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Research Article

Developing Scientific Creativity Test to Improve Scientific Creativity Skills for Secondary School Students

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Abstract: This research aimed to describe the effectiveness of scientific creativity test to train student's scientific creativity learning outcome for the secondary student. The effectiveness of scientific creativity test was evaluated using the indicators achievement and self-assessment. The test was planned to develop scientific creativity skills. Achievement indicators consisted of: unusual use, technical production, hypothesizing, science imagination, science problem solving, creative experimental, science product, and scientific creativity. This research was conducted using one group pre and post-test. The test was implemented with 140 students on the secondary school at the SMP 3 Jember, Indonesia. The result showed that there was an improved indicator achievement in motion and simple machines material with average g-score = 0.67 (medium-g), 93.7 % of students assessed themselves as being able to practice scientific creative skills by using scientific creativity test, that scientific creativity test enabled them to practice scientific creative skills. The research showed that scientific creativity test was effective in improving scientific creativity skills.

Keywords: test, scientific creativity, scientific creativity skill.

INTRODUCTION

Learning science for junior high school on Curriculum 2013 is expected to reach competency standards graduates consisting of dimensions of attitudes, knowledge and skills. On the dimension of attitude, qualifying ability is expected to have behavior that reflects the attitude of the faithful, noble, knowledgeable, confident, and responsible to interact effectively with the social and natural environment in a range of relationships and existence. On the dimension of knowledge, qualifications are expected ability to have factual knowledge, conceptual and procedural in science, technology, arts, and culture with human insight, national, state, and civilization-related phenomena and events that seem eye. While the dimensions of qualification skills students are expected to have the ability to think and the ability to follow an effective and creative in the realm of the abstract and the concrete in accordance with the learned in schools and other similar sources (Permendikbud, No 54 of 2013). Think of the Curriculum 2013, with its focus on attitude, knowledge and skills rather than just content. A creative attitude says that exploring towards that the answer is more valuable than finding the answer itself (Bowkett, 2006). With education today, focusing more on the learning skills than of content, creativity is about ability to think, not just recall but to apply, suggest, extend and model, to create analogy (Longshaw, 2009). Learning science is expected to improve students' overall competence covering attitude, knowledge (cognitive and psychomotor), and skill. Science learning can encourage students, be better able to observe, ask, reason, and communicate (present), what is obtained or known after the students receive the learning materials.

Creativity is part of higher-order thinking and is related to one's cognitive ability to its intellectual nature. Creativity will happen if a person continually produces a new product or when he executes a task that results in a novelty. According to Ofsted (2003) creativity is a mindset based on a way to encourage someone to do something that can produce a creative product. This is according to the research results of Lowa State University developing HOTS model (Higher-Order Thinking Skills) that creativity cannot be seen, but the result of that creativity can be seen, that is in the form of product. Creative products are products that result from the process over time. Runco (1996) suggests that the creative mindset can be seen from a regular way of thinking related to one another, a coherent way of thinking, knowledge and concept that directs with the mind, and is influenced by the environment. Creativity is also interpreted as thinking consistently and continuously producing something creative, original in accordance with the needs (Runco, 2007).

In considering the scientific creativity of individual secondary school students within a given school system, the creative environment is out of control of the students so we will aim for a three-dimensional model. In considering the students' scientific creativity in secondary schools where the individual's condition is within a given school system, the creative environment is beyond the student's control, a three-dimensional model is developed which aims to provide a creative environment (Hu & Adey, 2010). The structure of the design is the theoretical foundation for measuring scientific creativity, scientific creativity research and the development of scientific creativity. Therefore it is necessary to do an effort

on how to develop the scientific creativity of students through the development of a test that is able to develop the ability of scientific creativity. According to Torrance, central features of creativity are fluency, flexibility and originality (Hu and Adey, 2002): **'**Fluency means the number of original ideas produced, Flexibility is the ability to 'change tack', not to be bound by an established approach after that approach is found no longer to work efficiently. Originality can be explained statistically: an answer which is rare, which occurs only occasionally in a given population, would be considered original' (Aktamis, *et. al*., 2009).

The Scientific Structure Creativity Model (SSCM) model explains that scientific creativity is defined as the intellectual nature or the ability to produce or potentially produce a certain product that is original and has an individual or social value, designed in the mind with a specific purpose, using the information provided (Hu & Adey, 2010).

This definition can be spelled out through a collection of hypotheses about the structure of scientific creativity.

