Constructing Essay Questions To Assess Scientific Creative And Critical Thinking Simultaneously Related To Collision Problem Based On Students Responses

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Abstract. Assessing creative and critical thinking especially for high school student is not an easy task. Using multiple choice to reveal their creative idea and its reasoning is not an option. Therefore in this work we construct an essay question to assess scientific creative and critical thinning simultaneously based on student responses. This instrument is design to measure scientific creative and critical thinking. Simultaneously related to collision problem. A critical model answer is develop to Scientific Stucture Cretivity Model (SSCM) rubric’s and Assessment of Critical Thinking Ability (ACTA). The constructed instruments are tested to 12 tenth grade students then analyzing their responses with model answer. We reconstruct the test and tested to another 12 tenth grade students. The last reconstruction test has reveal more students ideas and their reasoning. From this result we can consider that this instrument can be an alternative to assess scientific creative and critical thinking simultaneously related to collision problem based on student responses.

Keywords: Essay Questions; Scientific Creative Thinking; Scientific Critical Thinking, Collision Problem

1. Introduction
The 21st century globalization are a huge impact in the development of science and technology that led to the change of paradigm in learning that requires students having multiple to take their life. Students need to get skills especially skills of century 21st so that they can survive and compete. One skill of the 21st century is learning and innovation skills that consists of 4 aspects. There are critical thinking, communication, collaboration and creativity. Partnership for century 21 said that knowledge able core subject is not enough, must be accompanied with the capacity to thinking. Skill of creative and critical thinking is part of skills 4c's required at the 21st century. Human resources creative and critical in given rise the idea certain will be able to solve the problems facing in the 21st century. In the process to solving science problem the capacity of creative and critical thinking is not enough. The solution should be scientifically creative and reasonable. Some learning design to enhance critical thinking skill have been applied in university course. Problem based learning combined with literacy strategies and phi-log habits of mind based strategy for middle school is believed can enhance students scientific creative and critical thinking.

Hu, et al explained that scientific creative thinking can be developed through problem solving in science where students must exploring when imagine a solution to combine new knowledge or new technique. These matters strengthen to develop other achievement instead just a constructive achievement. In recent study in science learning process especially problem/project based learning both creative and critical thinking is needed for student to solve problem or create project. So, both creative and critical thinking can be considered as student learning achievement. There for an instrument that simultaneously assess both thinking skill is needed. To see the proper of their scientific creative and critical thinking after the in this paper the instrument is design to measure scientific creative and critical
thinking simultaneouly related to collision problem. A model answer is developed to Scientific Structure Creativity Model (SSCM) rubric’s and Assessment of Critical Thinking Ability (ACTA).

Brian White, et al [6] said that critical thinking ability is a result of interpretation, analysis, evaluation, and conclusion accentuated the facts of conceptual, methodologically, criteria, or consideration contextual. They further investigated an instrument test with an indicator referring to Assessment of Critical Thinking Ability (ACTA) from journal A Novel Instrument for Assessing Students Critical Thinking Abilities.

The measurement of scientific creative and critical thinking skill in a single instrument simultaneously is something new, so that the students responses still dependent on composition/the arrangement of each word in the matter. It is make the students responses were not reference to the indicators question. Therefore, made a reconstruction to produce a test that truly capable of measuring scientific creative and critical thinking as well as directing students on answers that deals with science especially physics in a single instrument.

The essay question made based on the results of the student responses who have not been in accordance to a model. We analyzed the student responses one by one then seen what is lacking the answer. The questions form an essay that created based on Gronlund, n.e.(2000). Assessment of student achievement, 7th Ed. Massachusetts: Allyn and Bacon.

2. Method
We use mix method research in this study. The plot of this research can be seen in Figure 1. Research Method Chart.

![Figure 1. Research Method Chart](image)

3. Result and Discussion
Reconstruction about scientific creative and criticl thinking skills created based on the answers of students in each stage of the research. We analyzed each answer made by students. If the answer students do not yet fulfill the rubric made by Hu and Adey next made against the reconstruction. Test scientific creative thinking made by combining some different aspects of the question. One example of the first reconstruction question 1a to scientific creative thinking skill combining aspects of fluency, technical
product and thinking, while for scientific critical thinking skill made by indicator adapted from ACTA for example in question c the indicators is integrate knowledge conflict into a conclusion.

Questions presented is essay question, that get students for give their diverse responses and not only chase on only one response. The diversity of the answer in open ended question wider from the closed question. About the first reconstruction consists of 4 items question about scientific creative thinking and 3 items question about scientific critical thinking. Then after conducted second reconstruction the question item reduced to 2 item question about scientific creative thinking and 3 item question about scientific critical thinking. On third reconstruction the item of questions remain the same as on the second reconstruction, but some changes in the structure of the sentence.

Fluency score obtained by summing each answer with regard to the creation of the roadblock design, each answer is given a score of 1 without looking at the answer true or false. Flexibility score obtained summing by add up every answer a different perspective, any answer given score 1. Originality score obtained by giving a score of 2 If the answer of the students belong to the 5% answer given the entire score of 1 if the student, the student's answer included in 5-10% answer given the whole student, and a score of 0 if students just answer the question with examples of answers on the matter. As for scientific critical thinking penskorn made using the indikar based pad journal ACTA.

