

## Analysis of Students' Critical Thinking in Geometric Wave Topics: A Study on the Limitations of Student Worksheets in Physics Learning

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**Abstract.** The development of 21st-century learning demands all aspects of development with the integration of technology and innovation so it becomes a challenge in the world of education. In addition to innovative technology, the challenge in education is to improve students' critical thinking skills (CTS). The purpose of this study is to analyze students' CTS through physics learning based on geometric wave phenomena. The method used in this study is quantitative descriptive. Data collection techniques are obtained from observation results, critical thinking test instruments, and student response questionnaires. Data analysis techniques using EFA (exploratory factor analysis) include the eigenvalue factor and alpha Cronbach (MPF and BAPF). Based on the results of the CTS questionnaire, 75 students have low CTS with EFA results on Eigenvalue obtaining values from two factors of 0.507 and 0.907, then the Cronbach alpha value on two factors (MPF and BAPF) is 0.825 and 0.443. The results show that the level of CTS is included in the low category with a score of 13.75%. One of the factors that results in low skill scores is the lack of facilities in the form of interactive LKPD teaching materials.

**Keywords:** Critical thinking, learning methods, teaching, materials, LKPD

## Introduction

The current fact is that education in Indonesia is still not of maximum quality in improving these skills. Based on PISA data, Indonesia is in a worrying position with a ranking of 62 out of 72 OECD countries based on science and mathematics capabilities from 2018 to 2023 (Ismawati et al., 2023). In addition to science and mathematics capabilities, in terms of education in general according to Unesco, Indonesia needs to improve education due to existing challenges (Safitri et al., 2022). The national situation shows that improving the quality of education is currently very much needed. This improvement is one of the efforts to increase the national accreditation status of the country (Wasis et al., 2018).

Education is inseparable from the process, system, and evaluation of learning, which greatly influences the quality of education. Simple learning methods often hinder the development of students' critical thinking skills (CTS), especially in understanding complex physics concepts (Pereira et al., 2023). The lack of use of interactive learning media, including student worksheets at have not been designed adaptively, makes students less

motivated to explore and relate physics material to everyday phenomena. As a result, students tend to be passive and have difficulty developing analytical and problem-solving skills, which are important for training critical thinking (Hwang et al., 2015).

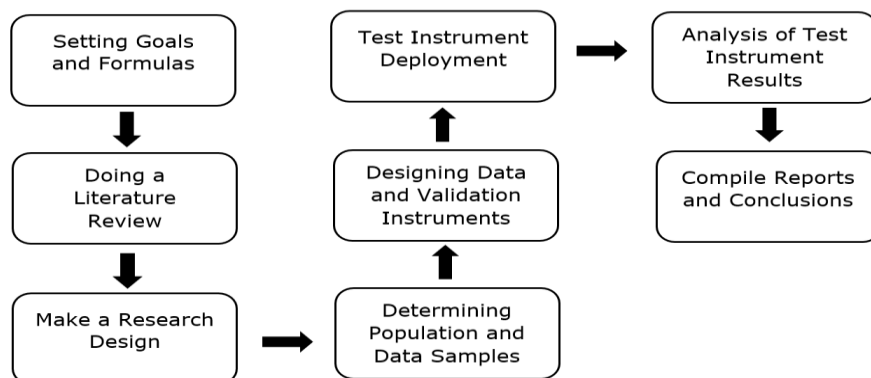
The use of PBL based LKPD on renewable energy material can improve students' CTS through contextual problem analysis and conclusion activities (Anggraeni, 2022). Developed PBL-based LKPD on fluid dynamics material that encourages students to identify problems and build scientific arguments critically. Analyzed the need for PBL-based E-LKPD on filtration material designed to train students' skills in formulating questions and evaluating experimental procedures (Morales, 2021). Developed liveworksheets-assisted E-LKPD based on the predict-observe-explain (POE) model on the kinetic theory of gases to improve students' ability to think logically and reflectively. Implemented interactive PBL-based E-LKPD on temperature and heat material which was proven to be effective in improving students' ability to compare data and assess scientific arguments (Ningrum, 2024). Physics LKPD based on the POE model on parabolic motion material was able to train students in making predictions and reflecting on observation results critically (Roffey & Quinlan, 2021). The discovery learning model assisted by E-LKPD on dynamic electricity material was effective in developing students' abilities in evaluating solutions to experimental problems (Shofiyah, 2024); developed problem-based LKPD on Newton's law material that facilitated students to think critically through accurate case analysis and the preparation of scientific solutions (Subariyanto, 2022). From several studies, it can be seen that no researchers have tried to analyze students' CTS on geometric wave material using interactive LKPD. From several studies, it can be seen that no researchers have tried to analyze students' CTS on geometric wave material using interactive LKPD (Susilawati, 2023).

Based on this urgency, this study aims to analyze the CTS of students in geometric wave material based on contextual phenomena using interactive LKPD. This is based on the fact that one of the components in improving education is the use of appropriate media and learning models (Hanif, 2020), so it is necessary to analyze the need for media development in physics learning. This study also involves describing the need for assessment instruments in physics learning that are in accordance with the learning models and media used. In the future, this research can be a basis or study in the development of innovative learning.