1. Scientific creativity differs from other creativity as it

   Focuses on creative science experiments, finding problems and solving them creatively.

2. Creativity is a capability that does not involve non-intellectual factors, although non-intellectual factors affect scientific creativity.

3. Scientific creativity depends on scientific knowledge and skill.

4. Scientific creativity must be a combination of static structure and developmental structure. Adolescents and adults according to scientists have the same basic mental structure of scientific creativity but more developed.

5. Creativity and analytic intelligence are two different factors of mental ability. (Hu & Adey, 2010).

The measurement of scientific creativity is focused on creative thinking and scientific creative processes. Students' scientific creativity is assessed by using a holistic approach, by asking questions relating to the use of their scientific process skills (Nur, 2014). Hu and Adey (2010) developed seven indicators of creativity tests, namely 1) Unusual Use (UU), 2) Technical Production (TP), 3) Hypothesizing (H), 4) Science Imagination (SI), 5) Science Problem Solving (SPS), 6) Creative Experimental (CE) and 7) Science Product (SP). The seven dimensions are also adapted by other researchers such as Lin et al. (2013); Wang & Yu (2011), Hu et al. (2013) and Astutik (2017). Teaching scientific creative thinking supports the scholars by emphasizing the links between environmental education and broader theoretical approaches that currently (Susantini, *et.al*, 2016:74).

Based on the description above, the scientific creativity test was validated with three aspect in terms of: the contents validity, knowledge and writing validity. Furthermore, the resulting validity is a developing test that is valid for teach skills of scientific creativity and can be implemented for student in the class. In this case, the teachers' role as a facilitator as well as a motivator so that the teacher should be able to continue to motivate the students so that students can play an active role in the development of scientific creativity students.

The purpose of this research is to analyze the effectiveness of scientific creativity test to train student's scientific creativity learning outcome for secondary student. To describe the effectiveness of scientific creativity test to develop scientific creativity skills based on aspects of indicators achievement and self-assessment. Indicators achievement to assess the skills of scientific creativity in terms of: 1) unusual use (UU), 2) technical production (TP), 3) science imagination (SI), 4) hypothesizing (H), 5) science problem solving (SPS), 6) creative experimental (CE) and 7) science product (SP).

Methods

This research is used to determine the effectiveness and self-assessment of scientific creativity test were developed to improve the scientific creativity skills of students in learning on the secondary school at the SMP 3 Jember, Indonesia. The scientific creativity test was implemented for student in the class with the materials, is motion and simple machines.

Implementation of scientific creativity test in teaching expressed in seven (7) item. All of item from SCSM namely original item and item test in this research is known by adapted item. The difference between the original item and the adapted item is the development of the test on the subject and the time limit of the test (Carson, 2011). The subject of this research is motion and simple machines. The test time for each item is adjusted to the question form. For items 1 to 5 it takes 3 minutes for each item while item 6 is given 10 minutes and item 7 is given 20 minutes. Item 1 is about unusual use (UU), item 2 is technical production (TP), item 3 is hypothesizing (H), item 4 is science imagination (SI), item 5 is science problem solving (SPS), item 6 is creative Experimental (CE) and item 7 is science product (SP). The time limitation tests are intended to give students opportunities in creativity. With the time limitation of student creativity is more easily measured because in the same time expected results will be maximized.

Some questions of the original test have been modified according to the material that are motion and simple machines. The test was administered to a sample of 140 students selected from year-8 in a secondary school in Jember, Indonesia. This research was conducted at State junior high school of 3 Jember, Indonesia. The students took science classroom during odd semester in academic year 2016/2017. The research was applied using one-group pre-posttest design (Fraenkel, *et al.*, 2009:265).

Data collection was conducted using an essay test and questionnaire method with a self-assessment sheet. The data needed to achieve the goal is the result of data learning outcome of scientific creativity skills. Data collection was

conducted using an essay test and questionnaire method with a self-assessment sheet. The effectiveness of students' scientific creativity skills is determined by the n-gain <*g*>.

The gain score calculation underlies the Hake formula (1998):

Normalized Gain < *g* > = (score post-test – score pre-test) / (100 – score pre-test)

The test score analyzed using average normalized gain < *g* > which is defined as the ratio of the actual average gain to the maximum possible average gain, i.e. where Sf and Si are the final (posttest) and initial (pretest) class average (Hake, 1999). Hake (1999) defined g score >0.7 as highly engaged activity to promote particular understanding; 0.7>g>0.3 as medium-engaged activity; and g<0.3 as poor-engaged activity. The self-assessment sheet were analyzed descriptively. Analysis of the data to answer the problem and achieve the goal of the research was done by using descriptive.

