Measurement of critical thinking in physics: the identification of students’ critical thinking skill through the work report on momentum conservation?

D I Saputri\(^1\), W Sunarno\(^1\), and A Supriyanto\(^2\)

\(^1\)Physics Education Sebelas Maret University, Indonesia
\(^2\)Physics Department, Sebelas Maret University, Indonesia

*Corresponding author: deaivonia1204@gmail.com

Abstract. This study aims to measure students' critical thinking skills through the ability to make practical work reports. The method used is qualitative descriptive method in the form of critical thinking skills through assessment of student work reports and questionnaire data. Rubric that used to measure students' critical thinking skills with 10 indicators: clarity, accuracy, precision, consistency, relevance, strength, reason, depth, breadth and fairness. The study sample was 34 students. The results showed that students' critical thinking skills through work reports were still 17.6% of students already had very high critical thinking skills, 58.82% had moderate critical thinking skills and as many as 23.53% students have weak critical thinking skills. Students have a high category in the breadth. Then clarity, accuracy, precision, consistency, and relevance have a moderate and evidence has a weak. The results of the student and teacher questionnaires about the application of practicum also stated that before practicum students were still sometimes given time to conduct preliminary studies.

1. Introduction
Education is one of the main factors for the progress of the nation. The main of Indonesian National education is to develop the potential possessed by students, so that students can become; people of faith, knowledge, piety, creative, independent and responsible. One effort to develop students' potential is to improve the school curriculum, so that it can be the same as the educational goals in Indonesia. Critical Thinking is very important in everyday life, because with the critical thinking we can develop other skills. For example, students can make decisions and solve problems [1]. The main goal for professionals in elevated institutions is to prepare students to have critical thinking skills [2]. Malathi has also said that critical thinking skills are very important and relevant for educating students in the 21st century. It has the aim so that students can overcome complex real-life problems [3].

Critical thinking skills are activities that use the mind [4]. Critical Thinking Skill is high thinking skills in a complex way, because it involves cognitive skills such as analysis and synthesis to solve problems and make decisions [5]. Critical thinking skills can be developed through learning activities. Through learning activities, students are expected to be active and independent. One way to practice critical thinking skills is to provide practical questions, that are equipped with feedback [6]. The purpose of critical thinking is that students can find the truth behind an event. So that, it gets a deep understanding.

According to Travis, critical thinking skills is important to measure, because critical thinking skills can be used as an indicator of learning success in achieving basic competencies [7]. Jacob and Sam [8]
do critical thinking assessments by using classification questions, questions investigating assumption questions, questions investigating a reason and evidence, questions about point of view and perspective, and question about questions. A rubric used to measure students' critical thinking skills through making practicum reports. The indicators include: clarity, accuracy, precision, consistency, relevance, evidence, reason, depth, breadth and fairness [9]. The teacher can measure the critical thinking skills through student practicum reports [10]. The practicum activities are activities that can provide stimulation, interest and attention to students through their theoretical experiences and real-world experiences [11]. Through practicum activities, students are trained critical thinking to develop arguments well. [12]. This study aims to measure students' critical thinking skills through the ability to make practical work reports.

2. Methods
The participants in this study is X MIA-1 class students at SMA Ar Rosyidah Magetan and Physics Teacher at SMA Ar Rosyidah Magetan. Samples for students were 34 students and 2 teachers. The method used in this study is a quantitative descriptive method. Students are given the task to make a lab report based on the format of the writing Title, purpose, material, theory, procedure, results of observations, data analysis, conclusions and references. The assessment of students' critical thinking skills is modified by the score as in the Table 1.

Table 1. Rubric for Laboratory Work Reports[9]

| Trait evaluated               | Cognitive skill applied | Level/ score | Criterion for obtain level (scores) of the rubric                                                                 |
|------------------------------|-------------------------|--------------|------------------------------------------------------------------------------------------------------------------|
| Abstract                     | Synthesis               | 3            | All points are complete, concise information, titles, goals are less than 100 words, clear hypotheses, clear word articulations. |
|                              |                         | 2            | All the criteria are complete, but there are still unclear words.                                                |
|                              |                         | 1            | There are one or more criteria absent                                                                           |
| Source of information        | Knowledge of evaluation | 3            | The source of the information is written in the report, and the citations are formatted consistently. Sources of information cited in the document. |
|                              |                         | 2            | There is one criteria is shown                                                                                 |
|                              |                         | 1            | One or more criteria are absent                                                                                 |
| Organization                 | Analysis                | 3            | The material and title are appropriate, the information presented is relevant and in the right amount.            |
|                              |                         | 2            | One criterion is not met, but Contains a clear section title with relevant material in each section.            |
|                              |                         | 1            | Requires major improvements on all criteria                                                                   |
| Relevance                    | Knowledge and application | 3            | Appropriate scientific term is used, the lab reports written systematically, students can write reports with integrate information from class, or in their own activities. |
|                              |                         | 2            | One criterion is lacking, but another attempt is shown.                                                        |
|                              |                         | 1            | Scientific terminology is used, but no other criteria are shown.                                              |
| Content                      | Comprehension           | 3            | Students make lab reports in their own words. Its contents are easy to understand. There is suitable material. The sentences in the lab report are simple. The sentence used is the active sentence. |
|                              |                         | 2            | The material in his report is difficult to understand well, but effort is shown towards understanding.         |
The content is too broad. The focus is not on the scientific aspect of the topic.

