Stem-Based Science Learning In Junior High School: Potency For Training Students’ Thinking Skill

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ABSTRACT

STEM (Science, Technology, Engineering, and Mathematic) education including science learning, is needed to face 21st century development, especially for training thinking skill. STEM is believed to increase students’ thinking skill, interest, and STEM literacy. This study aims to know the extent of thinking skill trained through science learning in Junior High School, and to know challenges and potencies of developing STEM-based science learning. The study was conducted in SMP N 1 Masaran through various data collection methods. Data were collected by in-depth interviews to 7 science teachers, observation, documentation, and literature study about plan and process of science lesson, also STEM education as an approach. And then, data were analyzed reflectively toward various documents and literatures. Assessments which categorized "higher order thinking skill" were below 5% of all assessments provided to students. There is potencies that able to develop to train students’ thinking skill through STEM-based science learning which appropriate with national curriculum in Indonesia. Teachers can innovate in developing strategies and lesson plans to incorporate content Technology, Engineering, and Mathematic in science lesson for train students’ thinking skill.

Key Words: Roundtable, Cognitive Style, STEM-based Science Learning; Thinking Skill; Training Thinking Skill.

INTRODUCTION

Indonesia as a developing country needs many professional workforce to compete at global economics and facing 21st century challenges. Various skills needed to prepare professional workforce. Workforce skills and demands have changed
dramatically in the last 20 years. There has been a rapid increase in jobs involving nonroutine, analytic, and interactive communication skills (National Education Association, n.d). Employers report that a significant percentage of graduates lack the skills required in the labor market in Indonesia. Skills gaps exist in terms of basic skills, but even more so in terms of soft skills such as thinking and behavioral skills (LaRocque, 2015).

Twenty-first century’s skills such as ability to think (logical, analytical, critical, and creative), ability to solving problems, communication skills, and collaboration skills become important to be pay attention at its developments (Pacific Policy Research Center, 2010). Indonesian education is still under-develop in increasing the thinking skills and soft skills. Science literacy, include science concept on Indonesian students still relatively low. In 2009, Indonesia got rank 57 from 65 countries and 64 from 65 countries in the 2012 (OECD, 2013).

In global competition, Indonesia need to raise Human Resources’ skills in having an ability to good think, also need to raise workforce in STEM field. STEM education need to be pay attention at applied schools. National curriculum can be maximised by inserting STEM characteristics without changing the curriculum itself. Science teachers at junior high schools important to be motivated to be the driving force of the traditional learning transition into STEM-based science learning. The transition will be a bottom-up movement and bring a good impact.

STEM Education

STEM as an acronym of science, technology, engineering, and mathematics became international concerns at job field as well as education to prepare STEM workforce. STEM based education built Human Resource (HR) that able to reasoning and think critically, logics and systematic so they ready to face global competition also able to raise country’s economy (Asmuniv, 2015). STEM education engages students in metacognitive activities. Implementation of STEM education in the classroom provides opportunities to students for understanding the importance of the integration of different disciplines and its applications. Students can improve their logical thinking through it all (Anwari et al., 2015). STEM education has comprehensive characteristics in giving chances for students to train their ability to think. The application of STEM education have a big chances to train students' thinking skills through its characteristics.

STEM’s perceived potential fulfill a student’s learning experience by aiding him or her in ability to transfer learning (Berry, Reed, Ritz, Lin, Hsiung, and Frazier, 2004). STEM as education has characteristics which integrate among STEM subjects in collaborative learning and student-centered by inquiry and engineering design process to find the solution of real-world problems. Student can solve new problems and draw conclusion based upon previously learned principles applied through science, technology and engineering, and mathematics (Roberts, 2012). High quality STEM education programs should include (a) integration of technology and engineering into science and math curriculum at a minimum; (b) promote scientific inquiry and engineering design, include rigorous mathematics and science instruction; (c) collaborative approaches to learning, connect students and educators with STEM fields and professionals; (d) provide global and multiperspective viewpoint; (e) incorporate strategies such as project-based learning, provide formal and informal learning experiences; (f)
incorporate appropriate technologies to enhance learning (Kennedy and Odell, 2014; Kelley and Knowles, 2016).

