Analysis of students’ scientific creativity and science process skills at UIN Walisongo Semarang

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Abstract. Many studies show a low scientific creativity of students. One of the causes is the teacher's inability to ask questions that encourage students to think scientifically creative so that it causes low science process skills. The study aims to analyze the scientific creativity and science process skills of students of UIN Walisongo Semarang. This is a qualitative research use descriptive method. The research subjects were determined by purposive sampling. Data collection method uses respondents' answers to the Scientific Creativity test and deep interviews. The data were analyzed using the Miles and Huberman models. The result showed that the scientific creativity of students had not a well-developed. While the science process skills of respondents have well developed.

1. Introduction

Scientific creativity is one of the abilities that students need to have in facing competition in the 21st century. Scientific creativity arises as an answer to the demands of the times that require graduates that are able to think genuine, are different from others, scientific, and innovative. Scientific creativity is related to creativity in science education, which can be interpreted as an individual's ability to develop perceptions and improve understanding of nature [1]. In addition, scientific creativity can be described as a thinking skill that enables individuals to produce numerous original ideas of different areas by utilizing an interdisciplinary and innovative perspective in science, technology, and arts in order to resolve a particular problem [2]. Many studies on scientific creativity have shown the importance of scientific creativity in education [3]. However, many studies show the low scientific creativity of students [3, 4, 5]. This problem is inseparable from the rigorous understanding of teachers and students about the nature of sciences, so that they are unable to develop their imagination and creativity in producing scientific knowledge [6].

The development of students' scientific creativity is influenced by many factors, including teaching and learning science [7, 8, 9], executive administration, motivation, personality, and instructional attitude [8, 9], and sense of humour [9]. Based on these studies, it appears that learning is a major factor influencing the scientific creativity of students. Ren, et al. found that the creative imagination of Chinese students increased when involved in science-related competitions and visits to places related to science [10]. It is undeniable that this learning activity greatly helps students to develop scientific process skills that support the imagination of their scientific creativity. In addition, the results of other
studies show that scientific creativity have a strong relationship to scientific process skills [6]. The understanding and perceptions of the students about the role of creativity in science regulate the relationships between Science Process Skills and Scientific Creativity. However, developing scientific creativity is more complex and there various learning activities can be tried to foster scientific creativity, for example Creative Problem Solving, Problem Solving in the STS Context, Creative Science Inquiry, Creating Analogies to Understand Phenomena and Ideas, Challenging students to find connections among apparently unrelated facts and ideas, and Mystery Solving [11].

Science process skills is a set of skills needed in scientific activities using scientific processes and approaches [12]. These are very important to students, because they are used in every day life. Science process skills can be categorized into two levels that are basic science process skills and integrated science process skills. Basic science process skills consist of observing, classifying, measuring, using numbers, using space and time relationship, inferring, predicting, and communicating. Integrated science process skills consist of identifying variable, formulating hypotheses, defining variables operationally, experimenting, and interpreting data and drawing conclusions [13].

2. Methods
Scientific creativity tests have been conducted on 31 Physics Education students of UIN Walisongo Semarang at Academic Year 2018-1919. The test was carried out using the scientific creativity test [14]. There are seven items to measure students' scientific creativity in fluency, flexibility and originality aspects. But in this article only four items will be discussed.

2.1. Research model
This is a qualitative research use descriptive method to analyze students’ scientific creativity and science process skills. It was conducted on Physics Education’s students UIN Walisongo Semarang.

2.2. Sampling
The sample was determined using purposive sampling. Students of Class A at Academic Year 2018/2019 are divided into three categories, namely low, medium and high scientific creativity students. Each category consist of two students, male and female.

2.3. Data collection
Data was obtained by documentation and interview methods. The documentation method is used to determine respondents' answers to scientific creativity test. While interviews were to obtain respondents 'answers about the reasons behind the answers and reveal students' science process skills.

2.4. Analysis of data
Data was analyzed using Miles and Huberman Models. Data were collected, classified, compiled, analyzed and interpreted, then linked to the results of other studies to draw conclusions.