Presentation Evaluation

1 The reports is well written in Indonesian and has a professional appearance: type written, neat and easy to read. All previous formative evaluations were addressed. The presentation conforms to the required format.

2 Efforts on all criteria were made but not fully achieved

3 One or more of the criteria are not met.

| Intellectual Standards | Trade Evaluated |
|------------------------|------------------|
| Clarity                | √                |
| Accuracy               | √                |
| Precision              | √                |
| Consistency            | √                |
| Relevance              | √                |
| Evidence               | √                |
| Reasons                | √                |
| Depth                  | √                |
| Breadth                | √                |
| Fairness               | √                |

After measuring students' critical thinking using 10 indicators, we can find out the students' critical thinking categories. We can see and classify critical thinking categories through the tables. Anwar categorized critical thinking into 5 categories namely: very high, high, moderate, weak, and very weak.

Table 3. The Category of Critical Thinking Skills by Anwar [13]

| No. | Value  | Critical Thinking |
|-----|--------|-------------------|
| 1   | ≥ 84   | Very high         |
| 2   | 68 – 83| High              |
| 3   | 52 – 67| Moderate          |
| 4   | 36 – 51| Weak              |
| 5   | <36    | Very weak         |

3. Results and Discussion

After the students conduct the experiment and make a trial report the calculation of the score is carried out by 2 different teachers according to the score table 1. Scores are sorted and categorized into clarity, accuracy, precision, consistency, relevance, evidence, reason, depth, breadth, and fairness. The average value and standard deviation of student lab reports can be seen in Table 4.
Table 4. The Average Final Score of Each Indicator By Two Evaluator Based on Student Lab Reports.

| Intellectual Standard | N  | Mean  | SD  |
|-----------------------|----|-------|-----|
| Clarity               | 34 | 63,73 | 14,42|
| Accuracy              | 34 | 62,25 | 13,8 |
| Precision             | 34 | 61,44 | 16,69|
| Consistency           | 34 | 57,52 | 13,8 |
| Relevance             | 34 | 57,11 | 14,08|
| Evidence              | 34 | 49,02 | 10,81|
| Reasons               | 34 | 56,86 | 17,94|
| Depth                 | 34 | 63,73 | 14,42|
| Breadth               | 34 | 70,26 | 17,67|
| Fairness              | 34 | 56,86 | 17,94|

Based on the results of data analysis, it is found that students have a high category in the breadth which has a range of values 68 - 83 according to table 3. Then clarity, accuracy, precision, consistency, and relevance have a moderate category that has a value range 52-67 according to table 3. And evidence has a weak category that has a range of values 36 - 51 according to table 3. The following is the presentation of students as a result of all aspects that have been assessed and categorized according to the range of critical thinking category[13].

Table 5. Percentage Categories of Students' Critical Thinking for Momentum Conservation Practicum Reports

| Intellectual Standard | N   | Very High | High | Moderate | Weak | Very Weak |
|-----------------------|-----|-----------|------|----------|------|-----------|
| Clarity               | 34  | 17,65     | 5,88 | 64,7     | 12   | 0         |
| Accuracy              | 34  | 0         | 17,6 | 41,2     | 35   | 5,88      |
| Precision             | 34  | 17,65     | 0    | 61,8     | 8,8  | 11,8      |
| Consistency           | 34  | 8,82      | 8,82 | 50       | 32   | 0         |
| Relevance             | 34  | 0         | 17,6 | 35,3     | 41   | 5,88      |
| Evidence              | 34  | 8,82      | 8,82 | 5,88     | 68   | 8,82      |
| Reasons               | 34  | 17,65     | 14,7 | 55,9     | 5,9  | 5,88      |
| Depth                 | 34  | 8,82      | 8,82 | 5,88     | 68   | 8,82      |
| Breadth               | 34  | 17,65     | 14,7 | 55,9     | 5,9  | 5,88      |
| Fairness              | 34  | 8,82      | 8,82 | 5,88     | 68   | 8,82      |

