How to Assess Creative Thinking Skill in Making Products of Liquid Pressure?

L Chasanah1, I Kaniawati2 and H Hernani3

1Pendidikan IPA, Universitas Pendidikan Indonesia, Bandung, Indonesia
2Departemen Pendidikan Fisika, Universitas Pendidikan Indonesia, Bandung, Indonesia
3Departemen Pendidikan Kimia, Universitas Pendidikan Indonesia, Bandung, Indonesia

*luluul_chasanah@student.upi.edu

Abstract. The primary skills that must be possessed in the 21st century curriculum are learning and innovation skills. One of the learning strategies that can train students to innovate and improve creative thinking skills is by applying Science, Technology, Engineering and Mathematics (STEM) in learning. Based on an interview to one of the science teachers that learning that aims to train learning and innovation skills has not been applied to learning in the classroom because there is not enough time, learning materials and assessment instruments used. This study aims to determine the results of the implementation of performance assessment of creative thinking skills on STEM-based learning in junior high school for the material of liquid pressure. This research uses descriptive method. Participants in this study were junior high school students 8th in Kudus area. The research instrument consists of observation sheet, performance assessment and documentation. The result showed that creative thinking skills performance assessment can assess student’s creativity in making products of STEM-based learning for junior high school.

1. Introduction

The main skill that must be possessed in the 21st century curriculum is learning and innovation skill. The 21st century skills expected of the students include: (1) Life and career skills, (2) Learning and innovation skills, (3) Information media and technology skills [1]. In reality, schools are less prepared to prepare students to solve real-life problems, because the knowledge gained in schools sometimes can not reach. Even students who have high math skills, not necessarily math ability can solve problems during the process of designing or designing an idea [2]. Based on an interview to one of the science teachers who teach in junior high school learning and innovation skills of students has not been applied to learning in the classroom, because teachers are more likely to measure the conceptual mastery. The limited time, learning materials and assessment instruments used to be the reason teachers do not choose a model of learning that aims to train students to innovate.

One of the learning strategies that can train students to innovate and improve the skills of creative thinking and creative product creation is by applying STEM in learning. The STEM approach is one very effective way to encourage students to think in high-level and problem-solving skills by placing mathematics and science in the context of technology and engineering [3]. STEM-based learning aims to prepare students who are more creative and technology literate in solving related problems in real life. In STEM-based learning, students will perform engineering process design. Engineering Process
design is a useful learning strategy for implementing STEM education in the 21st century curriculum [4]. With engineering, students are trained to use their creativity in creating a project as a solution to the problems they find in real life. Creativity is important in engineering process design. The process of engineering activities has several stages that can be done repeatedly as a cycle such as: brainstorming, design, construct, test / evaluation and sharing solutions [5]. At first the idea of the engineers was not solving the problem, but they tried some ideas then learned from their mistakes and tried again. The steps the engineer uses to come up with a solution are called the design process. This characteristic of engineering process design that will lead the students to train their ability to work with other students in classroom learning and to practice creative thinking skills better.

Based on the research entitled how integrative STEM can benefit students in engineering design exercises, showing that students who participate in learning using engineering modules demonstrate an increased knowledge of concepts, higher-order thinking and significant project design activities than students who use Technology education module in learning [2]. This study aims to investigate the implementation of the performance assessment of creative thinking skills on STEM learning on liquid pressure lesson for junior high school students.

2. Experimental Method
This research uses descriptive method. Participants in this study were eight grade students of junior high school in Kudus area, Central Java of academic year 2016-2017. Participants were selected using purposive sampling technique by taking one of the classes of available classes. Students in a class chosen as participants have heterogeneous abilities. The performance assessment used in this research trains creative thinking skills on STEM-based learning. Aspects of creative thinking skills in this assessment are based on aspects of creative thinking skills namely fluency, flexibility, originality and elaboration [6, 7]. The assessment of performance in this research is divided into performance assessment by processing performance assessment by product. Performance assessment by process uses steps of engineering process design. The 7 main steps of engineering process design according to Suwarma are identifying problems, discussion, design, construct, test or evaluation, revealing solution and redesign. Performance assessment by product aims to assess the results of creative products made by students. The aspect of creative products in this study uses creative product assessment [8]. The performance assessment by product consists of novelty, resolution and elaboration.