3. Result and Discussion
Based on the results of the scientific creativity test, six respondents were chosen with three categorizations. The details of the respondents are shown in Table 1.

| Code | Category of SC | Gender  |
|------|----------------|---------|
| H-1  | High           | Male    |
| H-2  | High           | Female  |
| M-1  | Moderate       | Male    |
| M-2  | Moderate       | Female  |
Respondents’ answers to scientific creativity tests and interviews can be described as follows.

3.1. Item 1

Question: If you are given a piece of glass, what scientific question would you like to examine? Write as much as you can!

This item aims to measure respondents’ sensitivity to science problems. By asking questions about a problem, the respondent has been able to find a problem as a science process skill and show how many respondents had a scientific creativity component [14]. In general, respondents answered this item by asking similar questions. For example: "What is the glass-forming material?", "What is the process of making glass?", "What is the formation of shadows on the glass?", and "How to make a rainbow with glass?" The first and second questions have the same point of view, namely glass as an object. While the third and fourth questions to emphasize more on the function aspect of glass of reflection and refraction of light.

Based on the variety of questions, it appears that the respondents’ thinking framework are still uniform and strongly influenced by their experience. Even two respondents consider the same between glass and mirrors. This shows that respondents’ flexibility is still low because they are not able to shift to a different field. Scientific creativity cannot be built if it relies on the same frame of reference from the same thinking continuously and has not been able to escape the frame that limits their thinking.

In order to obtain in-depth information related to the emergence of the question, the researcher asked respondents, "Why did you ask this question?" Following are some of the respondents’ answers:

H-1: "I've seen glass crafts shows on television. The Glass is heated at a certain temperature becomes easier to form."

H-2: "I remember the reflection of light by the mirror”

H-1’s answer shows that he has observed the glass making process and identified the variables in the event. Likewise, what happened to the H-2’s answer, even though there is an incorrect assumption that glass is the same as a mirror.

3.2. Item 2

Question: Think about what science ideas you can do with a helmet to make it look more attractive and useful. Explain why you consider the idea interesting?

This item aims to reveal the ability of respondents to develop technical products scientifically. Respondents are not only asked to express "questions" of ideas, but have been asked to provide solutions to these “questions” through scientific creativity design of a helmet. From this item it can be seen the students’ skills in formulating hypotheses, designing experiments, evaluating data and the ability to generate new ideas as a component of scientific creativity.

Generally the designs submitted by the respondents included: "Helmet glass is made like a monitor screen of smart devices", "The helmet is equipped with automatic cool. So it is comfortable for motorcyclists", "The helmet is made elastic to be able to adjust the user's head size", and "Helmet equipped with a mobile charger". Overall, the helmet design has shown flexibility of respondents. Respondents no longer think that the helmet only functions as a head protector. In fact, respondents began to show sensitivity to problems that occur to the community, especially in urban areas, such as hot air and the need for electricity sources. This way of thinking will be able to encourage someone to innovate in various fields.

However, if we look at current trends in science and technology, the design submitted by the respondent has not shown originality in thinking. Originality is the ability to produce unusual or new
ideas [15]. Originality is also defined as the ability to produce rare and unusual responses [16]. The design is available now and the information is easily accessible by respondents. So that most likely the emergence of the design idea is influenced by the knowledge possessed by the respondent, not the original idea that is really new to the imagination of the respondents. This was confirmed from the results of the interview, where M-2 stated that he obtained his ideas from Google Glass.

Researcher : "Why do you propose the idea of making helmet glass like a monitor screen equipped with smart devices?"

M-2 : "I was inspired by Google Glass which has many features like taking pictures, recording videos dan surfing in the internet."

Researcher : "Are you sure the idea will work? Why?"

M-2 : "Yes, actually the helmet's glass functions is not much different from glasses. If Google Glass can be realized, then my ideas can certainly be realized "

The interview results show that M-2 is good at formulating hypotheses that helmet glass can be made the same function as Google Glass. In addition, it shows her ability in designing an experiment although it is not described in detail.

3.3. Item 3

Question: Two napkins are available. How do you test it, which one is better? Write down as many ways as possible (simple tools, principles and procedures!)

This item aims to measure the ability of creative experiments that is expected to be able to encourage students to produce real scientific products, such as the skill to determine variables, experimenting, and drawing conclusions that are part of science process skills.

