Analysis of Students' Critical Thinking Skills Profile and Implementation of PBL on Sound Wave Material

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Abstract **– In the 21st century, students are expected to be able to have critical thinking skills to be able to read and solve problems in their daily lives. For this reason, it is important to determine appropriate learning models and media. Problem-Based Learning (PBL) is a learning model that can improve critical thinking skills. This research was conducted to determine students' critical thinking skills and determine the application of learning models in physics subjects, especially in the PBL learning model. The sample consisted of 50 class XI students in one of the high schools in Gresik. The research results from the question instruments show the low level of students' critical thinking skills. The results of interviews with physics educators explained that physics learning activities so far have used several innovative learning models and media. Questionnaire responses showed that students had the perception that they had met the indicators of critical thinking skills, and also showed interest in implementing the 3D digital module. So it can be concluded that there is a need to implement physics learning using the help of interactive learning media such as 3D digital modules to increase students' activeness in learning and train critical thinking skills.**

Keywords **– Problem-Based Learning, critical thinking skill, physics.**

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1. Introduction

Physics is a science that studies natural phenomena and technological advances that occur in everyday life in a systematic way [1] and is a branch of Natural Science [2]. Based on this definition, in physics learning, teachers need to provide contextual examples and problems, which enable students to train problem-solving skills and the level of critical thinking in searching for and analyzing the right concept for the problem. Critical thinking skills are important for individuals, especially students, to possess in the 21st century, [3], [4].

Critical thinking skills are the level of skill that a person has in reading known concepts to create a solution to a problem. Critical thinking skills are very important in the world of education today [5], and they are fundamental skills in the effective decision-making process [6]. With critical thinking skills, someone can solve problems logically and responsibly [7], [8]. Apart from that, the level of skilled critical thinking certainly influences students' learning outcomes [9]. By implementing appropriate learning activities, students can get used to practicing critical thinking skills [10].

Much research has been conducted discussing the level of critical thinking skills, especially in physics subjects. According to research conducted by Sarip et al. [11], the percentage of critical thinking skills of 256 class X high school students is still relatively low. Likewise, the research output of Affandy et al. [12] on dynamic fluid material and research by Ardiyanti & Nuroso [13] on static fluid material shows that the percentage of critical thinking in class XI among the high school students is also still low. This phenomenon is influenced by various factors, namely the lack of suitability of the use of learning models, and a lot of research has been carried out recently regarding the development of certain learning models to increase the level of critical thinking [14]. In this research, the author took the initiative to test and analyze the level of students' critical thinking skills in sound wave material as well as making observations regarding students' learning conditions in physics subjects.

2. Methodology

This research was carried out using descriptive qualitative methods. Descriptive qualitative methods are generally used to research objectively natural conditions to obtain data that occurs in the field. From the data obtained, it will then be used as a benchmark in developing a PBL learning model based on 3D digital modules. Data analysis was carried out using the Rasch Model using the Ministep application to determine the level of critical thinking skills per research subject from each class.

The data collection technique consisted of interviews with physics teachers and administering test instruments and questionnaires to class XI students at one of the high schools in Gresik. The samples tested were 50 students divided into 3 classes. The teacher's interview consists of 6 questions to find out the physics learning process that has been implemented in schools so far.

The questionnaire consists of 12 questions to find out the percentage of critical thinking skill levels according to each student and to determine students' interest in 3D digital module devices. The test instrument contains 15 descriptive questions to measure students' critical thinking skills, especially on sound wave material.The data obtained consisted of 2 types, namely output data from critical thinking skills instruments and a questionnaire regarding the need for a PBL learning model assisted by 3D digital modules. The samples were divided into three classes, with two classes containing 20 samples and one class containing 10 samples. The instrument questions consist of 15 items, each of which represents one indicator of critical thinking skills according to Ennis [15], so each indicator is represented by 3 items. The grid of test instrument items is written in Table 1 below.