The effectiveness criteria for improving learning outcomes and scientific creative ability are based on the provisions as shown in Table 1:

Table: 1 Criteria of Effectiveness Improvement of Learning Outcomes and ability of Scientific creative

Gain Normalized	Criteria	Creative
(g) ≥ 0,7	High	
0,3 ≤ (g) < 0,7	Medium	
(g) < 0,3	Low	

result an d discussion

The development of the scientidic creativity test has been validated with three aspect in terms of: the contents validity, knowledge and writing validity carried out by 3 (three) validators, all of whom are experts in the field of Physics Education. A summary of the results of its validation analysis can be shown in Table 2.

Table 2: The Summary of Validation Results of the Scientific Creativity test

Indikator Test	**Score**	**Criteria**	**Coef.**	**Reliabilit y**
Unusual use (UU)	3.33	Valid	85.71%	Reliabel
Technical Production (TP)	4.00	Very valid	100.00%	Reliabel
Hypothesizing (H)	4.00	Very valid	100.00%	Reliabel
Science Problem Solving (SPS)	3.33	Very valid	85.71%	Reliabel
Creative Experimental (CE)	4.00	Very valid	100.00%	Reliabel
Science Product (SP)	4.00	Very valid	100.00%	Reliabel
Average	**3,66**	**Very valid**	**95,23%**	**Reliabel**

Data in Table 2 shows that the validation score for each component is in the range of values from 3.33 to 4.00.

Indikator test Unusual use (UU), Technical Production (TP), Hypothesizing (H), Science Problem Solving (SPS), Creative Experimental (CE), Science Product (SP) with each score in the category is very valid

Implementation of the scientific creativity test performed to obtain an indicators achievement skills of scientific creativity. Results of the Achievement indicators in pretest and posttest of motion material and simple machines material shown in Table 3.

Table 3. Achievement indicators in pre-test and post-test and G-score

Indicators of Scientific Creativity Skills	**Score Test**		**N-Gain**
	Pre	**Post**	
Unusual Use (UU)	36.7	87.8	0.81
Technical Production (TP)	42.2	78.9	0.63
Hypothesizing (H)	42.2	86.7	0.77
Science Imagination (SI)	44.4	80.0	0.64
Science Problem Solving (SPS)	35.6	65.6	0.47
Creative Experimental (CE)	44.4	78.9	0.62
Science Product (SP)	30.0	81.1	0.73
Scientific Creativity (SC)	39.4	79.8	0.67

Average indicators achievement for unusual use increased from 36,7 in pre-test to 87.8 in post-test, technical production increased from 42,2 in pre-test to 78.9 in post-test, hypothesizing increased from 42,2 in pre-test to 86,7 in post-test, science imagination increased from 44,4 in pre-test to 80,0 in post-test science problem solving increased from 35,6 in pre-test to 65,6 in post-test, creative experimental increased from 44,4 in pre-test to 78,9 in post-test, science product increased from 30,0 in pre-test to 81.1 in post-test. Average indicators achievement of scientific creativity skill gained 39.4 to 79.8 Table 3. This indicated that test showed an improvement in test score after the scientific creativity test was implemented. Average achievement indicators in pre- and post-test shown in Figure 1.

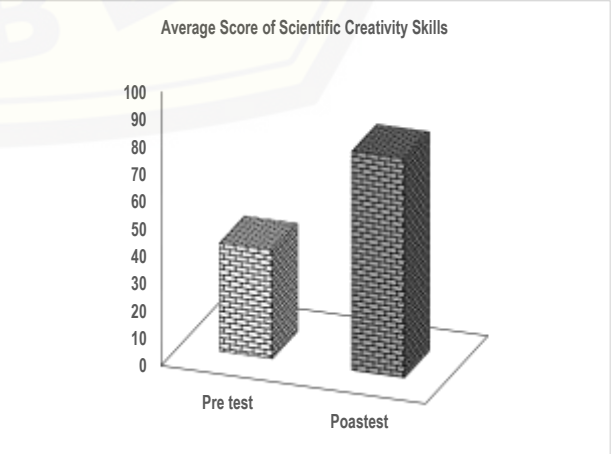

Figure 1. Average score in pretest and posttest of scientific creativity skills

Implementation of scientific creativity test in SMP 3 Jember, Indonesia can develop students' scientific creativity skills in order to improve the results test of scientific creativity skills as shown in Figure 1. Meanwhile, g-score of motion and simple machines material for unusual use gained 0,81 (high-g), technical production gained 0,63 (medium-g), hypothesizing gained 0,77 (high -g), science imagination (SI) gained 0,64 (medium-g), science problem solving gained 0,47 (medium-g), creative experimental gained 0,62 (medium-g), and science product gained 0,73 (high-g). Therefore, average g-score of material gained 0,67 (medium -g). This score indicated that scientific creativity test could fairly engage students to conduct scientific creative skills.