One of main STEM education characteristics is integrate science, technology, engineering and mathematics in learning process to find the solution of real-world problems (Firman, 2015). This interdisciplinary bridging among discrete disciplines is now treated as an entity, STEM. It offers a chance for students to make sense of the world rather than learn isolated bits and pieces of phenomena (Morrison, 2006).

STEM Integration

Integrated STEM education continues to rise more questions than there are presently answers (English, 2016). Bybee (2013) conceptualize integration of STEM to several pattern from the simplest on, where S-T-E-M as "silo" and taught in separated, up to STEM as a transdiscipline subject. The degree to which STEM is integrated is dependent upon many factors, including the level of education (Roberts, 2012).

Roberts and Cantu (2012) illustrate three approaches that can be used in STEM education (Silo, Embedded, and Integration). The disciplines of silo approach are taught separately which keeps the domain knowledge within the confines of each discipline. In embedded approach, domain knowledge from at least one discipline is placed within the context of another. The embedded components are not usually evaluated or assessed. In integration approach, the STEM content areas are taught as though they were one subject. Integration can be done with a minimum of two disciplines but is not limited to two disciplines. A more comprehensive perspective on STEM integration divided to 4 integration class from the lowest to the highest, (1) Disciplinary, (2) Multidisciplinary, (3) Interdisciplinary, and (4) Transdisciplinary (Vasquez, Sneider, and Comer, 2013; English, 2016).

STEM-Based Science Learning

![STEM-Based Science Learning](Source: Roberts and Cantu, 2012; Firman, 2015)

High integration of STEM into transdiscipline subject form requires comprehensive restructuring of the curriculum, making it relatively difficult to implement in the context of the conventional curriculum in Indonesia (Firman, 2015). A fully integrated STEM curriculum is most easily achieved at the elementary level, which the student is still taught by a class teacher with a large portion. An embedded STEM curriculum is perhaps more feasible at the secondary level (Junior high school) (Roberts, 2012). Embedded STEM education as described by Roberts and Cantu (2012) and Firman (2015) as in Figure 1. It has possibility to be conducted without
restructuring junior school curriculum in Indonesia. This integration applied by incorporate the content of technology, engineering, and mathematics in STEM-based science learning (Firman, 2015).

Thinking Skills

Refer to Piaget, Suharnan (2005) has divided cognitive development into 4 levels, i.e., motoric sensory level (0-2 years), pre-operational level (2-7 years), concrete operation level (7-11 years), and formal operation level (11 years and more). The time when children turn 11 is a time when children begin to leave primary education and go to secondary education. Adolescence is a transitional of thinking level. Piaget (1965) divide adolescence into three levels of thinking, (1) concrete operation thinking level, (2) transitional thinking level, dan (3) formal operation thinking level.

According to Minderovic (2006), humans have a universal nature to think logically and follow logical inference. It is commonly defined as higher cognitive skills. The ability to think logically is the foundation of thinking skills. The better the students' ability to think logically, the better the student's ability in analyzing, constructing, and concluding, a concept (Usdiyana, Purniati, Yulianti, and Harniningsih, 2009). Albrecth (1984) argues that logical thinking is not obtained magically or genetically, this ability is the process of organizing information obtained from learning process. This statement is in line with Lawson dan Blake (1974) which believe that the school system not only focuses on teaching facts and concepts from the knowledge domain only, but is more important to help students acquire the ability to think.

Problem-based learning as one of characteristics of STEM learning, present a real-world problem to encourage students for creating the solution. Engaging students to solve a problem, or run a project to solve problems in learning process can improve their thinking skills. King, Godson, and Rohani (1998) state that often facing problems and dilemmas can train students to think logically. Yaman (2005), claimed that the implementation of the PBL in the science lessons succeeded in improving the logical thinking ability required to gain high-level reasoning ability.