## Methods

The research uses a quantitative descriptive method. Quantitative research is Research that functions to examine samples with statistical data analysis using certain numerical samples (Pramudita et al., 2023). The results of this study were obtained based on primary data and secondary data as reinforcement in the study (Bauer et al., 2021). Primary data was obtained from observation results, critical thinking test instruments, and student response questionnaires. Observations can be obtained at each meeting with each observer based on responses from educators. Furthermore, secondary data was obtained from a literature review that was the theoretical basis of the study. The following is a draft research design.

The conclusion of the study is based on the objectives of the desired study. The study was conducted in several high schools in Lamongan Regency, East Java. Samples from the study were taken randomly from the total population involved (Sutrimo et al., 2024). This study was conducted in learning to analyze the initial ability of students in critical thinking on wave material. At the same time, to determine the need for media that is by the interests and learning in schools. The following are indicators of critical thinking used in the study (Bhakti et al., 2023; Black, 1988; Facione, 2015; Lintangesukmanjaya et al., 2024).



**Figure 1.** Research Design

The CTS indicators used refer to the Facione framework, the tendency to think critically can be true by thinking systematically, full of curiosity, and independently to improve the quality of cognitive abilities in students' thinking. The results of the test instrument with CTS indicators were given to students before studying the wave material with certain learning. The data were analyzed using descriptive statistics. Meanwhile, the CTS in this study are based on the score of answers to the questions described as presented in Table 1.

**Table 1.** Level of CTS

CTS Level	Score
Superior (S)	81 – 100
Above Average (AA)	61 – 80
Average (A)	41 – 60
Below Average (BA)	21 – 40
Poor (P)	0 – 20

(Source: Satriawan et al., 2020)

### Research Design and Procedures

This study uses quantitative analysis techniques to evaluate students' CTS through the results of the test instrument assessment and response questionnaires. The data analysis process is carried out in two main stages, namely the analysis of critical thinking indicator scores and exploratory factor analysis (EFA) to measure the validity and reliability of the response questionnaire. The total and average scores are calculated for each indicator, and based on the analysis, the overall average score is as in Table 2 to indicate the level of CTS (Satriawan et al., 2020).

Data visualization is carried out through a comparison diagram of scores between indicators to identify indicators with the highest and lowest values. In addition, the response questionnaire was analyzed using EFA with the Kaiser–Meyer–Olkin (KMO) test and the Bartlett test to measure data fit. The results of the KMO test were 0.802 and the Bartlett test was significant ( $p < 0.001$ ) indicating that the data was suitable for factor analysis (Suprpto, 2019). PCA revealed two main factors with eigenvalues  $> 1$ , which cumulatively explained 50.89% of the total variance. Reliability was measured using Cronbach alpha, with an overall value of 0.803 indicating high reliability, although there was a factor with moderate reliability (0.443) due to differences in students' perceptions of the questionnaire items. This approach allows the study to identify specific weaknesses in students' CTS and reveal the need for teaching materials that better support the development of these skills. Visualization of the results through value diagrams and loading

factors helps to summarize the findings comprehensively for the preparation of recommendations for further learning development. This study employed an experimental method with a one-group pretest-posttest design, which lacked a control group (Sugiyono, 2017). The design was chosen so that one group would receive intensive and planned treatment so that the result obtained would be more optimal. The objective was to assess the efficacy of the case-based learning (CBL) model when integrated with question-and-answer methods and class discussions, and in enhancing.

## Results and Discussion

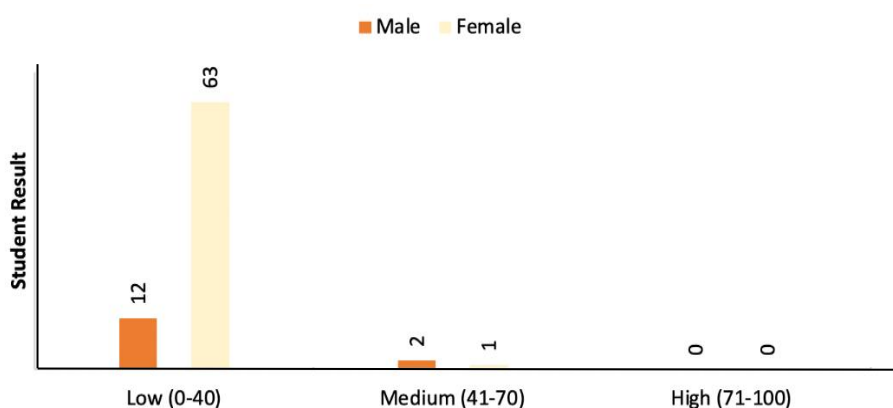
### Critical Thinking Indicator Assessment Results

Based on the assessment with a score interval for each indicator of 0 to 100, the results of the analysis of the answers of 78 students in the assessment of the critical thinking question instrument were as follows.