Table 1. Critical thinking skills instrument content

Aspect	Indicator	No. Item	Total Items
Elementary Clarification	1. Focusing the question 2. Analyze the argument 3. Ask and answer clarifying questions	2, 10, 14	3
Basic Support	1. Consider whether the source is trustworthy or not 2. Observe and consider the results of the observation	1, 7, 12	3
Inference	1. Make deductions and consider the results of the deduction 2. Make an induction and consider the results of the induction 3. Make and consider value decisions	3, 5, 13	3
Advanced Clarification	1. Define terms and consider definitions 2. Identify assumptions	4, 6, 8	3
Strategies and Tactics	1. Determine action 2. Interact with other people	9, 11, 15	3

3. Results and Discussion

SUMMARY OF 20 MEASURED Person

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	25.8	15.0	-.45	.19	1.00	-.03	1.11	.09
SEM	1.8	.0	.06	.00	.11	.30	.23	.36
P.SD	7.8	.0	.28	.01	.47	1.33	.99	1.59
S.SD	8.0	.0	.28	.01	.48	1.36	1.01	1.63
MAX.	51.0	15.0	.44	.21	1.89	2.12	4.98	5.10
MIN.	17.0	15.0	-.78	.18	.49	-1.62	.48	-1.39

REAL RMSE	.21	TRUE SD	.18	SEPARATION .84	Person RELIABILITY .41
MODEL RMSE	.19	TRUE SD	.20	SEPARATION 1.02	Person RELIABILITY .51

S.E. OF Person MEAN = .06

LACKING RESPONSES: 1 Person
Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .52 SEM = 5.41
STANDARDIZED (50 ITEM) RELIABILITY = .78

Figure 1. Table of average measurements for class XI-4 samples

Based on Figure 1, it can be seen that the average value of the measure section is -0.45. This value is below the logit value of 0, which indicates that the critical thinking skills of students in class XI-4 are still below average or relatively low. This is confirmed by the variable map shown in Figure 2. In Figure 2, one can see the distribution of each student's critical thinking skills on the left and the item difficulty level on the right. As we move up, the scale indicates increasingly higher levels of critical thinking skills and increasingly difficult items.

On the map, one can see 1 student with absence number 05 who has a logit number above 0, which indicates that the student has an above-average level of critical thinking skills. There is also 1 student with roll number 03 who has a logit value equal to 0, which means the student has an average level of critical thinking skills. Meanwhile, 18 other students had logit numbers below 0, which shows that the majority of students have relatively low critical thinking skills.

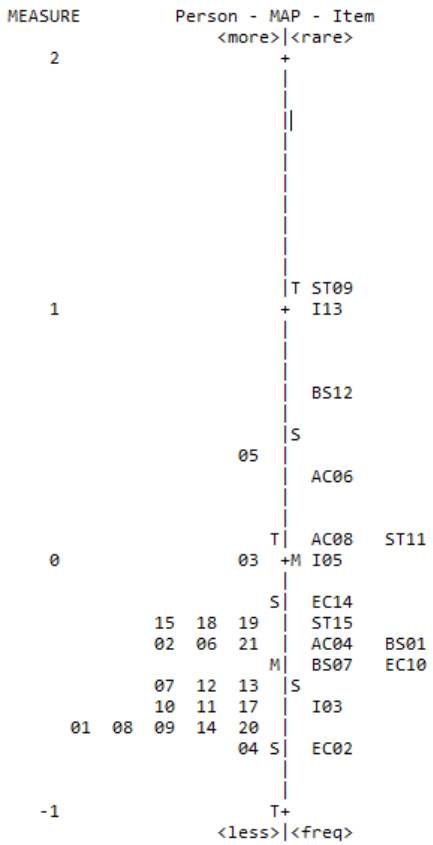

Figure 2. Map of research variables for class XI-4

Figure 2 also shows the level of difficulty of the items along with codes indicating representative indicators of critical thinking skills. Items with the prefix code *EC* represent the Elementary Clarification indicator, *BS* represents the Basic Support indicator, *I* represent the Inference indicator, *AC* for the Advanced Clarification indicator, and *ST* for the Strategies and Tactics indicator.

For students whose logit number is below 0, on average they can work on items with codes EC02 and I03. This shows that on average participants were only able to complete 1 item with the Elementary Clarification indicator and 1 item with the Inference indicator out of a total of 3 items per indicator. Therefore, it can be concluded that class XI-4 students still have a low level of critical thinking skills in all five aspects.