Other than problem-based learning, application of STEM education in learning as an integration could optimize students' thinking skills. This opinion stated based on Pursitasari, Nuryanti, and Rede's research (2015), that the integrated-thematic learning can optimize students' thinking skills.

The questions that arise in this study are (1) how far thinking skills was trained by the curriculum, strategy, lesson plan, and assessment in the science learning process in SMP N 1 Masaran ? and (2) how transition potenions of science learning process from traditional become STEM-based science learning implemented to train students’ thinking skills ? This study exploring the effort to improve students' thinking skills through students’ activity in science learning process at junior high school. Also exploring STEM characteristics as an education as well as learning process and its impacts in students' thinking skills.

METHODOLOGY

The study used qualitative descriptive method. The process of qualitative research involves emerging questions and procedures; Collecting data in the participants' setting; Analyzing the data; And making interpretations (Creswell, 2009). The study was
conducted to explore informations that related to preparation and process of learning science about training students' thinking skills in SMP N 1 Masaran, Sragen regency. In addition, this study also explore the potencies of reformation (transition) on learning science from traditional approach to STEM-based science learning for training students' thinking skills more intensively than before.

**Participant**
This study involves 7 in-service science teachers and 69 students. The science teacher consists of 5 males (Mr. Ramlan, Mr. Hariyanto, Mr. Aris, Mr. Sutejo, Mr. Azim) and 2 females (Mrs. Rifat, and Mrs. Norma). Students were divided 3 grades (grade 7, grade 8, and grade 9).

**Data Collection and Analysis**
Data were collected by various methods such as documentation, observation, and indepth interview. Documentation method aim to collect data of curriculum learning, including teaching materials, syllabus, learning strategy and model, lesson plan, and also assessment. Observations method was conducted in 3 classes to look into process of learning science in the classroom. Indepth interview method was conducted to each science teachers to explore the potencies and challenges of train students' thinking skill, including by STEM-based learning. And then, data were analyzed reflectively toward various documents and literatures, and described specifically (Sugiyono, 2015).

**RESULTS AND DISCUSSION**
Learning process is the main concern of this study to explore the train of students' thinking skill. The learning that is deemed appropriate to the characteristics and needs of the students and is proven to increase the critical and creative thinking skills is learning that contain learning activities together, read, ask, and look for possible answers, in the tournament and ends with a reflection group (Wulandari, Hamidah, and Setiawan, 2014). Based on the data obtained from archives and interview results, the strategy of learning science in SMP N 1 Masaran has been in accordance with national curriculum in Indonesia (Curriculum 2013), which all the process of learning science used scientific approach. Learning process with scientific approach is an active learning process which oriented on students as center of learning. The process of scientific learning is a combination of learning process that previously focused to exploration, elaboration, and confirmation equipped with observing, asking, reasoning, trying, and communicating (Ministry of Education and Culture, 2013).

Problem and project based learning are in accordance with the scientific approach and suggested to do in Curriculum 2013. However, 4 of 7 teachers have not understood and used that model learnings in a past year yet. While 3 other teachers, they could design the learning strategy of that models, but they admitted applying in learning process in classroom rarely. The responsibilities of positions as school principal (Mr. Ramlan), as well as the vice principal (Mr. Hariyanto and Mr. Aris) is one of the obstacles.

The result of observation of learning process on science in classroom that was done on grade 7, 8, and 9 showed that there is a gap between practice on learning and lesson plan that has been made by techers. The learning activity should contain scientific approach, but the components of it have not been implemented in learning process. Learning process has not been oriented on students. Learning activity of scientific approach aims to train thinking skill that was categorized low.
The train of students' thinking skill can be done by familiarizing students to face the learning problems (King, Godson, and Rohani, 1998), both presented in the lesson and the questions on assessment. Refering to Cottrell's idea (2005: 1) who argued that “Critical thinking is a cognitive activity, associated with using the mind”, so, students will be commoned to solve problems with a certain level that rely on their thinking skill, then students' thinking skill will increase.