**Table 2.** Results of critical thinking indicator question assessment

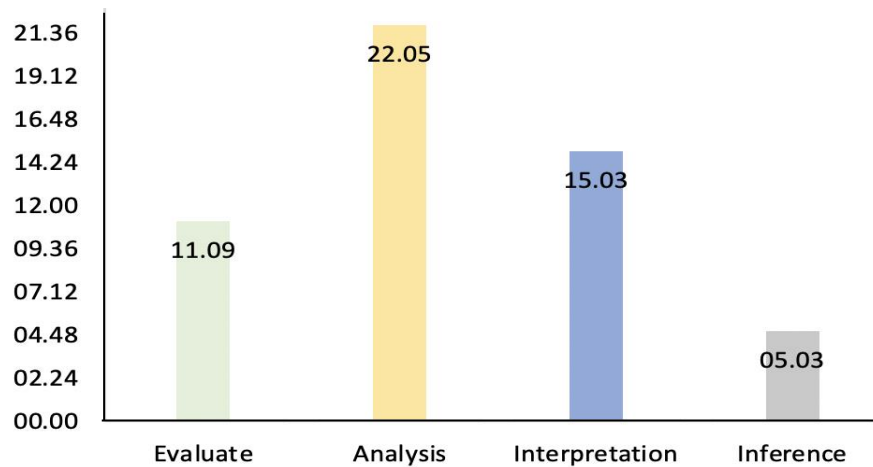
Number	Score	Rate (%)
1	930	11.9
2	1760	22.5
3	1200	15.3
4	420	5.3
Rate		13.75

As explained previously, the critical thinking test instrument is used to determine students' skills in answering questions on the integrated wave material of critical thinking indicators. From the average overall score of the critical thinking indicator, students have a score of 13.75% in the low category with an interval of 0 to 20. Based on the average score category for each question, the following are the results of the scores obtained by students in working on the questions (Yulia & Rusdianto, 2018).



**Figure 2.** Student result

There were no students who were able to get high category scores, this difficulty is related to the skills in answering each question given (Al-Fikry et al., 2018). If analyzed per indicator in the CTS used, the comparison diagram of scores for each critical thinking indicator is as follows.



**Figure 3.** Comparison of students' CTS indicator score

Based on Figure 3, inference is the indicator with the lowest value. This means that students have difficulty concluding and weighing information from relevant data (Nainggolan et al., 2023). In addition, it was also found that analysis is an indicator of CTS with the highest value. Students can analyze simply based on the phenomena or problems given (Rini et al., 2021). However, the value of the overall indicator is relatively low so all of these indicators have a level of difficulty for students.

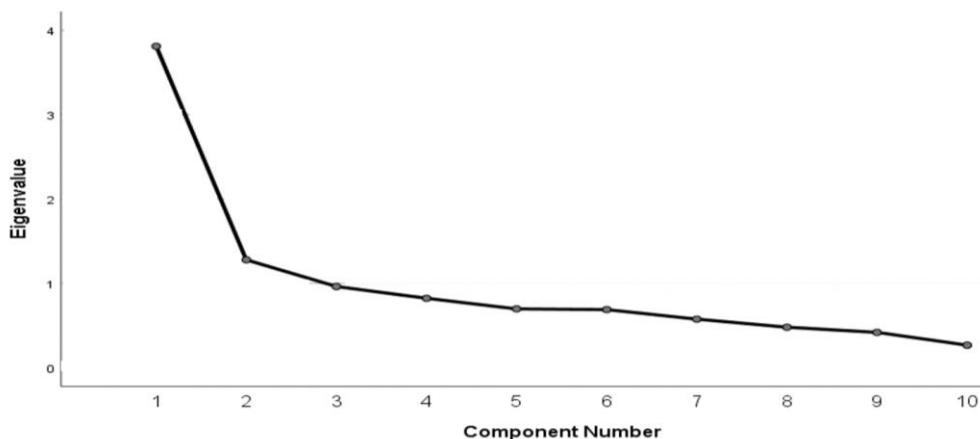
### Student Response Questionnaire Results

In addition to the results of CTS data, there are data from questionnaires distributed to students after they have completed critical thinking test questions. Based on the research that has been conducted, the results of the questionnaire were obtained using EFA analysis. Table 3 shows the Kaiser–Meyer–Olkin (KMO) value of 0.802 and the Bartlett test results are significant ( $\chi^2 = 534.997$ ,  $df = 45$ ,  $p < 0.001$ ) indicating that the data is suitable for factor analysis (Suprpto, 2019). The eigenvalues of the two proposed factors from the PCA are all greater than one (Figure 4 and Table 3).

**Table 3.** KMO results

Result	Score
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy.	0.802
Approx. chi-square	534.997
Bartlett's Test of Sphericity	df
	45
Sig.	0.000

Based on Table 3, the results of the analysis show that the KMO value of 0.802 indicates that the sample is sufficient for factor analysis because this value is above the recommended threshold of 0.6 (Kaiser, 1974). The Bartlett test produces a chi-square value of 534.997 with a degree of freedom (df) of 45 and a significance value of  $p < 0.001$ , which indicates that the correlation between items is significantly strong enough to be further analyzed using factor analysis (Suprpto, 2019).



**Figure 4.** Eigenvalue diagram the implementation of the case-based learning

Scree Plot Figure 4 shows the presence of two main factors that have eigenvalues greater than 1, according to the Kaiser criterion (Figure 4). The first factor has an eigenvalue of 3.810 and explains 38.099% of the total variance, while the second factor has an eigenvalue of 1.279 which contributes 12.79% of the total variance (Table 3). Cumulatively, these two factors explain 50.89% of the total data variability, which means that more than half of the variability in students' responses to LKPD can be explained by these two factors.