SUMMARY OF 20 MEASURED Person

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	29.0	15.0	-.22	.17	.97	.01	1.07	.17
SEM	2.4	.0	.07	.00	.08	.20	.14	.25
P.SD	10.6	.0	.30	.02	.33	.88	.62	1.11
S.SD	10.9	.0	.31	.02	.34	.90	.64	1.14
MAX.	50.0	15.0	.33	.25	1.62	1.70	2.28	2.04
MIN.	8.0	15.0	-.96	.16	.46	-.98	.27	-.99

REAL RMSE .18 TRUE SD .24 SEPARATION 1.34 Person RELIABILITY .64
MODEL RMSE .17 TRUE SD .25 SEPARATION 1.45 Person RELIABILITY .68
S.E. OF Person MEAN = .07

Person RAW SCORE-TO-MEASURE CORRELATION = .99
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .65 SEM = 6.25
STANDARDIZED (50 ITEM) RELIABILITY = .88

Figure 3. Table of average measurements for class XI-3 samples

Based on Figure 3, it can be seen that the average value of the measure section is -0.22. This value is slightly above the average value for class XI-4, but still below the logit value of 0, indicating that the critical thinking skills of students in class XI-3 are still below average or relatively low. This is confirmed by the variable map shown in Figure 4.

In Figure 4, it can be seen that 4 students with absence numbers 10, 02, 01, and 14 have a logit number above 0, which indicates that these students have a level of high critical thinking skills. Meanwhile, 16 other students had a logit score below 0, which shows that the majority of students have relatively low critical thinking skills.

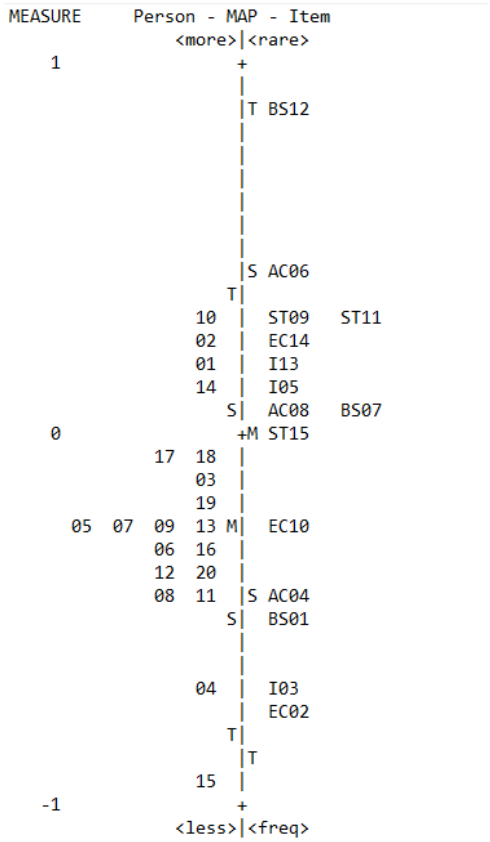

Figure 4. Map of research variables for class XI-3

Figure 4 also shows the level of difficulty of the items along with codes indicating representative indicators of critical thinking skills.

For students whose logit number is below 0, on average they can work on items with codes AC04, BS01, I03, and EC02.

This shows that on average participants were only able to complete 1 item for each indicator, except for the Strategies and Tactics indicator, out of a total of 3 items per indicator.

Therefore, it can be concluded that class XI-3 students still have a low level of critical thinking skills in all five aspects.

SUMMARY OF 10 MEASURED Person

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	22.7	15.0	-.61	.22	1.03	.09	.99	.05
SEM	4.1	.0	.17	.01	.17	.39	.24	.43
P.SD	12.4	.0	.51	.04	.51	1.16	.71	1.28
S.SD	13.1	.0	.54	.04	.53	1.22	.74	1.34
MAX.	45.0	15.0	.23	.30	2.02	2.60	2.92	3.49
MIN.	7.0	15.0	-1.40	.18	.53	-1.16	.38	-1.18

REAL RMSE	.24	TRUE SD	.45	SEPARATION 1.84	Person RELIABILITY .77
MODEL RMSE	.22	TRUE SD	.46	SEPARATION 2.07	Person RELIABILITY .81
S.E. OF Person MEAN = .17					

Person RAW SCORE-TO-MEASURE CORRELATION = .99
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .83 SEM = 5.06
STANDARDIZED (50 ITEM) RELIABILITY = .93

Figure 5. Table of average measurements for class XI-1 samples

Based on Figure 5, it can be seen that the average value of the measure section is -0.61. This value is the lowest when compared to the other 2 classes, and below the logit value of 0, indicating that the critical thinking skills of students in class XI-1 are still below average or relatively low. This is confirmed by the variable map shown in Figure 6.

In Figure 6, it can be seen 2 students with roll numbers 08 and 11 who have a logit number above 0, which shows that these students have a high level of critical thinking skills above average. Meanwhile, 8 other students had logit numbers below 0, which shows that the majority of students have relatively low critical thinking skills.