3.1 Scientific Creative Thinking

As follow for example is one items for example those on scientific creative. We analyzing all 12 student responses in every part of reconstruction based on rubrics Hu and Adey (A scientific creativity test for secondary school students, [5] to scientific creative thinking. The question item for the discussed is one of the scientific creative thinking there is flexibility and critical thinking ability 1 for the example item of scientific critical thinking [6].

First Reconstruction

| Question: | When you create a design separator to prevent an accidents and damage to the car due to off track. What are some of the factors you are considering in your design? (scientific creative aspect: thinking, flexibility, science knowledge) |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Students Responses:

![Material untuk membuat separator nyai.](image)

Figure 2. Student First Response
Figure 2 is an example of student responses, we analyzed flexibility aspect where students provide an viewpoint about factors for making the roadblock. Seen from chart 1, 58% of students responses only received score 1 on the flexibility aspect, there are not based on Hu and Adey rubric's about scientific creative thinking test. The test made that students can release much their opinion. The highest score acquired students were 4.

Second Reconstruction

**Question:**
If you are designing a roadblock for the highway with the conditions as in figure a. Calculate the material, size, and shape of the roadblock so that the roadblocks can avoid fatal accidents on the highway!(scientific creative aspect: thinking, flexibility, science knowledge)

**Student Response:**

![Image of student response](image1)

**Figure 3. Student Second Response**

**Chart 2. The Number Of Students To Flexibility Score**
One of the 12 student responses show that there is a change in the answer when it is given about a specific mention a factor to be reckoned with in making roadblock. About the reconstruction based on Gronlund, N.E. [7]. Assessment of student achievement, 7th ed. Massachusetts: Allyn and Bacon the linked a direct question can measure the result of learning. From figure 2 the answer show factors to be reckoned in making roadblock like material, size, and shape that each factors given explanation. In student responses about material used in making roadblock are varied. It is starting to refer the indicator that was described by Hu and Adey. Where students selecting a diverse in making roadblock. **Third Reconstruction**

**Question:**
If you are designing a separator for a highway with the conditions as shown in Figure a. Calculate as material, size, shape and others on the road divider so that this roadblock can avoid fatal accidents on the highway! (scientific creative aspect: thinking, flexibility, science knowledge)

**Student Responses:**

One of student responses show that more change response to specific response, they said specific and fungsion of factors to be reckoned with in making roadblock. All of students also provided a different perspective from the case and other response. This is indicated by the appearance of score 6 on the second reconstruction.
3.2 Scientific Critical Thinking

As follow for example is one items for example those scientific critical thinking skill. We analyzing all 12 studens responses in every part of reconstruction based on ACTA (A Novel Instrument for Assessing Students’ Critical Thinking Abilities, [6]). The question item for the discussed below is one of the scientific critical thinking ability 1 for the example item of scientific critical thinking.

Pre-Reconstruction

| Question |
|----------------|
| Your friend opine that roadblocks must be made of strong materials such as concrete walls for roadblock solutions. Does this idea correspond your design? If not explain! |

Student Responses :

![Student Response Image]

Figure 5. Student Response Of Pre- Reconstruction

| Chart 4. Number Of Students To Critical Thinking Ability 1 |
|-----------------------------------------------------------|
| Score | score | score | score |
| 3     | 4     | 3     | 2     |

CRITICAL THINKING ABILITY

Student responses just following the option without give their opinion. 59% student agree about the opinion and 41% disagree. Only one student (8,33%) who express their opinions in the answer. Then analyzing the student responses and given a score. Overall the score students seen in chart 4. Based on rubrics ACTA that score maximum is 4. But in firts reconstruction there not students who can reach a maximum score.
**Second Reconstruction**

**Question:**
Two of your friends give different opinions on the design of a good roadblock. Your first friend suggests that in order to reduce an accident, the roadblocks used must be made of strong materials. While your second friend believes that the roadblocks must be made of elastic material. From which two opinions do you choose? Explain! If you do not choose from those two opinions, please share your opinion!

**Student Responses:**

![Image](https://via.placeholder.com/150)

*Figure 6. Students Response Of Second Reconstruction*

![Chart](https://via.placeholder.com/150)

*Chart 5. Number Of Students To Critical Thinking Ability*

Student responses just follow the opinion provided. 25% of students agree with strong material, 50% agree with elastic material, and 25% students agree with both opinions by adding their personal opinion. Only 16.66% students describing the advantages and disadvantages of each option.
Third Reconstruction

**Question:**
Two of your friends give different opinions on the design of a good roadblock. Your first friend suggests that in order to reduce an accident, the roadblocks used must be made of strong materials. While your second friend believes that the roadblocks must be made of elastic material. By taking into considering the two opinions of your friends and the existing table data. Share your own opinion what good material is used for the roadblock!

**Student Response:**

![Student Response Of Third Reconstruction.](image)

**Figure 7. Student Reponse Of Third Reconstrucltion.**

![Chart 6. Number Of Students Critical Thinking Ability 1.](image)

50% of students answer have been able to consider and choose the opinions and then developing into a conclusion that is able to provide solution from the problem. Is a significant increase in the score maximum rekontruksi first into a third reconstruction sebasar 50%.

4. Conclusion
The instrumen test could be an alternative to asses reveal responses student. Sentences arrangement and a clear task make significan different the student idea and reasoning. Adding a scientific data in question can reveal scientific creative and critical thinking skill we can see the increase in maximum score of scientific creative thinking from the chart 1, 2, & 3.

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