The average results of the sum of values for each aspect of students' critical thinking skills through lab reports turned out to be as much as 17.6% of students already had very high critical thinking skills, 58.82% had moderate critical thinking skills and as many as 23.53% students have weak critical thinking skills. In addition to calculating the results of the lab report, an assessment is also carried out Questionnaire for students and teachers for the sake of seeing practicum at SMA Ar Rosyidah. The results of the assessment can be seen in Table 6 and Table 7.
Table 6. Mean Score and Standard Deviation for each Statement Based on Questionnaire for Students

| No. | Statement                                                                 | Rating         | Mean  | SD  |
|-----|---------------------------------------------------------------------------|----------------|-------|-----|
| 1   | I work well in groups during practicum                                     |                | 3,265 | 0,448 |
| 2   | The material practiced is consistent with the material taught in the class |                | 3,588 | 0,5  |
| 3   | Practical work instructions are easy to understand, and clear             |                | 2,618 | 0,652 |
| 4   | Complete laboratory equipment                                              |                | 2,147 | 0,359 |
| 5   | Practicum lessons begin with giving problems in groups that must be solved|                | 2,735 | 0,448 |
| 6   | Before practicum i was given the opportunity to conduct a preliminary study in preparation for the experiment and design an experiment. |                | 2,029 | 0,171 |
| 7   | The teacher gives a brief explanation of the topic of the experiment.     |                | 2,382 | 0,493 |
| 8   | The teacher gives feedback after the lab is finished.                     |                | 2,03  | 0,174 |
| 9   | The teacher gives an opportunity to discuss the results of the experiment during the practicum. |                | 2,471 | 0,507 |
| 10  | The teacher conveys the results of the lab report with the concepts students learn and evaluates the lab report. |                | 2,765 | 0,431 |

*a scale for ranking: 1.00, never; 2.00, sometimes; 3.00, often; 4.00, very often, ^N = 34

Student questionnaire results about practical activities also showed good results and were positively assessed by students (M> 2.5) found in the questionnaire statements number (1), (2), (3), (5), (10). There are 5 questionnaire statements that have sufficient value.

Table 7. Mean Score and Standard Deviation for each Statement Based on Questionnaire for Teacher

| No. | Statement                                                                 | Rating         | Mean  | SD  |
|-----|---------------------------------------------------------------------------|----------------|-------|-----|
| 1   | Physics lessons are equipped with activities to make a report on practicum |                | 3     | 0   |
| 2   | The purpose of the lab is clearly explained                               |                | 4     | 0   |
| 3   | Practicum implementation is integrated with lessons in class             |                | 4     | 0   |
| 4   | The material that is practiced is consistent with the material that is pursued in the class |                | 3     | 0   |
| 5   | Before practicum, the teacher explains the purpose of each practicum     |                | 2.5   | 0.71|
| 6   | Before practicum students are asked to conduct a preliminary study first and design experiment |                | 2     | 0   |
| 7   | After practicing, students are asked to make oral presentations          |                | 2.5   | 0.71|
| 8   | Students discuss the results of their experiments in class               |                | 3     | 0   |
| 9   | The teacher provides feedback on the student lab report                  |                | 3     | 0   |
| 10  | The teacher gives an opportunity to discuss the results of the experiment during the practicum and evaluates the lab report |                | 2.5   | 0.71|

The results of the questionnaire given to the teacher about the implementation of the practicum give synchronous results with the students, as many as 10 statements give Mean results of more than 2.5 and 1 statement shows the results of less than 2.5, namely the statement of students before practicum. In the student questionnaire point 6 students before practicum students were asked to do a preliminary study first to have a mean of less than 2.5 can be concluded that this has not been done well (sometimes).
4. Conclusion
Students' critical thinking skills are developed through the ability to report the results of physics practicum about impulses and momentum. In its application through the assessment of student practicum reports conducted by two different teachers in getting the results of critical thinking skills of students in SMA Ar Rosyidah Magetan as much as 17.6% of students already had very high critical thinking skills, 58.82% had moderate critical thinking skills and as many as 23.53% students have weak critical thinking skills. Students have a high category in the breadth. Then clarity, accuracy, precision, consistency, and relevance have a moderate And evidence has a weak. The results of the questionnaire about the implementation of practicum are of low value in the statement before practicum. Students are asked to conduct a preliminary study before hand, but sometimes it is done and there needs to be an increase so that students can be better in writing lab reports.

References
[1] Sutini, Akbar S, Nengah, P I, Hery S, 2017 J. Res. Method Educ. 7 5
[2] Changwong K, Sukkamart A, Sisan B 2018 J. Int. Stud. 11 37
[3] Malathi 2016 J. Soc. Behav. Educ. Econ. Bussinesss Ind. Eng. 10
[4] Cotrell, S 2005 Critical Thinking Skill :Developing Effective Analysis and Argument (New York: Palcrave Macmilan).
[5] Halpern D F 2007 The nature and nurture of critical thinking :Critical thinking in psychology. (Cambridge, NY: Cambridge University Press).
[6] Fabriana A P, Agus S 2017 Adv. Soc. Sci. Educ. Humanit. Res. 158
[7] Taufiq S, Edi I 2018 Bioedukasi: J. Pendidik. Biol. 11 105
[8] Kian S H, Seibu M J 2012 Malays. J. Educ. Technol 12
[9] Oliver-Hoyo M T 2003 J. Chem. Educ, 80 899
[10] Yunita A S A, Senam, Endang W 2017 AIP Conf. Proc. 1868 030013.
[11] Ottander C, Gunnel 2006 J. Biol. Educ. 40 113
[12] Petroselli C L 2008 Science Education Issues and Development (London: Nova Science). 1 59
[13] Saifuddin A 2012 Penyusun Skala Psikologi (Yogyakarta: Pustaka Pelajar)