Table 4. Student self-assessment of self-capability

Aspect	**Answer Percentage (%)**	
	Positive	**Negative**
I acquire opportunity to create many ideas to answers the new and logical problem (fluency)	93,4	6,6
I acquire opportunity to provide many ideas to answers the problem from different perspective (flexibility)	92,2	7,8
I acquire opportunity to provide many ideas to answers that are question unusual or unique and clever (originality)	95,7	4,3
Total	281,3	18,7
Total Percentage	93,7	

The scientific creativity test enables a suitable variety of opportunities for students to be creative in multiple ways. The scientific creativity test allows student to do a research and conduct an experiment on a topic of their interest and ability under supervision of a teacher also to encourage students to participate in class in order to improve their scientific creative skills, i.e. unusual use, technical production, hypothesizing, science problem solving, creative experimental and science product and social skills e.g. interaction with friend and teacher can also increase student' interest and attention to a lesson. Using the scientific creativity test in learning, student will be able to evaluate their own learning outcomes, develop their ability of creative skills, do experimental in laboratory and helps students to understand the material by themselves

The scientific creativity test provides a suitable variety of opportunities for students to be active in science teaching learning of motion material and simple machines material with scripted lesson plans on secondary school student so that has given a good value on the ability of affective, cognitive and psychomotor (Morrison, 2007; Lynch, 2009). The findings showed that scientific creativity test developed successfully able to improve students' scientific creativity. Value skills of scientific creativity of students acquired during the learning includes indicators: the use of unusual (UU), think of ways to create new products or improve existing ones into something technically new production, Technical Production (TP) raises new questions or viewpoints new forms of imagination or hypothesis in science, Hypothesizing (H) develop problem-solving capabilities of scientific students, Science problem solving (SPS) testing creative experimentation with a variety of possible methods to produce creative products experimental creative, creativity experimental (CE) and machine design product design creative Science Product (SP). (Lin et al (2013); Wang and Yu (2011); Hu et al (2013); Astutik, et al (2015) results showed that the scientific creativity test can improve the skills of scientific creativity. Teachers play a role in guiding and providing feedback on the discussion and elaboration of scientific creativity should be given specific inputs and as soon as possible due to the absence of feedback students gain a little knowledge. To get a good mastery of skills scientific creativity, learning steps are performed using the skills of scientific work and overcome the weaknesses skills of scientific work in the early stages of learning are given help in stages (scaffolding) in students, which helps gradually to students until the students gain knowledge and gradually freed after a student is believed to be capable. Guidance given to students include, understanding the problem formulation, formulation of hypothesis, identify variables and determine the operational definition of variables. At this stage, to overcome the difficulties of student teachers are expected to find a suitable strategy or method associated with formulating the problem, formulating a hypothesis, identify variables and formulate an operational definition of variables to build trust and their identity in learning (Grossen, 2008: 248).

Based on the research result to the positive self-assessment concerning how to conduct scientific creativity test, students found that the scientific creativity test was helpful in helping them to learn how to apply scientific creativity in science teaching. This was in line with studies from (Aktamis & Ergin, 2008: Lynch, et al. 2009) and (Astutik, et. al., 2016), (Grossen, 2008) that indicated positive views of students in science teaching who received science learning in secondary school.

CONCLUSION

The results showed that the scientific creativity test can improve indicators skills of scientific creativity, namely: the use of unusual (unusual use), production techniques (technical production), hypothesis (hypothesizing), solving the problem of science (science problem solving), creative experimentation (creative experimental) and products of science (science product). Improved indicators of scientific creativity demonstrated by the increase in the value of the pre-test to post-test on aspects of fluency, flexibility and originality. Self-assessment of students toward mastery aspects of fluency, flexibility and originality obtained high value as indicated by the positive response (93.7%) stated that students can undertake aspects of fluency, flexibility and originality in scientific creativity skills indicators.

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