3. Result and Discussion

3.1. Creative thinking skill performance assessment in STEM-based learning

The study was conducted in 8F class at SMP N 1 Kudus, Central Java. The number of Students in one class is 34 students. The learning model used is by applying STEM-based learning model [9]. At the time of engineering process design activities, students may choose to make a motor boat or hydraulic jack. In the learning process, students are divided into 10 groups. Each group is given a worksheet as a guide for activities. Learning activities use engineering process design steps. The steps of engineering process design can be seen in figure 1.
Figure 1. Engineering process design cycle (Suwarma, 2015)

Figure 1 shows that engineering process design steps, there are 7 main steps that can elicit students' creative thinking skills. Activity to identify problems at the engineering process design first step guides the students to find the problems of the phenomena that are displayed. Discussion activities guide students in seeking and developing an idea. Design of engineering process design step will guide students in making combinations or sections in making a product. Construct of engineering process design step will guide students in enriching and developing an idea or product. Test or evaluation will guide the students to find product weakness. Revealing solution at the engineering process design step guides the students in sparking many ideas, answers and problem solving. Redesign activity guides the students in adding details of an object so that getting a more perfect product.

This study uses performance assessment to measure students' creative thinking skill in doing engineering process design. The example of creative thinking skill performance assessment can be seen in Figure 2.

| No | Creative Thinking Skill Criteria | Engineering Process Design Steps | Rated Aspect | Score |
|----|---------------------------------|----------------------------------|-------------|-------|
| 1  | Flexibility                      | Identify Problems                | Student finds the problems of the phenomena that are displayed | 1 2 3 4 5 |
| 2  |                                | Discussion                       | Student seeks and develops many ideas | 1 2 3 4 5 |
| 3  |                                | Revealing Solution               | Students give many ideas, answers and problem solving | 1 2 3 4 5 |
| 4  | originality                      | Design                           | Student tries to design a product with a new look that is not the same as his/her friends' ideas | 1 2 3 4 5 |
| 5  |                                | Construct                        | Student is skilled and fast in making product | 1 2 3 4 5 |
| 6  |                                | elaboration                      | Student can develop and match his/her friend's ideas | 1 2 3 4 5 |
| 7  |                                | Test or Evaluation                | Students review the product to find the weaknesses | 1 2 3 4 5 |
| 8  |                                | Redesign                         | Student adds details for objects to fix the weaknesses | 1 2 3 4 5 |

Figure 2. Creative thinking skill performance assessment in STEM-based learning

This study uses 2 types of performance assessment that are creative thinking skill performance assessment and creative product performance assessment. The example of performance assessment by product can be seen in Figure 3.
Figure 3. Creative product performance assessment in making product of liquid pressure

Figure 3 shows the seven aspects of creative product performance assessment. This study uses the assessment of creative products including related aspects of novelty, resolution and elaboration [10]. The novelty aspect measures the extent to which the resulting product differs from previous products in terms of processes and materials. The elaboration aspect measures the extent to which the resulting product is the result of creative ideas adding parts for more detail, can be in the form of color enhancements to make the product more attractive. The resolution aspect measures the extent to which the resulting product can work. The resulting product must be usable according to the intended purpose. In addition, the resulting product must have value for use and is an application of the concept of the lesson being studied.

3.2 The principle of floating

An object floating on a liquid surface (like a boat) or floating submerged in a fluid (like a submarine in water or dirigible in air) the weight of the displaced liquid equals the weight of the object. Thus, only in the special case of floating does the buoyant force acting on an object equal the objects weight.

![Diagram](a) (b)

Figure 4. The principle of floating of an object

It is important to realize that, while they are related to it, the principle of flotation and the concept that a submerged object displaces a volume of fluid equal to its own volume are not Archimedes' principle. Archimedes' principle, equates the buoyant force to the weight of the fluid displaced.

3.3 Pascal’s law

Pascal's law or the principle of transmission of fluid-pressure is a principle in fluid mechanics that states that a pressure change occurring anywhere in a confined incompressible fluid is transmitted throughout the fluid such that the same change occurs everywhere.
Hydraulic jacks depend on force generated by pressure. Essentially, if two cylinders (a large and a small one) are connected and force is applied to one cylinder, equal pressure is generated in both cylinders. One cylinder has a larger area, the force the larger cylinder produces will be higher, although the pressure in the two cylinders will remain the same. Hydraulic jacks depend on this basic principle to lift heavy loads: they use pump plungers to move oil through two cylinders. The plunger is first drawn back, which opens the suction valve ball within and draws oil into the pump chamber. As the plunger is pushed forward, the oil moves through an external discharge check valve into the cylinder chamber, and the suction valve closes, which results in pressure building within the cylinder.

3.4 Creative thinking skill performance assessment

Based on data analysis the highest score obtained by students is 4.5 and the lowest score obtained by students is 2.8 from a maximum score of 5.0. The average score that students get is 4.07 with very good category. These data are shown in Figure 6.

Figure 6 shows there are two students that get lower score than the average class’ score. This is because of personality, motivation and environment. Based on observations gained during the learning process, students are less motivated to learn and tend to be quiet during group discussions. Creativity is influenced by several factors namely the process of intelligence (intelligence), knowledge, thinking style, personality, motivation and environment [11]. Based on several theories and how to see the creativity of the research that has been done before, there are 4 main aspects that affect the creativity, namely: (1) internal factors that include intelligence and personality; (2) external factors consisting of education and social culture; (3) facilities in the process of creating creativity; (4) Individual motivation [12]. Creativity consists of cognitive abilities, personality and past experience [8].