Schraw and Robinson (2011) classified the thinking skills on Bloom's Taxonomy into two levels: Lower Order Thinking Skills consist of knowledge, comprehension and application, and Higher Order Thinking Skills consist of analysis, synthesis and evaluation. Lorin Anderson revised the "synthesis" part into "creating" and put it as the highest part in cognitive thinking skill proces. Based on the classification that has been done, The revised Bloom’s Taxonomy has six levels sequence of: (1) remembering, (2) understanding, and (3) applying for Lower Order Thinking Skills, and (4) Analyzing, (5) evaluating, and (6) creating for Higher Order Thinking Skills (HOTS) (Schraw and Robinson, 2011; Anderson and Krathwohl, 2001; Yulaelawati, 2004).

Based on the results of data analysis on Table 1. that was obtained from 7 assessments made by science teachers grade 7, 8 and 9, the questions of assessment were categorized low on improving students' thinking skill. The high-level of cognitive’s issues have a percentage below 5% of all questions in the assessment were given to students. The questions are still oriented on the “remembering” level and have not reached “evaluating” level yet and at all on “creating” level.

<table>
<thead>
<tr>
<th>Cognitive Level</th>
<th>Percentage (%)</th>
</tr>
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<tbody>
<tr>
<td>Grade 7</td>
<td>Grade 8</td>
</tr>
<tr>
<td>Remembering</td>
<td>77,4</td>
</tr>
<tr>
<td>Understanding</td>
<td>18,0</td>
</tr>
<tr>
<td>Applying</td>
<td>3,3</td>
</tr>
<tr>
<td>Analyzing</td>
<td>1,3</td>
</tr>
<tr>
<td>Evaluating</td>
<td>0</td>
</tr>
<tr>
<td>Creating</td>
<td>0</td>
</tr>
</tbody>
</table>

Masaran, one of sub-district in Sragen, Central Java - Indonesia should not left behind on educational developing, if they want to improve the nation's competitiveness in the global economy. Malaysia, as a country bordering on Indonesia and having strong cultural links has started research to develop STEM since 1999 by involving various participant from students (school), graduates (university), practitioners, and adult (Jayarajah, Saat, and Rauf, 2014). The STEM education which is the concern of the education world in both the western and the ASEAN countries (Malaysia, Thailand, Singapore, dan Philippines) needs to be considered to be gradually applied to Indonesian education.

Compared to Technology and Engineering, Science and Mathematics are two strong domains in Indonesian education, especially in junior high school level. So STEM is usually interpreted to mean science or mathematics. STEM could mean increasing the recognition of engineering in K-12 education including junior high school level (Bybee, 2010). Amidst the realization that the T and E will play a critical role with regard to our welfare in the 21st century, need supports and attempts a
transition from “science and mathematics” to “STEM and STEM education” (Sanders, 2009).

The development of STEM literacy in Indonesia is needed, although it is not an easy case. It takes at least one decade to develop education of STEM (Bybee, 2010; Firman, 2015). However, the development of STEM especially in education, will gradually bring a good change for the people's STEM literacy. Beside of other stakeholders, the contribution of science teachers is a main key to suppor developing STEM on educational, especially in science domain. Science teachers should have a strong enthusiasm to begin integrating science learning with others STEM subjects.

STEM education is an unfamiliar thing to science teachers in SMP N 1 Masaran. Teachers have not known its concept yet. Although one of all teachers has heard it, but he did not know the characteristics and the implementation of it. Embedded STEM-based science learning can be a preliminary to start developing STEM education in SMP N 1 Masaran, while still follow national curriculum (curriculum 2013), without restructure it (Firman, 2015).

Based on the study, we found potencies that can be empowered in developing of STEM in Masaran, especially SMP N 1 Masaran. The potencies were classified into 2 main groups, that is internal potencies of the school, and the external potencies that around the school. Internal potencies needs to be developed first. Development can start from within the classroom by entering technology, engineering, and or mathematics contents into science learning process.

