Tambora erupts in 1815 as a learning material to train the students' critical thinking skills on energy learning in the living system

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Abstract. Critical thinking skills have not been optimally trained to students in the learning activity. This research aims to develop Tambora erupts in 1815 as a learning material to train the critical thinking skills especially on the aspects of interpretation and inference on the subject of energy learning in the living system. This research was conducted on 32 junior high school students through the learning material from the real event of the eruption of Mount Tambora. The responses to the students’ critical thinking on the aspects of interpretation and inference were analyzed by the students’ worksheet integrated with critical thinking skills. The critical thinking skills on the aspect of interpretation show that 80% of the students in the total amount are able to make question appropriately according to their knowledge. On the aspect of inference, it shows that 75% of the students in the total amount are able to make hypotheses of the questions that they have made. The result shows that the learning material can be used to train the critical thinking skills. However, this learning material does not train critical thinking skills in the aspects of self-regulation, explanation, evaluation, and analysis. Therefore, the future researchers need to develop the subject of energy learning in the living system that can be used to train those skills.

1. Introduction
Science education plays an important role in developing the quality of human resources, either in human development of various technologies used to support their lives or in applying the concept of science in life. This proves the great importance of science education as the driving force for achieving the goal of becoming a developed country which is capable to meet the challenges and demands of economics driven by science and technology. The main purpose of science education is not just as simple as producing future generations of scientists, this science is needed to develop children’s understanding of the various events in nature and also contribute to the future ability of the children [1]. One of the themes in science lesson in junior high is energy in the living system. Energy learning has become a part of the education curriculum in Indonesia from elementary to university level. Energy is one of the global issues and challenges of the future. Energy is required by living things to survive in its survival. One of the living things is human who will always need energy in every activity and how to use, manage, and maintain energy sustainability. With the importance of this issue, there is an opportunity to trace the mastery of the concept and critical thinking of the students in the learning
process related to the energy issue, in order to develop qualified human resources according to 21st-century challenges. The learning skills which are needed to face the demands of the 21st century are critical thinking skills [2].

The result of a preliminary study in several junior high schools in central Java shows that the learning process of science, especially on energy learning in the living system is still teacher-centered learning. The students tend to listen to the teacher’s explanation without being actively involved in the learning process. The material that should have been implemented in observing and questioning activities which actually involve the students’ activeness was not optimal because it was delivered using the lecture method. Such learning activities tend to make the students memorize the material without forming their own knowledge. In addition, the teaching and learning process is also not maximal as it does not relate the material to the problem in the real life. This shows that critical thinking skills have not been optimally trained to the students in the teaching and learning process. Whereas, based on the core competence of graduates in the curriculum of 2013, the students are required to have effective and creative thinking and acting skills in the abstract and concrete realm [3]. One of the thinking skills in the abstract realm is critical thinking skills. Critical thinking skills are needed to prepare the students to be competent graduates in solving problems in the future [4].

Problem Based Learning (PBL) is considered suitable for training the students’ critical thinking skills as it is designed to help the students develop their thinking skills, problem-solving skills, and intellectual skills; studying the roles of adults by experiencing them through real or simulated situations, and becoming independent learners [5]. In addition, based on Permendikbud RI no. 103 the year 2014 about learning in Primary and Secondary Education indicates that the teaching and learning process arranged in lesson plan must use the scientific approach in which the model of Problem Based Learning is embedded. Problem-based learning is a learning that makes a problem as a foundation, usually a real-world problem as a trigger for learning to improve process skills, problem-solving skills, and broad life learning [6]. To maximize the implementation of problem-based learning model needs to be supported by the selection of problems as learning materials. The effectiveness of problem-based learning depends on the problem presented [7].

The presentation of the problem in problem-based learning is in the first stage which is the students’ orientation to the problem. The stage of students’ orientation to the problem has a pattern of interrelationship with indicators of critical thinking aspects of interpretation and inference. While critical thinking itself consists of aspects of interpretation, inference, self-regulation, analysis, explanation, and evaluation [8]. This research selected the eruption of Mount Tambora in 1815 as the problem presented in the lesson. This is because the eruption of the Mount Tambora gave several impacts in which one of them was the close of the sunshine, even in the region of Europe at that time was known as the year without summer [9]. Whereas it is well known that the sun is the main energy source of life. Therefore, the purpose of this research is to develop the eruption of Mount Tambora in 1815 as a learning material to train critical thinking skills especially on the aspects of interpretation and inference in energy learning in the living system.

2. Experimental Methods

The development of this article refers to the research model 4D (Four D Model) proposed by Thiagarajan. The development of the instructional design with a 4-D model consists of four stages: defining, designing, developing, and disseminating [10]. The defining stage is the process of analyzing the characteristic of the event of the eruption of Mount Tambora as a learning material in training critical thinking skills. The designing stage is carried out to design the presentation of the problem of the eruption of Mount Tambora as a learning material. In addition, the developing stage is done to analyze the validation test results and the responses of the students’ critical thinking skills viewed from the assessment results of the students’ worksheets which are integrated with the critical thinking skills. The critical thinking skills in this research focus on the aspects of interpretation and inference. Expert validation was carried out by three competent validators, who are experts in education and currently lecturers of the Science Education of Graduate School at Sebelas Maret University, while the responses
toward the students’ critical thinking skills result were conducted to 32 junior high school students at SMP N 1 Jaten. If the result of the students’ critical thinking skills is good, the teaching materials can be used to train critical thinking. In this research, the average score (P) of the validators’ assessment and the result of the critical thinking skills which are adjusted to the assessment criteria of the learning material are elaborated in Table 1:

| Percentage (%) | Categories  |
|----------------|-------------|
| 90 – 100       | Excellent   |
| 80 – 89        | Good        |
| 70 – 79        | Fair        |
| < 70           | Less        |