3.5 Creative product performance assessment

Based on data analysis the highest score that students get is 4.57 while the lowest score is 3.71. The average result of creative products that students get in this research is 4.27 with very good category. These data are shown in Figure 7.
Creativity can vary in context, where creative products in one context may not be considered creative in other contexts [13]. Variations of creative products are expressed through the level of creativity, the creativity of Big-C and Little-C [14, 15]. Most people will not achieve the creative genius of Einstein. This type of creativity is called Big-C creativity, referring to the idea that the intellectual domain contributes over time [16, 17]. Most people do creativity every day, which is the creativity of Little-C. This type of creativity involves “the possibility of thinking” [18], which includes the moment of discovery, a moment of discovering like this which happens to the student in completing the tasks assigned by the teacher. The students in completing the task of making a motorboat, faced some problems to solve and found the solution. Although these activities are not unique to people in general, they are new to students. Thinking of creativity that is completely product-oriented, however will only limit and confuse creativity with productivity [19].

4. Conclusion
Based on discussion result that creative thinking skills performance assessment can assess student’s creativity in making products of STEM-based learning for junior high school. Elaboration aspect of creative thinking skills gets the highest score because students are motivated to put forward their best ideas. In one group, each student is required to take part in completing the task given by the teacher. And the other hand, the aspect of creative products that gets the highest score is resolution because the students already understand the concept of the lesson being studied.

Acknowledgments
The authors would like to thank Mrs. Suwarma, M.Si. Ph.D and Mr. Dr. Muslim, M.Si as validator of creative thinking skill performance assessment that used in this research. The authors would like to thank postgraduate program in Universitas Pendidikan Indonesia, especially to science education program of postgraduate program in Universitas Pendidikan Indonesia.

References
[1] Triling B and Fadel C 2009 Problems as Possibilities: Problem-Based Learning for K-16 Education (Alexandria: ASCD)
[2] S-C Fan and K-C Yu 2015 How an integrative STEM curriculum can benefit students in engineering design practices International Journal Technology Des Education DOI 10.1007/s10798-015-9328-x
[3] Jones R B 2008 Science, Technology, Engineering, and Math http://www.learning.com
[4] Crismond D P and Morgan J 2012 The Informed Design Teaching and Learning Matrix Journal of Engineering Education 101 4 pp 738-797
[5] Suwarma I R 2015 Sosialisasi dan Pelatihan Pendidikan STEM not published
[6] Munandar S C U 1977 Creativity and Education: A Study of the Relationship Between Measures of Creative Thinking and a Number of Educational. Variables in Indonesian Primary and Junior Secondary Schools (Jakarta: UI)
[7] Munandar S C U 1999 Mengembangkan Bakat dan Kreativitas Anak Sekolah Petunjuk Bagi Guru dan Orang Tua (Jakarta: Grasindo)
[8] Treffinger D J, Young G J Selby E C & Shepardson C 2002 In Office of Educational Research and Improvement (ED), Washington, DC. (Ed.) Assessing creativity: A guide for educators, research monograph series, U.S Connecticut: Order Department

[9] Laboy D 2010 Integrated STEM Education Trough Project-based Learning. www.learning.com/imaginemars

[10] Besemer S P and Treffingger D 1981 Analysis of creative products: Review and synthesis Journal of creative behavior 15 pp 158-178

[11] Stenberg R J &Lubart T I 1993 Creative giftedness: A multivariate investment approach. Gifted Child Quarterly 37 vol 1 pp 7-15

[12] VanTassel-Baska J 1998 Excellence in educating gifted and talented learners. Denver, CO: Love

[13] Beghetto R A &Plucker J A 2006 The relationship among schooling, learning, and creativity: “All roads lead to creativity” or “You can’t get there from here”? In J. C. Kaufman & J. Bear (Eds.), Creativity and reason in cognitive development Cambridge, England: Cambridge University pp 316-332

[14] Plucker J A, Beghetto R A& Dow G T 2004 Why isn’t creativity more important to educational psychologists? Potentials, pitfalls, and future directions in creativity research Educational Psychologist 39 2 pp 83–97

[15] Kaufman J C &Beghetto R A 2009 Beyond big and little: the four c model of creativity Review of General Psychology 13 1 pp 1–12

[16] MacKinnon D W 1978 What makes a person creative? In D W MacKinnon (Ed.) Search of human effectiveness: identifying and developing creativity New York: Universe Books

[17] Craft A 2000 Teaching creativity: philosophy and practice New York: Routledge

[18] Runco M A 2003 Creativity, cognition, and their educational implications. In J. C. Houtz (Ed.), Tsshe educational psychology of creativity Cresskill, NJ: Hampton pp 25-56