**Table 4.** Eigenvalue Factors

Component (Factors)	Initial Eigenvalue		
	Total	Variance (%)	Cumulative (%)
1	3.810	38.099	38.099
2	1.279	12.790	50.889

Based on Table 4, the results of the factor analysis show that two main factors influence students' responses to the student worksheet. The first factor has an eigenvalue of 3.810 and contributes 38.099% to the total variance, making it the most dominant factor in explaining the diversity of student responses. The second factor has an eigenvalue of 1.279 with a contribution of 12.79% to the total variance. Cumulatively, these two factors can explain 50.89% of the total data variability. In the factor analysis, item loadings ranged from 0.507 to 0.907, while items with factor loadings below 0.400 were excluded due to their low contribution to forming the factor (Suprpto & Ku, 2016; Suprpto, 2019). The reliability test showed that the first factor had a Cronbach alpha value of 0.825, indicating high reliability and strong internal consistency. Meanwhile, the second factor has a Cronbach alpha value of 0.443, which is relatively low, so it needs to be evaluated further to improve reliability or consider the possibility of other influencing factors. Overall, this analysis shows that the two main factors are strong enough to represent more than half of the variability of student responses to LKPD, although strengthening of the second factor is needed to improve the overall quality of the instrument. Overall, the Cronbach alpha value is 0.803 as in Table 6.

Based on the analysis conducted, two main factors have been identified as a fairly strong representation of the variability of student responses to LKPD. The first factor, namely the MPF has a Cronbach alpha value of 0.825, indicating a high level of reliability. This factor can explain 34.50% of the total variance, with items that have quite strong loading factors, such as items C (0.787), B (0.735), and E (0.717). On the other hand, the second factor, namely BAPF has a lower Cronbach alpha value, namely 0.443, which is

below the threshold of 0.60 for acceptable reliability (Sugiyono, 2022). This factor explains 16.38% of the total variance, with items such as I (0.718), J (0.691), and A (0.545).

**Table 6.** Loading factor

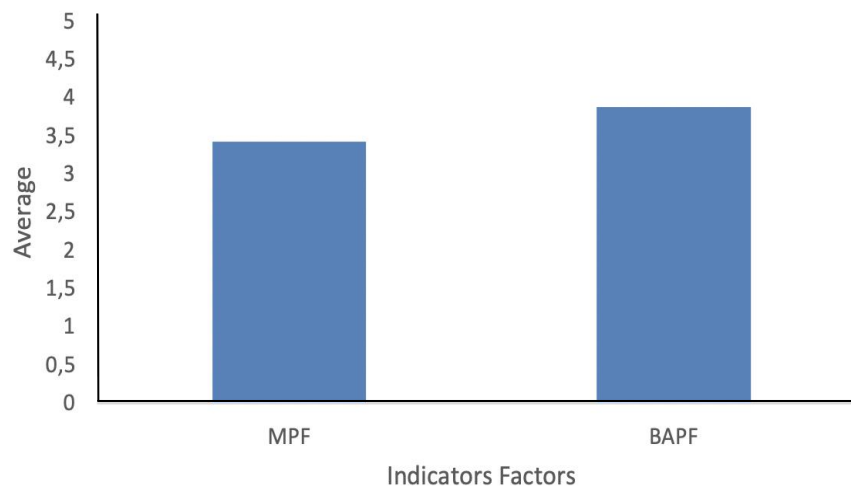
	(MPF) $\alpha = 0.825$	(BAPF) $\alpha = 0.443$
B	0.735	
C	0.787	
D	0.584	
E	0.717	
F	0.701	
G	0.762	
H	0.463	
A		0.545
I		0.718
J		0.691
Total variance explained = 50.89% and overall Cronbach alpha = 0.803		

Description:

MPF= Physics learning method

BAPF= Physics learning teaching materials

This lower reliability value indicates an inconsistency in student responses, which is most likely caused by differences in needs or perceptions of existing physics teaching materials. Questionnaire analysis can be represented in each factor as in Figure 5.



**Figure 5.** Diagram of each factor

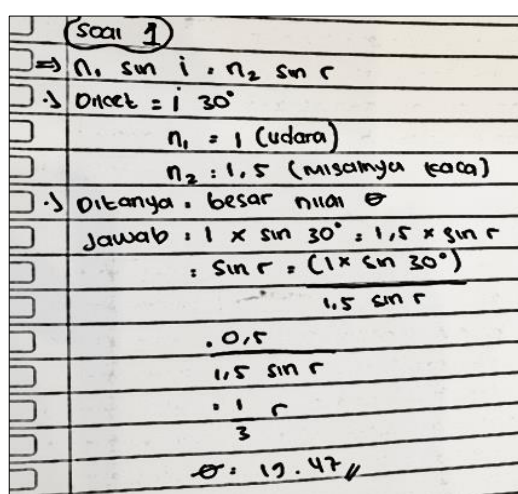
The results obtained show that MPF gets a lower graph than BAPF. Diagram 5 shows the total variance explained by these two factors is 50.89%, with an overall Cronbach Alpha value of 0.803, indicating that the instrument is generally quite reliable. However, the results of the diagram (Figure 5) show that the average score of MPF is lower than BAPF, indicating that students need more reinforcement in the aspect of physics teaching materials than learning methods.

### Analysis of Question Item Difficulty

Based on the results of the scores in the question instruments given to students to determine their CTS, an analysis of the difficulty of the question items can be carried out as an evaluation of the reasons and obstacles in critical thinking (Harjilah et al., 2019). The following is an analysis of the difficulty of the question items with 4 indicators of critical thinking.

