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Harmonization of Science, Technology, and Society (STS) in Science Learning to Prepare 21st Century Generation

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Tugu Yogyakarta

PREFACE

Praise be to Allah SWT for all the blessings and guidance given to us all, so that the program book of the International Seminar on Science Education (ISSE) 2015 bringing about *Harmonization of Science, Technology, and Society (STS) in Science Learning in the 21st Century* held on 31 October 2015 in the Rectorate Hall, Yogyakarta State University can be completed. This book comprises a number of abstracts presented in the seminar, written by lecturers and students from Yogyakarta State University and other universities.

We owe many parties for the success of the seminar. Therefore, we would like to sincerely extend our gratitude to:

1. Rector of Yogyakarta State University, Prof. Dr. Rochmat Wahab, M.Pd., M.A. for facilitating all the activities of the International Seminar on Science Education (ISSE) 2015;
2. Director of Graduate School of Yogyakarta State University, Prof. Dr. Zuhdan Kun Prasetyo, M.Ed. for providing all the facilities of the International Seminar on Science Education (ISSE) 2015;
3. the invited speakers for their willingness to share thoughts and insights on science teaching and learning in the seminar;
4. all committee members for the time, effort, and thoughts for the success of this activity; and
5. all presenters and participants who have come a long way to contribute to the success of the seminar.

However, we realize that there are some imperfections in this book and in the seminar. Thus, suggestions and constructive criticism are very much welcome. Finally, we do hope that this book can bring some contributions to learning of science in the 21st century.

Yogyakarta, 31 October 2015
Chairperson

Dr.rer.nat. Senam

Table of Content

Page

ISSN: 2476-9533 *Proceeding of International Seminar on Science Education*
Yogyakarta State University, October 31st 2015

DEVELOPMENT OF STEM-BASED PERFORMANCE ASSESSMENT IN PHYSICS LEARNING FOR STUDENT'S CREATIVE THINKING SKILL

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Abstract

This paper discuss about development of STEM-Based Performance assessment in Physics learning for creative thinking skills. Creative thinking skill is part of soft skill in 21st century learning. Creative thinking need to develop for face advance in society, environment, technology, and science. Real world problem that happened by student is a complex problem that need not only science literacy but also creativity. Integration of STEM literacy in learning bring Physics into contextual domain. In that case, **S**cience is defined as physics with concept that can be applied in student live, Technology as tools which can help conceptual finding, Engineering as physics project in order to modified a technology, and Mathematics that used to help calculate any physics quantity. Creative thinking skills includes process and product, so it takes more than assessment tests to measure creative thinking skills as a whole. Performance assessment is authentic assessment designed to assess input, proses and output. Performance assessment used in this study contains tasks which is based indicators of creative thinking. Students are required to use literacy of STEM to solve the tasks, so they would accustomed to be complex thinker and creative thinker. In that case, performance assessment can measure and also constructed students creative thinking skills. Performance assessment draws on a methodology that follows a cyclic procedure for instrument development and validation, where literature, experts, students and educators contribute in the procedure.
Keywords: Performance assessment, STEM, Creative Thinking Skill

INTRODUCTION

Competition workplace of the 21st century increasingly large as the impact of globalization. The globalization occurs in almost all nations in the world today, therefore Indonesia as part of the nation was also affected of globalization must prepare its people, especially the younger generation, in order to face the competition in the 21st century workplace. The international workplace competition is also felt in Indonesia after the emergence of the agreement AEC (ASEAN Economic Community). AEC agreement made by Indonesia government aims to increase the number of professional workforce. Recent research from the International Labour Organization, or ILO mentioned the opening of labor markets brought great benefits. ILO (BBC, 2014) specifies that the demand for professional workforce will increase by 41% or about 14 million. While the demand for labor middle class will be up 22% or 38 million, while the workforce increased by 24% a low level, or 12 million. To meet the demand for professional workforce, it is necessary to increase the capabilities and skills of the 21st century for the young generation.

The main preparation to prepare young people for the challenges of globalization

is education. Education is required to prepare the younger generation in achieving competencies that are needed in today's workplace. Educators as the spearhead of education should develop the necessary skills of learners in life. National Science Teachers Association, NSTA (2011) stated that every educator who in education environments must develop 21st century skills are consistent with best practices instructional that include curriculum development, pendagogi, teacher preparation in learning and teacher professional development.

Increased skill and ability for young prospective workers is the responsibility of education. Education is an integral part of the process of preparation of qualified human resources, strong and skilled. Through education, the candidate will obtain a quality workforce, productive, and competitive.