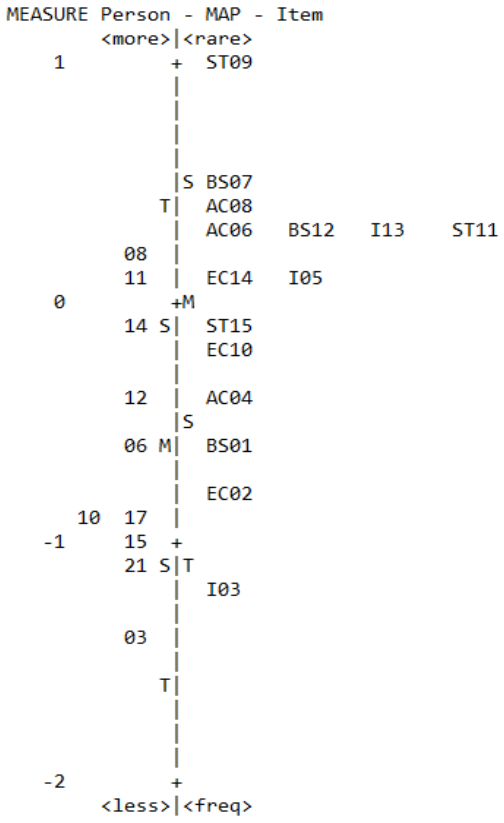

Figure 6. Map of research variables for class XI-1

Figure 6 also shows the level of difficulty of the items along with codes indicating representative indicators of critical thinking skills. For students whose logit number is below 0, on average they can work on items with the code I03. This shows that on average participants were only able to complete 1 item for the Inference indicator, out of a total of 3 items per indicator. Therefore, it can be concluded that class XI-1 students still have a low level of critical thinking skills in the fifth aspect. Interviews were also conducted with physics teachers at the high school to find out the learning conditions of students in physics learning activities. There was 1 physics teacher who was the interviewee. There are 6 questions asked to find out the habits of teaching physics subjects at school.

Q1. So far, how are students' critical thinking skills in learning physics?
Answer:

Students' critical thinking skills in physics learning usually have to be trained in stages, they need to ask questions and also relate them to existing problems around them so that students can participate actively both individually and in groups.

Q2. So far, what learning models have you implemented during learning activities?
Answer:

Inquiry-Based Learning, Problem-Based Learning, Cooperative Learning.

Q3. What learning media have you used during physics learning activities? And why did you choose to use this media?
Answer:

Textbooks, PowerPoint, & animated videos. Because it is easier to use and allows students to understand things more easily.

Q4. Have you ever applied the Problem-Based Learning (PBL) learning model when teaching physics?
Answer:

There was, and it still continues to this day.

Q5. If so and still continuing, what makes you continue to apply the PBL learning model? And if it doesn't continue, what makes you stop?
Answer:

Students remember more easily if we relate it to a problem and this method can increase student activity and creativity.

Q6. In your opinion, what kind of learning model can improve students' critical thinking skills, especially in learning physics? And what learning media are effective in helping improve students' critical thinking skills?
Answer:

Problem-based learning with animated videos about everyday life. Because this method can trigger students to think critically.

The interview responses reveal that the teacher has implemented several innovative learning models, including inquiry learning models, PBL, and cooperative learning. Apart from that, students are also given lessons using animated videos and PowerPoint to attract their' attention.

Problem-Based Learning (PBL) is a learning model whose activities focus on training students to solve problems using the knowledge they already have to achieve an understanding of new concepts. Teachers provide examples and problems related to the concepts to be studied to students and guide them in the process of solving these problems [16], so that learning activities are more focused on students rather than teachers [17]. Learning models that focus on students are important in forming the ability to collaborate, innovate, and think critically, especially in the STEM field [18].

The PBL learning model itself has weaknesses, where the PBL objectives will not be achieved properly if students lack the motivation to find solutions to the problems given. Like other learning models, these approaches also emphasize student motivation as a key factor in achieving successful learning outcomes in school. Therefore, there is a need for assistance from learning media to attract attention and increase student motivation. The results of the interview above can be concluded that the teacher has implemented several types of innovative learning models which in theory and several previous studies can improve students' thinking abilities [19], [20], [21]. However, it can be assumed that the level of students' critical thinking skills is relatively low because students' motivation is also still low. In this case, teacher creativity in providing learning media as well as teaching materials can play an important role in increasing students' participation in learning activities [22]. Researchers then took the initiative to research further regarding learning media that can help and attract students' attention.