#### a. Evaluation

Students' answers show that they tend to solve problems without following systematic steps. For example, even though they use the appropriate formula, many are unable to evaluate the refraction angle step by step, which results in less accurate final results. Evaluation is an important indicator of critical thinking, as it helps students connect the relevance of data to the analysis of the situation (Satriawan et al., 2020).



The image shows a handwritten student answer on lined paper. The student has written the following steps:

- Soal 1
- $\Rightarrow n_1 \sin i = n_2 \sin r$
- $\rightarrow Diket = i = 30^\circ$
- $n_1 = 1$  (udara)
- $n_2 = 1,5$  (misalnya kaca)
- Ditanya = besar nilai  $\theta$
- Jawab =  $1 \times \sin 30^\circ = 1,5 \times \sin r$
- $= \sin r = \frac{1 \times \sin 30^\circ}{1,5 \sin r}$
- $= 0,5$
- $1,5 \sin r$
- $= 1 r$
- $3$
- $\theta = 19,47^\circ$

Figure 6. Example of evaluation answer

For example, if students only calculate the refracted angle once without verifying the results in each medium, they may misinterpret the path of light. Instead, after finding the refracted angle in the first medium, students need to check whether the angle is consistent with Snell's law when the light enters the next medium. In this way, students not only memorize the formula but also understand the physical processes that occur gradually. To overcome this difficulty, teachers can provide scaffolding in the form of step-by-step guidance in the form of reflective questions: "Does the refracted angle result found to match the conditions of the next medium?" or "What if the refracted angle is greater than the critical angle?". This will train students to evaluate their answers before moving on to the next stage, improving their conceptual understanding and CTS (Wale & Bishaw, 2020).

#### b. Analysis

The analysis indicator is the indicator with the highest value in this question. Students are given instructions to explain and analyze how the color spectrum can occur in certain phenomena. Most of the students' answers are as follows.

<input type="checkbox"/>	
<input type="checkbox"/>	2) fenomena tersebut terjadi karena dispersi cahaya
<input type="checkbox"/>	Air dalam gelas kaca bertindak sebagai prisma
<input type="checkbox"/>	sinar matahari yg merupakan cahaya putih. Sebenarnya
<input type="checkbox"/>	terdiri dari berbagai warna berbeda ketika cahaya
<input type="checkbox"/>	putih melewati air panjang gelombang yang berbeda
<input type="checkbox"/>	dibiaskan (dibelokkan) pada sudut yg berbeda
<input type="checkbox"/>	sehingga memisahkan cahaya putih menjadi spektrum
<input type="checkbox"/>	warna pelangi yg terlihat pada dinding

**Figure 7.** Example of analysis answer

Based on Figure 7, students' answers show a good basic understanding of the phenomenon of light dispersion. They can explain that water in a glass cup acts as a prism that breaks white light into a spectrum of colors due to refraction. This shows that students understand the process of color separation that occurs when light passes through a medium with a different refractive index. The main obstacle lies in the lack of explanation regarding the physical aspects of light waves. Students have not associated different wavelengths with changes in speed and refraction angles that cause light to separate into spectrum colors. This understanding is important to provide a more in-depth and systematic analysis (Agustin et al., 2020). Regarding improving the quality of analysis, students can be directed to consider how shorter wavelengths (such as violet) are deflected more sharply than longer ones (such as red). In this way, they will better understand that the observed phenomenon is not only the result of simple refraction, but because of the complex interaction between wavelength, speed of light, and refractive index of the medium. This approach will help students develop sharper and more structured analysis skills.

c. Interpretation

Interpretation also means interpretation, classifying data or opinions in different statements accompanied by certain solutions (Wale & Bishaw, 2020). Students are given light wave data to be solved with equations that they determine themselves.

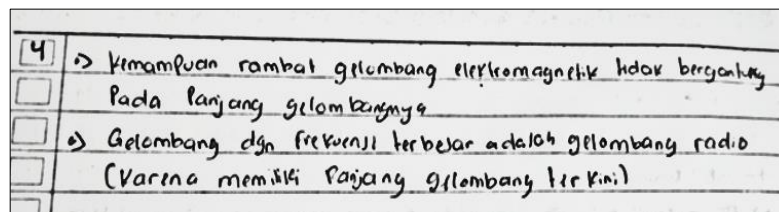
<input type="checkbox"/>			
<input type="checkbox"/>	3	lampu	frekuensi (f) (Hz)      Panjang gelombang (λ) (m)
<input type="checkbox"/>		4 x 10	16 x 10 <sup>12</sup> 1.875 x 10 <sup>-4</sup>
<input type="checkbox"/>		Neon	2 x 10 <sup>12</sup> 1.5 x 10 <sup>-4</sup>
<input type="checkbox"/>		Bohlan	Pada tidak lengkap      tidak dapat di bilang
<input type="checkbox"/>			
<input type="checkbox"/>		lampu yang ramah mata dan kesehatan	
<input type="checkbox"/>		→ Neon dan bohlan lebih ramah untuk mata karena memiliki	
<input type="checkbox"/>		spektrum lebih dekat ke cahaya alam.	
<input type="checkbox"/>		→ 4 x 10 = jika frekuensi mendekati UV, berfrekuensi berbahaya	
<input type="checkbox"/>		bagi mata dan kulit	