Workforce in the 21st century takes more than knowledge, but also creativity. International institutions Partnership for 21st Century Skills calls for creativity and innovation as one of the essential skill sets of future citizens. Baety (2011) also mentions that creativity is the most important skill in the 21st century According to Fisher (1990), creative thinking is one of the important aspects of thinking skills. Creative thinking ability is indispensable students to face the future that have complex problems. Fisher (2005) says that creative thinking skills are essential for success in learning and success in life. Creativity prepare them with flexible skills that they will need to face an uncertain future (Wang, 2011).

Education in Indonesia should apply a system of learning that prepares students in develop creative thinking skills to face the work place competition. Improving the education system can be implemented through the improvement of learning systems and assessment system. Discrepancies learning system and assessment system would result in suboptimal educational system.

In fact, educational or teaching activities in schools have not been fully facilitate students to develop creative thinking skills. There are still many schools that only implement the learning process with the students as recipients of a number of information without much to develop the skills they need to participate in the real world, such as creativity.

Contextual learning system that emphasizes the concept of the invention will facilitate the creative thinking skills development. This is consistent with the essence of learning physics as one of the Natural Sciences that emphasizes of collection the mastery of knowledge (facts, concepts, or principles) and the process of discovery. Creativity is a complex psychological aspects, creative thinking skills includes a series of processes and

final product. Hence creativity assessment performed by the various instruments and carried out continuously (Semirwan, 2008).

Creative thinking is included in pattern of divergent thinking, so that the assessment process can not be done simply by a convergent test that is often used today. The assessment process of creative thinking as stated by Osborn & Parnes (Khatena, 1992) must noticed an assessment of the various ideas that emerged and also followed up with an evaluation based on the criteria of value and role. Therefore needed assessments can assess the whole aspect of the product and aspects of the learning process.

DISCUSSION

Creativity in Physics Learning

Creativity is a complex construct but the importance of identifying and facilitating creativity in educational system has been widely recognized (Diakidoy & Constantinou, 2001). To identifying and facilitating creativity in education setting requires an understanding of creativity by educators and education practitioners. Meanwhile, according to Piaget (Neira & Soto, 2013) Creativity is the ultimate form of the game symbolic childs, when the symbols are assimilated in their mind. Guilford (1950) defines creativity as the capacity or ability to generate alternative answers of the problems was given, with an emphasis on variety, quantity and relevance of results. Guildford's early research (1959, 1986, 1988) identified divergent thinking components which were quickly appropriated for creativity assessment. Fluency, flexibility, originality, and elaboration are Guildford categories commonly encountered for rating student creative performance. Creativity assessment is made difficult by many things some about the nature of creativity. One of the most fundamental questions in creativity theory and research is the issue of domain specificity (Baer & McKool, 2009). creativity for specific domains might differ from the indicators of creativity in other domains. The difference is situated on specifications and characteristics of the domain of science itself. in that case, the creativity from the perspective of art may differ with creativity in physics as natural science.

The structure of scientific creativity in Natural Science education by (Hu & Adey, 2002: 392) described as follows:

(1) Scientific creativity is different from other creativity since it is concerned with creative science experiments, creative scientific problem finding and solving, and creative science activity.

(2) Scientific creativity is a kind of ability. The structure of scientific creativity itself does not include non-intellectual factors, although non-intellectual factors may influence scientific creativity.
(3) Scientific creativity must depend on scientific knowledge and skills.
(4) Scientific creativity should be a combination of static structure and developmental structure. The adolescent and the mature scientist have the same basic mental structure of scientific creativity but that of the latter is more developed.
(5) Creativity and analytical intelligence are two different factors of a singu- lar function originating from mental ability.

based on the above statement is known that the preparation of indicators creative thinking skills in the learning of physics need to pay attention to the characteristics of physics as a natural science. application of creative assessment for physics learning can help familiarize students to think creatively. it is in line with research conducted by (Kohl, Kuo, Kowalski, & Kowalski, 2010) Physics student performance on the Torrance tests definitely changes after an elective course on creativity, though it is not completely clear that the gains come from instruction.

Performance assessment base on STEM Approch

Performance assessment is process of assessment implemented by observing the activities of students in doing something.This technique is especially suitable for assessing achievement of competence mastery learning requires students to perform tasks. According to Jo Anne Wangsatorntanakhun quoted (Zainul, 1999:99), stated that performance assessment consists of two parts: "Clearly defined task and a list of explicit criteria of assessing student performance or product". Further stated also that performance assessment is realized based on the "four assumptions" principal, is: (1) Performance assessment is based on the active participation students, (2) The tasks given or done by students is an integral part of the overall learning process (3) Performance Assessment is not only to determine the position of students at some point in the learning process, but also to improve the learning process itself. (4) By knowing in advance the criteria that will be used to measure and assess the success of the learning process. Jonsson and Slingby (2007: 131) states that the performance assessment designed to examine aspects of the more difficult to understand in the learning process by letting students solve problems in a realistic or authentic.