Respondents’ answers are as follows,

- Use napkin A and B to clean up water spills. Put both of them on a water spill and observe which of them is able to absorb water spills faster. Better napkins are napkins that can absorb water faster.
- Expand the two napkins and pull on both ends. Observe which napkin is not damaged by the pull. A good napkin is a napkin that is more resistant to tensile force.
- Prepare two buckets and put water in it. Add detergent and stir until evenly distributed. Place two napkins that have been given the same stain, such as soy sauce or sauce. Soak for a while, then lift and rub the two napkins. Observe what happened to the napkin. Which napkin is cleaner? A good napkin is easy to clean from stains

Respondents’ answers have at least fulfilled three things, namely tools, principles and procedures for testing which napkins are better, even though they are not explicitly separated. For example, in the first answer. Sentence "Use napkin A and B to clean up water spills. Put both of them on a water spill and observe" show the napkin testing tools and procedures, where the tools are napkins and water. The sentence "which of them is capable of absorbing water spills faster" is the principle used in testing napkins by determining the variables. While the phrase "Better napkins are napkins that can absorb water faster" is a conclusion.

In general, respondents have been able to answer this item well. But the answers still revolve around testing the function and strength of napkins. Though there are still things that can be used to test the quality of napkins, such as the duration is dried. The majority of respondents' answers focused on scientific activities before and when napkins were used, so that they ignore scientific activities after the napkin was used. This shows that the respondents are not flexible and original because they do not consider activities carried out outside the habits of people in general. Though scientific creativity can be built in simple ways for everyday life.
3.4. Item 4

Question: Design a coconut fruit picking machine! Describe the function of each part!

This item aims to measure the ability of respondents in designing creative science products. The scientific creativity of this item is determined by the function of the engine being designed. The function of each machine part includes at least: finding, reaching, picking, transporting to the ground, sorting, placing in containers, and moving from one tree to another. All respondents’ answers are in the form of pictures, both simple machines and machines with complicated structures. Some of these answers can be classified into two groups of answers, namely simple answers as non-creative designs and complex answers as creative designs. Non-creative designs are only machines to reach and pick coconuts from trees to fall on the ground. Whereas what is desired is that the machine is able to sort the coconut, put it in a container, and move from one tree to another. Here are the design of coconut fruit picking machines that have been done by respondents.

(a)
(b)

Figure 1. Design of a simple coconut picking machine

The machine design in figure 1 (a) has similarities in principle and ways of reaching and picking mangoes that are often used by the community. There are cutting parts (knives), sticks or bollards, and connecting wire knives with handrails. If you look at the shape or design of this machine, then it appears that the way of thinking of respondents is strongly influenced by their experiences of seeing people picking fruit of a knife inserted into a stick. The only difference lies in the connecting rope between the picking hand and the cutting part. Meanwhile, in Figure 1 (b), the machine looks better because it is equipped with a coconut basket. However, this creativity still lacks flexibility and good originality. Because, so far the community has used a small basket to accommodate the fruit so as not to fall to the ground.

The design of coconut picking machines does require high creativity, considering the designer must think about everything related to the difficulties experienced by coconut pickers, the coconut garden condition, and must be able to replace the position of humans who are able to choose mature or not. The following are some machine designs with more complex shapes, constructions and functions.
The machine design in figure 2 (a) has considered the process of picking up coconut processing, but has not considered the machine movement from one place to another. While the machine in Figure 2 (b) emphasizes the process of picking coconut and machine movement. Both of these machine designs show a flexible but not original respondent's way of thinking. Flexibility appears in the integration aspect of the picking process to processing. While originality is not seen because respondents are still tied to the experience of the general public, the coconut pickers must climb the coconut stem. The ability of respondents in designing this machine also shows science process skills, namely composing hypotheses, designing experiments, and analyzing data, and drawing conclusions.

4. Conclusion

Based on the discussion above, it can be concluded that the scientific creativity of respondents is not well developed. It can be seen from the way of thinking of respondents who have not been able to get out of the frame of thinking so far. While the science process skills of respondents have developed well until the integrated science process skills, especially in the skills of determining variables, formulate hypotheses, design experiments, analyze data, and draw conclusions.

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