**Figure 8.** Example of interpretation answer

Based on Figure 8, students' answers show that they can collect and record numerical data related to the wavelength and frequency of light, but have difficulty interpreting the data into a deeper understanding. For example, they tend to just write down data without linking it to relevant physics concepts, such as the relationship between wavelength, frequency, and the speed of light. Interpretation in this context should involve students' ability to classify data and draw meaningful conclusions. For example, after recording the wavelength for various light spectrums, students should be able to explain the patterns that emerge. Such as that light with a shorter wavelength has a higher frequency, and how this affects the energy of the photon. To overcome this difficulty, teachers can provide guidance in the form of trigger questions such as: "What can be concluded from the change in wavelength to frequency?" or "How does this relationship explain the color of light we see?". In this way, students are trained not only to collect data but also to connect it to physics principles, so that they can make richer and more accurate interpretations. Most of the students' answers, had difficulty in finding patterns of interpretation from data into physics formulas. Most students simply rewrite the data they read (Marissa et al., 2024).

d. Inference

The inference indicator is the indicator with the lowest value among other indicators. The main difficulty in inference so far is concluding information and utilizing it in several decisions (Lintangesukmanjaya et al., 2024). Students are unable to conclude information in graphs containing information on wavelength and speed of light. Here are examples of student answers as follows.



**Figure 9.** Example of inference answer

Based on Figure 9, students' answers show that inference is the biggest challenge in solving the problem. Many students have difficulty in concluding information from graphs that present data on wavelength and speed of light. They tend to stop at the stage of reading the data without going further to connect the variables and draw logical conclusions. Inference requires the skills to relate existing data to relevant physics concepts, and then make decisions based on the analysis. For example, students should be able to observe patterns in the relationship between larger wavelengths and the constant speed of light, and then conclude how wavelength affects the energy or color of visible light. To help students develop this skill, teachers can provide guidance in the form of gradual questions: "What pattern is seen from the change in wavelength?" or "What conclusion can be drawn if the wavelength increases, but the speed of light remains the same?" With this approach, students are trained not only to read data but also to connect it to broader physics concepts, so that they can construct appropriate and meaningful inferences (Adilla & Jatmiko, 2021). Students' CTS are still relatively low and require improvement. The cause of students' low CTS is the lack of facilities for learning. This was proven by a student questionnaire using EFA analysis.

### **LKPD Findings and Phenomenon-Based Assessment Instruments**

Student response questionnaire analysis can be a source of data in determining student needs in future physics learning (Sari et al., 2021). According to the research results, students need learning that prioritizes surrounding phenomena. One of the learning methods that are suitable for phenomena is the PBL model (Yanti&Wijaya, 2023; Maskur et al., 2020). This learning prioritizes student activity in identifying problems from contextual phenomena. In addition to the need for a phenomenon-based learning model, students also need interactive teaching materials that are by the model. The learning methods used are also still lacking, so it becomes a student need as a complement to the need for teaching materials. Students still need interactive media teaching materials for physics learning. One of the interactive media or teaching materials that can be used in the PBL learning model is LKPD (Vivilia & Prahani, 2024).

LKPD is equipped with this phenomenon-based assessment instrument which is very suitable for use in the PBL model. This is because the active involvement of students through LKPD while getting a suitable assessment instrument will give an interesting impression, especially in solving phenomenal problems in everyday life. This can be a novelty in further research ideas to develop LKPD and assessment instruments based on phenomena in wave material. This study measures students' CTS in wave material through critical indicator-based question instruments, namely evaluation, analysis, interpretation, and inference. The results of the study showed that the average critical thinking score of students was still low, with an average score of 13.75% with a low category on an interval scale of 0% to 20% (Satriawan et al., 2020). The analysis indicator is the highest, indicating that students find it easier to understand phenomena rationally, although they still have difficulty linking them to deeper physics concepts, as found by Rini et al. (2021). Conversely, the inference indicator is the lowest, indicating that students have difficulty drawing conclusions and utilizing information for decision-making, in line with the research (Lintangesukmanjaya et al., 2024).

Questionnaire analysis using EFA identified two main factors that influence low CTS, namely less varied learning methods and limited interactive teaching materials. This finding is consistent with the research of Saphira et al. (2022), which found that the integration of interactive student worksheets can improve critical thinking scores, especially in the evaluation and inference indicators. Research by Nainggolan et al. (2023) also supports these results, stating that inference is often the weakest indicator because students have difficulty linking data to relevant conclusions. In addition, research by Suprpto & Ku (2016) and Suprpto (2019) shows that conventional learning methods and the lack of innovative teaching materials slow down the development of students' CTS. Furthermore, Adilla & Jatmiko (2021) revealed that the application of phenomenon-based LKPD can improve students' analytical and evaluation skills, although it still takes longer to train inference skills. Overall, these results strengthen the conclusion that it is necessary to adjust learning strategies that are more student-centered and enrich contextual and interactive teaching materials.

This intervention is expected to overcome students' difficulties in developing analytical, reflective thinking patterns, and better decision-making skills in physics learning. If this strategy is implemented continuously, a significant increase in students' CTS can be achieved. This research can be initial research towards the development of LKPD and assessment instruments based on phenomena on wave material to improve students' CTS in wave material. Theoretical studies and empirical data are advantages in research innovation (Samadun & Dwikoranto, 2022). In the future, this research step will be an implementation in realizing the goal of quality education through innovation in physics learning planning.