Stecher (2010: 3) defines a structured task performance is a situation in which the

stimulus material and requests for information or action presented to the students, which produces a response that can be assessed using the quality standards explicitly. The standard may apply to the final product or the process of creating scientific products. A performance appraisal is a collection of task performance. Oberg (2009) stated that the assessment of performance, offering a variety of ways for students to demonstrate what they know about the content, as well as the students explain additional set of skills in the classroom.

STEM Education

STEM education is an approach to teaching and learning that integrates the content and skills of science, technology, engineering, and mathematics (Maryland, 2012). Use of System approach in education aim to prepare students be able to compete and ready to work as field studies. STEM approach has the main principles related to communication, materials, ability to solve problems (problem solving), integration, technology and careers. Six key principles are summarized in science as materials, technology as a product of science, engineering as the ability to apply science and math components as a liaison between the components. The four components that include Science, Technology, Engineering and Mathematics is expected to be mastered by the learners so that they can properly career. (Bybee, 2010).

STEM literacy refers to the ability of a person to apply an understanding of how strict the competition works in the real world that requires four interrelated domains. National Governor's Association Center for Best Practices (2007: 7) define STEM literacy according to each of the four inter-related fields of study is, 1) Science Literacy as the ability in using science and applying contextual problem solving solving. 2) Technology Literacy as know how to use new technology which developed, undertanding new technology which developed, and have an ability to analisis how the technology give a significant effect in society life. 3) Engineering Literacy as understanding about how technology which developed by using engineering desaining process will use in study based project which integrate in every subject. 4) Mathematics Literacy as the abilty of student to analyze the reason and to communicate an idea effctively because of activate the students to formulate, to solve, and to construct the meaning as a solution of mathematic problem in every condition.

Besides developing knowledge in science, technology, engineering and mathematics, the integration of STEM education also seeks to foster soft skills such as scientific inquiry and problem solving skills. By improving problem solving skills with

the support of scientific behavior, to the integration of STEM education seeks to build a society that is aware of the importance of STEM literacy. Literacy "STEM refers to the ability of individuals to apply the understanding of how tight the competition works in the real world that requires four interrelated domains.

Development Performance Assessment Based on STEM for Creative Thingking Skill.

Assessment of creativity include learning characteristics associated with High Order Thingking and a high level of skill as well (Semiwan, 2008). Performance assessment is an assessment that is capable of assessing aspects of products and processes in learning because it uses various forms of tasks to obtain information about what and how much material has been studied students. performance assessment requires students to complete tasks using knowledge and skills performance that is embodied in the form of deeds, actions or performance. Kohl, Kuo, Kowalski, & Kowalski (2010) note that tasks that are explicitly focused on creativity are not common in a students' experience. get students to better understand the creative process by considering the measurement problem, and second, to solicit student ideas for creating a usable physics- specific instrument. So performance assessment are developed at STEM approach based on physics measurement and usable physics- specific instrument will facilitate students to understand creative processes.

Using STEM approach in physical learning is able to solve a problem contextually. Real-world problems can be explained through interdisciplinary integration in STEM. Wang et al. (2011) describes in combining cross-curricular content at critical thinking, problem-solving skills, and knowledge to reach a conclusion. Multidisciplinary integration requires students to connect the content of a particular subject, but the integration of interdisciplinary focusing students attention on the problems and combines the content and skills from various fields.

Performance assessment have more points when compared with traditional assessment. The advantages can be summarized as follows: 1) students can demonstrate a process; 2) a process which demonstrated can be directly observable; 3) provide a more complete evaluation and natural for some kinds of reasoning, verbal ability, and physical skills; 4) the existence of an agreement between teachers and students about assessment criteria and the tasks to be done; 5) assess learning outcomes and skills are complex; 7) gives a great motivation for learners; and 8) encourage the application of learning in real life situations (Airasian, 1991).

Performance assessment is an assessment that is appropriate to develop divergent

thinking patterns learners. Performance assessment will assess any activity undertaken by learners so that students will be more motivated to be active and berinofasi in learning activities because they feel any activity that meraka doing appreciated in the assessment. The tasks arising from performance assessment can be drawn up contextually, close to the lives of students and highlight real-word problem. The task will provide a space for students to innovate in finding solutions to problems that can stimulate and develop divergent thinking patterns learners.