Various kinds of learning device innovations have been widely used, one of which is digital modules.

Digital modules have advantages compared to printed modules where digital modules can be filled with interesting content such as animated images, audio, and video [23].

These features can certainly attract students' attention to independent learning activities so that they automatically increase their learning motivation. In addition, digital modules can be accessed via any device, whenever and wherever students are so that students do not need to be stuck studying in one place, such as at school or home [24]. Digital modules can still be developed using 3D technology. 3D digital modules are usually developed using the 3D PageFlip Professional application by converting a PDF into a 3D display book that can be flipped back and forth like a real book. 3D digital modules can also provide an interactive learning experience so that students do not get bored quickly because they only read a text or see pictures. Learning with interactive media allows students to reflect independently and encourages students to think critically [25].

The questionnaire contains 12 questions, with 6 focusing on students' reflections on their critical thinking skills and the other 6 addressing their interest in using 3D digital modules for learning physics. Students' questionnaire answers are added up per item, and then the percentage is calculated to find out the overall response for each item. The following are the questionnaire assessment criteria written in Table 2.

Table 2. Questionnaire assessment criteria

Scale	Criteria
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

The criteria for the range of questionnaire response scores is written in Table 3 below.

Table 3. Questionnaire response score range criteria

Score Range	Criteria
0 – 20%	Strongly Disagree
21 – 40%	Disagree
41 – 60%	Neutral
61 – 80%	Agree
81 – 100%	Strongly Agree

In Table 4, there is a list of questions as well as the percentage of overall students' responses from the 3 classes. Questions number 1-6 aim to determine students' own perceptions of the critical thinking skills they have.

From the results of calculating the percentage of each item, it was found that students agreed that they had the ability to analyze arguments, observation skills, the ability to analyze observation results, and define terms well. Apart from that, students also strongly agree that they can consider the source of information and find a solution to a problem well. This is certainly the opposite of the results of the critical thinking skills instruments they have answered.

Table 4. Results of overall questionnaire responses

No.	Question	Percentage (%)	Criteria
1.	I can analyze an argument well	76,4	Agree
2.	I can consider whether the source of information is trustworthy or not	82,4	Strongly Agree
3.	I can make observations well	77,2	Agree
4.	I can analyze an observation result based on existing concepts	77,2	Agree
5.	I can define a term well	76,4	Agree
6.	I can determine the appropriate action to overcome a problem	83,6	Strongly Agree
7.	I am more interested in reading material in digital books than printed books	68,8	Agree
8.	I want to be able to read material practically via cellphone without having to open a printed book	74,4	Agree
9.	I feel that I understand the material presented better if I add illustrations or videos compared to just writing	81,2	Strongly Agree
10.	I want to be able to get direct feedback when working on practice questions	83,6	Strongly Agree
11.	I can understand the material better if it is presented with real examples from everyday life	85,6	Strongly Agree
12.	I am interested in learning to use digital books that have a 3D display	82,4	Strongly Agree

Questions 7-12 aim to determine students' interest in using 3D digital modules. In Table 4, it can be seen that students agree that they are more interested in reading material in digital books and have the desire to be able to read material via phone to make it practical. Apart from that, students also strongly agree that they can understand the material better through contextual illustrations and videos, want to be able to get direct feedback when doing practice questions, and are interested in using 3D digital modules in learning.

4. Conclusion

Based on the research conducted at a high school in Gresik, it was found that the level of critical thinking skills of class XI students was still low in various aspects. This is inversely proportional to the results of the questionnaire responses which show that students have the perception that they can fulfill the indicators of critical thinking skills. The results of the physics teacher interview revealed that so far learning has been carried out using innovative learning models such as inquiry models, PBL, and cooperative learning. The teacher in question also usually uses PowerPoint and animated videos to help explain the material as well as attract students' interest. However, students' critical thinking skills are still relatively low even though learning activities use innovative learning models, so it can be concluded that the main problem experienced by students is a lack of motivation to learn.

Motivation for learning itself can be increased in various ways, one of which is using learning media that attracts students' attention. The results of the questionnaire also show that students are interested in carrying out learning using the help of 3D digital module media. Therefore, it can be concluded that there is a need to implement physics learning using the help of interactive learning media such as 3D digital modules to increase students' activeness in learning and improve critical thinking skills.

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