## Conclusion

CTS research has been conducted through student responses to test instruments with CTS indicators and measured using EFA on eigenvalue obtained values from two factors including MPF of 0.507 and BAPF of 0.907. The Cronbach alpha values on the two factors (MPF and BAPF) are 0.825 and 0.443. The results show that the level of CTS of students is included in the low category with a score of 13.75% from an interval scale of 0 to 20%. One of the factors that resulted in low skill scores was the lack of facilities in the form of interactive LKPD teaching materials.

## References

- Adilla, I.N., & Jatmiko, B. 2021. Keefektifan pembelajaran daring fisika SMA berbasis probing prompting untuk meningkatkan keterampilan berpikir kritis peserta didik. *Pendipa: Journal of Science Education*, 5(3):426-435. <https://doi.org/10.33369/pendipa.5.3.426-435>
- Agustin, L., Haryanto, Z., & Efwinda, S. 2020. Pengaruh model pembelajaran inkuiri terbimbing terhadap kemampuan berpikir kritis siswa kelas XI SMA Negeri 9 Samarinda. *Jurnal Literasi Pendidikan Fisika (JLPF)*, 1(1):56-64. <https://doi.org/10.30872/jlpf.v1i01.80>
- Al-Fikry, I., Yusrizal, Y., & Syukri, M. 2018. Pengaruh model problem based learning terhadap kemampuan berpikir kritis peserta didik pada materi kalor. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 6(1):17-23. <https://doi.org/10.24815/jpsi.v6i1.10776>
- Anggraeni, P., Sunendar, D., Maftuh, B., Sopandi, W., & Puspita, R. D. 2022. Why 6 Cs? The urgency of learning at elementary school. In *4th International Conference on Educational Development and Quality Assurance (ICED-QA 2021)*. Atlantis Press: 35-41. <https://doi.org/10.2991/assehr.k.220303.008>
- Bauer, G.R., Churchill, S.M., Mahendran, M., Walwyn, C., Lizotte, D., & Villa-Rueda, A.A. 2021. Intersectionality in quantitative research: A systematic review of its emergence and applications of theory and methods. *SSM-Population Health*, 14:100798. <https://doi.org/10.1016/j.ssmph.2021.100798>
- Bhakti, Y.B., Arthur, R., & Supriyati, Y. 2023. Development of an assessment instrument for critical thinking skills in physics: a systematic literature review. *Journal of Physics: Conference Series*, 2596(1):012067. <https://doi.org/10.1088/17426596/2596/1/012067>
- Heiman, M., & Slomianko, J. 1987. Thinking skills instruction: concepts and techniques. *Building Students' Thinking Skills Series*. National Education Association of the United States. [https://doi.org/10.1177/01926365880725\\_0830](https://doi.org/10.1177/01926365880725_0830)
- Facione, P.A. 2015. Critical thinking: What it is and why it counts. *Insight assessment*, 1(1):1-23. <https://www.law.uh.edu/blakely/advocacysurvey/Critical%20Thinking%20Skills.pdf>
- García-Morales, V.J., Garrido-Moreno, A., & Martín-Rojas, R. 2021. The transformation of higher education after the covid disruption: emerging challenges in an online learning

- scenario. *Frontiers in Psychology*, 12(2):1–6. <https://doi.org/10.3389/fpsyg.2021.616059>
- Hanif, M. 2020. The development and effectiveness of motion graphic animation videos to improve primary school students' sciences learning outcomes. *International Journal of Instruction*, 13(3):247–266. <https://doi.org/10.29333/iji.2020.13416a>
- Ismawati, E., Hersulastuti, Amertawengrum, I.P., & Anindita, K.A. 2023. Portrait of education in indonesia: learning from pisa results 2015 to present. *International Journal of Learning, Teaching and Educational Research*, 22(1):321–340. <https://doi.org/10.26803/ijlter.22.1.18>
- Lintangesukmanjaya, R.T., Prahani, B.K., Marianus, M., Wibowo, F.C., Costu, B., & Arymbekov, B. 2024. Profile of students' critical thinking skills in 3d module learning material on gas kinetic theory with inquiry model. *Jurnal Pendidikan Sains Indonesia*, 12(1):77–94. <https://doi.org/10.24815/jpsi.v12i1.33877>
- Maskur, R., Sumarno, Rahmawati, Y., Pradana, K., Syazali, M., Septian, A., & Palupi, E.K. 2020. The effectiveness of problem-based learning and aptitude treatment interaction in improving mathematical creative thinking skills on curriculum 2013. *European Journal of Educational Research*, 9(1):375–383. <https://doi.org/10.12973/eujer.9.1.375>
- Sutrimo, M.S, Sajdah, S.N., Sinambela, Y.V.F., & Bagas, R. 2024. Peningkatan literasi numerasi melalui model pembelajaran dan hubungannya dengan kemampuan self-efficacy: Systematic literatur review. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, 7(1):61–72. <https://doi.org/10.22460/jpmi.v7i1.21650>
- Nainggolan, S.S., Putri Johan, D. H., & Purwanto, A. 2023. Analisis kemampuan berpikir kritis siswa pada materi dinamika rotasi dan keseimbangan benda tegar di sman 7 kota bengkulu. *Jurnal Penelitian Pembelajaran Fisika*, 14(1):39–48. <https://doi.org/10.26877/jp2f.v14i1.13617>
- Ningrum, R.A., Qomaria, N., Hadi, W.P., Ahied, M., & Sutarja, M.C. 2024. Kelayakan E-LKPD berbasis literasi sains materi getaran dan gelombang. In *Jurnal Natural Science Educational Research* 7(1):121-128. <https://doi.org/10.21107/nser.v7i1.14215>
- Pereira, V.V., Samsudin, A., & Utama, J.A. 2023. Mengkaji keterampilan berpikir kritis siswa menggunakan model problem based learning berbantuan teknik probing prompting (PBL-PP). *Jurnal Muara Pendidikan*, 8(1):170–179. <https://doi.org/10.52060/mp.v8i1.1175>
- Pramudita, A.D., Rahmawati, E., Himmatul Ilmi, L., Amatullah, S., & Damayanti, Z. 2023. Analisis pengaruh kemampuan berpikir kritis terhadap pemahaman konsep gelombang elektromagnetik mahasiswa pendidikan fisika. *Jurnal Ilmiah Wahana Pendidikan*, 9(14):105–113. <https://doi.org/10.5281/zenodo.8170616>
- Rini, C.P., Dwi Hartantri, S., & Amaliyah, A. 2021. Analisis kemampuan literasi sains pada aspek kompetensi mahasiswa PGSD FKIP Universitas Muhammadiyah Tangerang. *Jurnal Pendidikan Dasar Nusantara*, 6(2):166–179. <https://doi.org/10.29407/jpdn.v6i2.15320>