In his research mitchell (1976) develop creative thinking indicators that have been submitted by Guilford's into fourteen basic elements of creative behavior. include 1) development of humor, 2) Fluency, 3) Flexibility, 4) Originality, 5) Elaboration, 6) Self-Concept, 7) experimenting with and Testing Ideas and Huences, 8) Learning Form Failure, 9) Tolerance of ambiguity , 10) Resourcefulness, 11) Problem Sensitivity, 12) Synergy, 13) Imagination, 14) Imagination. In practice teacher must first choose the appropriate curricular area to be Considered. In this case, physics emphasizes the ability to analyze problems in the experiment, the ability of humor does not prioritized in learning. So that students may not bring up all the creative attitude in general, but specifically scientific creative behavior.

Assessment of performance that already includes some indicators of creative thinking skills which implemented in the learning process and also adapted STEM approach. Indicators of creative thinking skills that had been developed in the assessment of performance into a series of systematic performance that shoul be done by a student in the learning process. Based on set of performance assessmet series, student integrate the fields of science, technology, engineering, and mathematics which applied in the assessment to solve physics problems. It's clear to conclude that the idea of STEM-based performance assessment can develop critical thinking skills of students. This explanation can be seen in Figure 1.

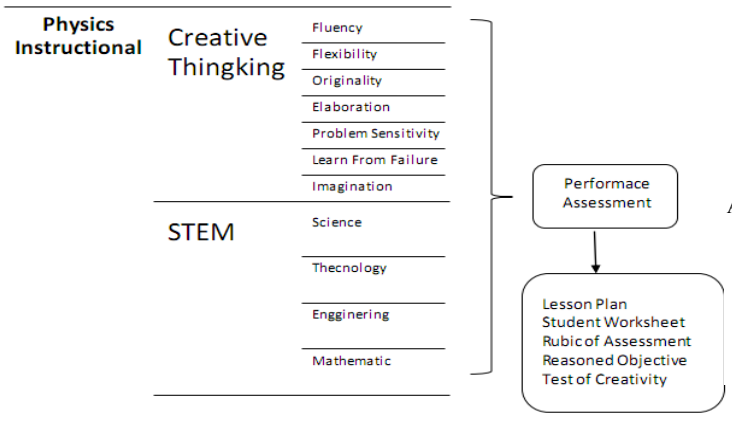

Figure 1 Modelling Performance Assessment Based STEM in Physics for Student's Creative Thinking

Figure 2 presents the cyclic nature of the STEM-based performance assessment development. The definition of Creative Thinking in the center of the cycle is in regard to both the abilities that constitute it and the items that measure it. Involved parties (experts, educators, students and existing literature), provide feedback on Systems Thinking definition through data that define the test's validity and reliability.

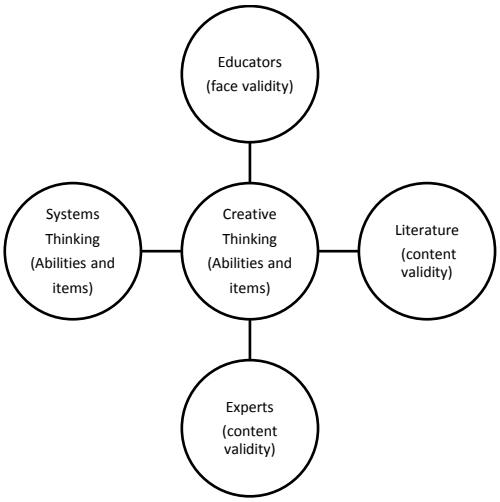

Figure 2 Development procedure for STEM-Based Performance Assessment

CONCLUSION AND SUGGESTION

Physics learning based on instructional expected to produce students who have the competence and skills. Creative thinking skills is one of the skills needed in the 21st century. Performance assessment based on STEM is the idea that direct students to promote their creative thinking skills. Tasks in performance assessment can be arranged contextually, close to the student life and highlights the real-word problems. Tasks will provide a space for students to innovate in finding solutions to problems that can stimulate and develop student's creative thinking patterns. The performance assessment used in this study was designed to include indicators of creative thinking skills systematically. Students are required to apply the use of STEM skills for the purpose of promoting their creative thinking skills as required to meet a set of performance assessment indicators. Performance assessment is an integral part of the whole process of learning, and assessment are used not only limited to knowing the position of the students in the learning process but also improve process belajar students. Improvement of student learning can be done by providing STEM-based performance assessment continuously in

the learning process, so that the patterns of creative thinking that will be formed in students.

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