3. Results and Discussion

3.1 The characteristics of Tambora’s eruption in 1815 as a learning material to train critical thinking skills

The Tambora volcano is located on the island of Sumbawa, western Nusa Tenggara, Indonesia. The eruption of Mount Tambora in April 1815 made the North American and European regions at that time experienced “one year without summer”. This had a huge socioeconomic impact, especially in terms of poor agricultural production, malnutrition, and consequently increasing the potential for disease and epidemic. [9,12]. This problem is well suited to be chosen as a problem in energy learning in the living system. The sun is the main source of energy in the living system especially human beings. Humans need food as energy, while food comes from plants that get energy from the process of photosynthesized sun-aided. Besides, other energy also comes from the sun including fuel oil because it comes from fossils that eventually still require sunlight. However, in the event of the eruption of Mount Tambora, it depicted the atmosphere of life due to the closed sun. Obviously, this will increase the students’ learning motivation to form their knowledge and train their critical thinking skills in energy learning in the living system.

The presentation of the problem as a learning material is adapted to the learning model that can train the students’ critical thinking skills. Based on the preliminary analysis that has been done, the model of problem-based learning is considered appropriate to train the students’ critical thinking skills and its effectiveness depends on the given problem. Article or phenomenon that is provided to the students is the right event that does occur which challenges the students to open their thoughts in learning. This is in accordance with the criteria selection of the learning material in problem-based learning that should contain issues elaborating conflict (conflict issue) that can come from news, video recording, and others [13]. That is why the form of presentation of the material is in the form of news about the impact of the eruption of Mount Tambora in 1815. The presentation of the problem in this model is in the first stage namely the students’ orientation to the problem. The stage of students’ orientation to the problem has a pattern of interrelationship with the critical thinking skills especially on the aspects of interpretation and inference. Interpretation according to Facione means to understand the meaning or significance of various experiences, situations, data, events, judgments, customs, beliefs, rules, procedures, or criteria [8]. Besides, inference means to identify and ensure the bases needed to illustrate a reasonable conclusion, to consider the relevant information [8]. Therefore, the learning steps done are the students are asked to interpret their thought and describe it in the form of problem formulation after reading and observing the article of the phenomena studied. The students are then given the opportunity to express what has been observed in the form of answers to questions that the students have made.
3.2 Expert validation toward the learning material

In this research, the validation of the learning materials is done by three professional lecturers who are lecturers of Science Education of Graduate School of the Faculty of Teacher Training and Education UNS. The learning material is decided valid if all three validators’ rating on all components of the learning design is in “Good” category. The validity of the learning material is shown in Table 2:

**Table 2. Expert validation result on Tambora erupts in 1815 as a learning material**

| Assessed Aspects                                         | Indicators                                                                 | Expert Validator | Score Percentage |
|----------------------------------------------------------|---------------------------------------------------------------------------|------------------|------------------|
| Selection and organization of the teaching material      | The appropriateness of the material with the learning objectives          | 3 3 4            |                  |
|                                                          | The appropriateness with the students’ characters                         | 3 3 3            | 81%              |
|                                                          | The appropriateness with the time allotment                                | 3 3 4            |                  |
|                                                          | The appropriateness of the learning resources/learning media with learning objectives | 3 4 3            |                  |
| Selection of learning resources and learning media      | The appropriateness of the learning resources/learning media with the learning materials | 3 3 3            | 83%              |
|                                                          | The appropriateness of the learning resources/learning media with the students’ characters | 3 4 4            |                  |
| The material develops the critical thinking skills      | The material develops the interpretation skill                            | 3 3 4            | 83%              |
|                                                          | The material develops the inference skill                                 | 4 3 3            |                  |
| Relevance to daily lives                                | The appropriateness of the material/ activities/energy training and energy source | 4 4 3            | 92%              |
| The organization of general presentation                | Supporting the involvement of the students to actively express and share ideas | 4 3 4            | 92%              |
| The presentation considers meaningfulness and usefulness | Linking one concept with another concept in explaining a phenomenon     | 3 3 3            | 83%              |
|                                                          | Linking concepts with real life                                           | 4 3 4            |                  |
| Variations in the way information is delivered          | Information is clear, accurate, and adds concept understanding          | 4 4 4            | 100%             |

Table 2 shows that the learning material which is developed is categorized as valid. It was obtained from the assessment of the validity of Tambora erupts in 1815 as a learning material. Expert validation result
shows that the validated learning material is categorized as valid with a score above 80% based on the predetermined criteria [11].

3.3 Responses to the students’ critical thinking skills
The learning material from the real event of the eruption of Mount Tambora was given to 32 students in SMPN 1 Jaten through the learning process in the classroom with the help of LKS media. The responses of the critical thinking skills on the aspects of the students’ interpretation and inference are analyzed using the students’ worksheets integrated with critical thinking skills. The critical thinking skills on the aspect of interpretation are shown by 80% of students are able to make inquiries according to their knowledge whereas on the aspect of inference is shown by 75% of students are able to make hypotheses of the questions they have made.

4. Conclusion
The above discussion indicates that Tambora erupts in 1815 as a learning material developed to improve the students’ critical thinking skills on energy learning in the living system has met the requirements to be used to train the students’ critical thinking skills. However, this learning material has not yet trained the critical thinking skills in the aspects of self-regulation, explanation, evaluation, and analysis. Therefore, in future research, it is necessary to develop material that trains such skills in energy learning in the living system.

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