- Roffey, S., & Quinlan, D. 2021. Positive education with disadvantaged students. *The Palgrave Handbook of Positive Education* (pp. 645-674). Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-030-64537-325>
- Safitri, A.O., Yunianti, V.D., & Rostika, D. 2022. Upaya peningkatan pendidikan berkualitas di Indonesia: analisis pencapaian sustainable development goals (SDGs). *Jurnal Basicedu*, 6(4):7096–7106. <https://doi.org/10.31004/basicedu.v6i4.3296>
- Samadun, S., & Dwikoranto, D. 2022. Improvement of student's critical thinking ability in physics materials through the application of problem-based learning. *IJORER: International Journal of Recent Educational Research*, 3(5):534–545. <https://doi.org/10.46245/ijorer.v3i5.247>
- Saphira, H.V., Rizki, I.A., Alfarizy, Y., Saputri, A.D., Ramadani, R., & Suprpto, N. 2022. Profile of students' critical thinking skills in physics learning: A preliminary study of games application integrated augmented reality. *Journal of Physics: Conference Series*, 2377(1): 012088). <https://doi.org/10.1088/1742-6596/2377/1/012088>
- Sari, P., Dwikoranto, D., & Lestari, N.A. 2021. Analisis respon dan ketertarikan peserta didik terhadap pelaksanaan pembelajaran fisika berbasis environmental learning di SMA. *Pendipa Journal of Science Education*, 5(3):337–344. <https://doi.org/10.33369/pendipa.5.3.337-344>
- Satriawan, M., Rosmiati, R., Widia, W., Sarnia, F., Suswati, L., Subhan, M., & Fatimah, F. 2020. Physics learning based contextual problems to enhance students' creative thinking skills in fluid topic. *International Conference on Mathematics and Science Education (ICMSce)* :1–7. <https://doi.org/10.1088/1742-6596/1521/2/022036>
- Shofiyah, N., Suprpto, N., Prahani, B.K., Jatmiko, B., Anggraeni, D.M., & Nisa', K. 2024. Exploring undergraduate students' scientific reasoning in the force and motion concept. *Cogent Education*, 11(1):2365579. <https://doi.org/10.1080/2331186X.2024.2365579>
- Subariyanto, M.I., Ambarita, A., & Yulianti, D. 2022. Pengembangan E-LKPD berbasis discovery learning untuk mengoptimalkan kemampuan berpikir kritis peserta didik SD. *Elementary: Jurnal Ilmiah Pendidikan Dasar*, 8(1):522–86. <https://doi.org/10.32332/elementary.v8i1.4620>
- Sugiyono. 2014. *Statistika untuk penelitian*. Bandung: Alfabeta.
- Susilawati, S., Yaqin, M.Z.N., Wahidmurni, W., & Putri, C. A. 2023. Assessment of needs for developing curriculum study program for masters of education in madrasah ibtidaiyah teachers towards excellent accreditation. *Nidhomul Haq: Jurnal Manajemen Pendidikan Islam*, 8(2):302–314. <https://doi.org/10.31538/ndh.v8i2.3959>
- Wale, B.D., & Bishaw, K.S. 2020. Effects of using inquiry-based learning on EFL students' critical thinking skills. *Asian-Pacific Journal of Second and Foreign Language Education*, 5(1):1-14. <https://doi.org/10.1186/s40862-020-00090-2>
- Wasis, W., Sulaiman, R., Sudibyoy, E., Yonata, B., & Prastiwi, M.S. 2018. The assessment model of undergraduate mathematics and science education competency based on

indonesian national qualification framework and 21st century demand. In *Mathematics, Informatics, Science, and Education International Conference (MISEIC 2018)* (pp. 117-121). Atlantis Press. <https://doi.org/miseic-18/25905022>

Yulia, I., & Risdianto, E. 2018. *Pengembangan LKPD berbasis inquiry berbantuan simulasi phet untuk meningkatkan penguasaan konsep gelombang cahaya di kelas XI MIPA SMAN 2 Kota Bengkulu*, 1(3):64-70. <https://doi.org/10.33369/jkf.1.3.64-70>