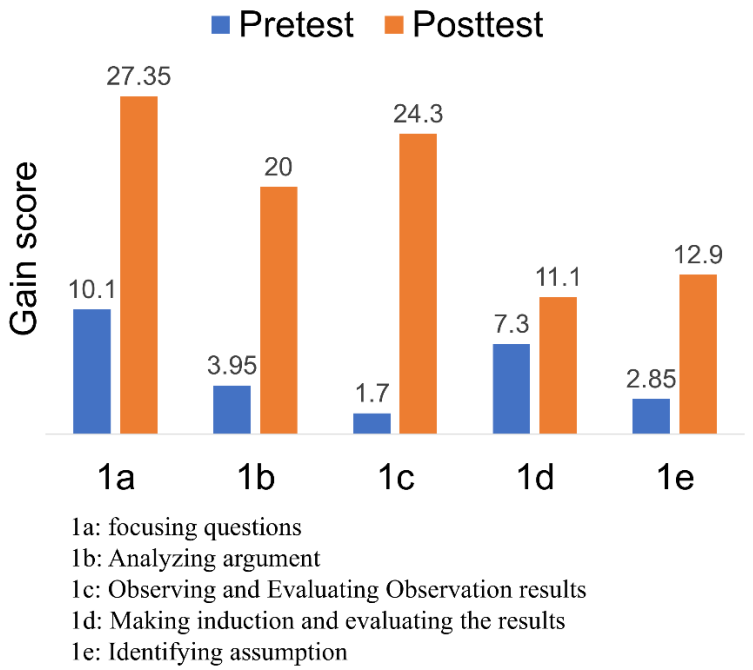

Figure 2. Gain calculation results for each indicator

The measurement of the indicator "observing and evaluating observation results" showed the highest gain value of 0.95 compared to the other indicators. This finding suggests that the Jigsaw-type cooperative learning model is effective in developing students' critical thinking skills in this particular context. This success may be attributed to the Jigsaw activities, which require students to explain concepts to one another and verify information among group members, thereby encouraging them to observe carefully and critically assess the results of their observations.

improvement was observed in the indicator "making inductions and evaluating the results," indicating that the implementation of this model had a less optimal effect on mastery of this indicator. This may occur because induction requires more complex thinking skills, namely, drawing generalizations from limited data. Students are required to identify patterns, manage information, and develop probabilistic conclusions. Challenges arise when they must determine whether the conclusions drawn are logically valid or merely coincidental.

The differences in achievement levels across indicators are also influenced by prior knowledge, the degree of participation in group discussions, and the limited time available for learning. These findings are consistent with Anggraini (2019), who reported that the Jigsaw model effectively enhances critical thinking skills, particularly in the indicators of observation and argument analysis, but is less optimal for the induction indicator due to its higher complexity. Fadilah (2019) further emphasized that the success of each critical thinking indicator depends on the applied learning strategies as well as students' cognitive readiness in understanding the concepts. Thus,

the variation in results across indicators can be explained by the complexity of the thinking skills required and the internal conditions of students during the learning process.

According to Ennis (2011), critical thinking is not merely about understanding information, but also involves the ability to evaluate, interpret, and develop arguments logically. Therefore, some indicators that require reflective thinking and in-depth analysis may necessitate additional learning strategies to be optimally achieved.

Each learning step outlined in the Lesson Plan (RPP) was observed by an observer during classroom activities. The observation aimed to determine the extent to which each step was implemented according to the planned design and to assess the teacher's consistency in executing the learning scenario. The observation results were then analyzed by comparing the number of steps actually carried out with the number of steps that should have been implemented. The collected data were systematically compiled to provide a clearer overview of the quality of learning implementation. The summarized results are presented in the form of a table showing the percentage of learning implementation, as shown in the following (**Table 4**):

Table 4
Recapitulation of Implementation Observation Results

Learning Steps	Percentage
Fase 1 Communicating Objectives and Motivating Students	100%
Fase 2 Presenting Information	80%
Fase 3 Base Group	100%
Fase 4 *expert group*	100%
Fase 5 Expert group returns to base group	100%
Fase 6 evaluation	100%
Fase 7 Giving Rewards atau Providing Rewards	100%
average	97,15

Based on the recapitulation table of learning implementation results, it can be seen that the teacher's activities in applying the Jigsaw-type cooperative learning model were categorized as very good, with an average implementation rate of 97.15%.

4. Conclusion

The implementation of the Jigsaw-type cooperative learning model has a positive effect on improving students' critical thinking skills in the topic of light waves. This is evidenced by the significant difference between pretest and posttest scores (Sig. = 0.000 < 0.05) and an average N-

Gain of 0.351, which falls into the moderate category. The Jigsaw cooperative learning model fosters an active, collaborative, and structured learning environment, encouraging students to process information, think logically, and construct arguments. The highest improvement was observed in the indicator "observing and evaluating observation results," with a gain score of 0.95 (high category), while the lowest improvement occurred in the indicator "making inductions and evaluating the results," with a gain score of 0.15 (low category). Classroom observation during the implementation of the Jigsaw model indicated a very good level of learning implementation, demonstrating that the learning process was conducted according to the Lesson Plan (RPP) and received positive responses from students.

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