Five from seven in-service science teachers that owned by SMP N 1 Masaran have reached master degree in education and one of them is head of MGMP-IPA (Musyawarah Guru Mata Pelajaran IPA) or science teachers forum for Sragen regency and also as instructor for the Curriculum 2013 (national curriculum) implementation. This potential can used by teachers to maximize the MGMP-IPA as a Professional Development (PD) sessions for teachers start from school-level, then regency-level. PD experiences for in-service teachers could also provide a strong conceptual framework of an integrated STEM approach and build their confidence in teaching from an integrated STEM approach (Kelley and Knowles, 2016). Development of instructional models which will implement on STEM-based science learning such as problem-based and project-based learning (PBL) can also be done in PD sessions. PD sessions were effective in communicating several important concepts about STEM PBL and also can help teachers acquire the necessary pedagogical skills to implement STEM PBL (Han, Yalvac, Capraro, M.M., and Capraro, R.M., 2014).

All students must be a part of the STEM vision, and all teachers must be provided with the proper professional development opportunities preparing them to guide all their students toward acquiring STEM literacy (Kennedy and Odell, 2014). The teachers can use all of the potential both inside and outside school area to be a source to design STEM-based learning strategies. In collaboration with Information Technology (IT) teachers, science teachers can use internet access and school computers to train technological skills such as students' design skills utilize Computer-Aided Design (CAD). Teachers can also maximize problem-based learning by encouraging students to reviewing information actively using library facilities and internet access. In the purpose of provide opportunities for students to build strong connections between concepts in learning and real-world phenomena, teachers can collaborates with industrial activity
around schools, such as factories, handicraft industry, and technopark in the STEM-based science learning strategies.

Masaran is one of the industrial sites of both large and small industries (BPS, Kabupaten Sragen, 2016). Its location nearby from Sragen Technopark, as well as Solo Technopark. Industrial activities and also the technopark are potentially empowered in the development of STEM education. Through various research and study, higher education such as Sebelas Maret University, and other colleges in central Java, especially Soloraya (Surakarta, Karanganyar, Sragen, Boyolali, Sukoharjo, and Klaten) can participate collaboratively in the development of STEM education. By focusing on student engagement, educators from institutions of higher education and K-12 schools can work together to develop pedagogical models that provide rigorous, well-rounded education and outstanding STEM instruction (Kennedy and Odell, 2014).

STEM education provides students with knowledge and concepts that have relationships and applications in everyday life. Students can improve their logical thinking through engineering design processes based on scientific knowledge (Anwari et al., 2015). STEM Learning also can improve students’ scientific literacy (Khaeroningtyas, Permanasari, and Hamidah, 2016). Although the learning results obtained take a long time, at least in a short time, STEM education can increase students’ interest in science lessons (Anwari et al., 2015). It is important for STEM fields development and to answer problem that “too many students lose interest in science and mathematics at an early age” (Sanders, 2009).

CONCLUSION

Science learning that is able to improve thinking skills is needed to prepare students to face the challenges of the 21st century. The current science lessons in SMP N 1 Masaran are still not maximal in training students' thinking skills, either it is logical, critical, analytical, creative thinking, or problem-solving ability. STEM-based science learning can be a good choice to apply STEM to science learning gradually and of course to train students' thinking skills.

SMP N 1 Masaran has potentials that can be empowered to apply STEM education starting from science lesson. By developing STEM education consistently, SMP N 1 Masaran can be a role model in STEM-based science teaching for other schools, especially in Sragen regency. Training, seminars, and conferences themed of STEM education needed to be held continuously to improve teachers' skills in STEM and learning strategies. Musyawarah Guru Mata Pelajaran (MGMP) as teachers forum can be upgraded to be Professional Development as a forum for teachers to develop skills in STEM learning. While it is not an easy task to play the role of a teacher in STEM learning (Han, Yalvac, Capraro, M.M., and Capraro, R.M., 2014), teachers especially science teachers are expected to participate actively in prepare students to facing 21st century through the field of Science, Technology, Engineering, and Mathematics.
REFERENCES


