The application of STEAM (Science, Technology, Engineering, Arts, and Mathematics)-based Learning in Elementary School Surakarta District

K Saddhono1*, I N Sueca2, G D D Sentana2, W H Santosa3 and R S Rachman4

1Universitas Sebelas Maret Surakarta, Indonesia
2IHDN Denpasar Bali, Indonesia
3UST Yogyakarta, Indonesia
4Universitas Sangga Buana Bandung, Indonesia

* kundharu_s@staff.uns.ac.id

Abstract. Innovative learning is one of the answers to deal with challenges in the current era. STEAM-based learning is needed by students in Indonesia as an effort to train their skills and talents in facing problems in the 21st century. This study aims to describe the integrated thematic learning planning, implementation, and assessment in SD Negeri Tegalrejo 1 Yogyakarta. It was a descriptive qualitative research. Subjects of this study were the classroom teacher, students of VB class, and headmaster. Technique of data collection were observation, interview, and documentation. Data were analyzed by using some steps, in terms of data reduction, data display and drawing conclusion. Technique of testing data validity deployed triangulation of data collection technique and data sources. The result indicates that the integrated thematic planning conducted by teacher has contained the minimum criteria of lesson plan. The implementation of STEAM-based integrated thematic learning has presented the characteristics of integrated thematic learning, in terms of using subject guide of Basic Competence (BC), in which each BC has its own material.

Keywords: Integrated Thematic Learning, Authentic Assessment, STEAM

1. Introduction

Indonesia needs to engrave the science-and-technology-based economy learning in the early period to utilize demography bonus in 2025-2045. Through the science-and-technology-based learning, it is expected that there are people who have good character and moral, who have willingness to improve and develop, and who have logic in science. The increasing development of science and technology currently cannot be avoided. Science-based products have existed in a huge quantity. This imposes students to be able to master not only science and technology but also art related to design, creativity and innovation.

Innovative learning is considered as an answer for coping with challenges in the 21st century that force human to have technology skill and information management, to learn and innovate, to develop career and
have global awareness and good character in fulfilling market needs related to the science-and-technology-based product. Along with the great number of the demand on science-and-technology-based products, the educational system that stimulates students to have creation and innovation is needed. This system is adjusted to the 2013 curriculum goals to prepare Indonesian people, so they have the ability to live as individuals and citizens who are faithful, productive, creative, innovative, affective and able to contribute to community life, national life, country and world civilization [1].

In line with 2013 curriculum goals, elementary and junior high schools deploy integrated thematic approach referring to learning arranged integrally in terms of learning theme. Themes used should not be too wide, but can be used for various fields, Science, Technology, Engineering, Art, and Mathematics (STEAM)-based integrated thematic learning is extremely required. In accordance with Graduate Competency Standard, learning targets included affective, cognitive and psychomotoric developments elaborated for each educational institution. In the process of STEAM learning, the information is constructed through taking collaborative and creatibity risks. This means that students use their skills and learning process in science, technology, technique, arts and mathematic in thinking and solving problems. Placing art and design in education can influence businesspersons to employ artists in discovering the innovation, so there are many leaders with art and design backgrounds [2]. The application of STEAM approach in the process of integrated thematic learning is expected to equip students with various skills needed by students in dealing with the competition in the 21st century.

STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning is one of the innovations for education in Indonesia. It attempts to develop human who is able to create the science-and-technology-based economy. Through STEAM, students are encouraged to think comprehensively with problem solving pattern based on five aspects in STEAM. These aspects aim to teach students to think critically and to have techniques or designs in solving problems in the world based on mathematical and their knowledge. STEAM-based learning can help stimulating their ability to face challenges in the 21st century. The concept of STEAM learning combined with integrated thematic learning and adjusted to the 2013 curriculum. For example, elementary schools, deploys theme-based learning. A theme is taught on STEAM-based subjects. This expected that STEAM-based learning results in the product reflecting future or current needs.

The STEAM-based learning is essential for students in Indonesia to train their skills and talents in facing the 21st century. The complexity of the 21st century demands skills from various fileds while STEAM-based learning can become the preparation and training to face all challenges of the 21st century. The design, creativity and innovation are art elements initially combained in STEM (Science, Technology, Engineering, and Mathematics) and later combined in STEAM (adding art element). In the 2013 curriculum, learning is integrated thematically and suitable for combining STEAM-based learning. Elementary and junior high schools are appropriate educational levels to apply STEAM since elementary school subjects are provided to be thematically integrated, and social and science subjects in junior high schools have been combined to support STEAM-based learning [3].

In the theme-based learning in elementary schools, a theme is taught on STEAM-based subjects. Mathematics, Social, Science, Indonesian languages and other subjects support to apply the STEAM-based learning. Some themes such as cita-citaku (my dream), hemat energi (thrifty to use energy), and others are interlinked to STEAM. The expected outputs are product and design made by students in relation to the design. For example, students make a simple magnifying glass, simple waterwheel and other product resulted from STEAM. The STEAM-based learning is able to train students’ skills and talents to face 21st century problems. Besides, theme and STEAM-based learning in elementary schools is expected to be able to produce output in terms of products and designs created by students in relation to the design [4].
Based on these phenomena, there are many teachers and students who still fail to understand STEAM (Science, Technology, Engineering, Arts, and Mathematics)-based Learning. Meanwhile, Ministry of Education and Culture suggests that the innovative learning in dealing with Industry Revolution 4.0 needs to do in each educational institution in Indonesia. In fact, until the end of 2018, the implementation of innovative learning is not optimally accomplished in schools. In a consequence, this study is essential to do in order to succeed the enhancement of STEAM (Science, Technology, Engineering, Arts, and Mathematics)-based Learning implementation in Sirakarta District. Conducting this study certainly help giving comprehension for teachers and students related to this leaning-based STEAM. The implementation of this study is reinforced by Regional Office of Education, Regional Office of Youth and Sports Affairs, Teacher Work Group (TWG) for the elementary school level in Surakarta District.

2. Method

This study was descriptive qualitative regarding its purposes. It was conducted between November and December, 2018. Subjects of this study mainly referred to teacher, students at the fifth grade, and the headmaster of a State Elementary School in Surakarta District. The teacher was a classroom teacher of the fifth grade. Students consist of 30 persons in the learning observation activity and 5 persons in the interview activity. This study deployed data collection techniques in terms of observation, interview, and documentation. The instruments utilized observation sheet, interview guide, and documentation. The activities of data analysis were data reduction, data display and conclusion drawing/verification. Data validity were tested through triangulation (data sources and data collection technique) and member check.

3. Result and Discussion

3.1 Learning Description in Elementary School

The success of learning process is disposed by planning. Learning goals are probably accomplished effectively and efficiently since learning is well-planned. Planning organized is written in Lesson Plan (LP). Each lesson plan corresponds with the applied syllabus or curriculum and is then developed as the condition of educational institution. Lesson Plan is improved in detail from a certain fundamental material or certain theme with reference to syllabus to drive students’ learning activities in fulfilling Basic Competence (BC), Technical Guide for Compiling Lesson Plan in schools [5]. Lesson Plan is compiled in accordance with theme/sub-theme or BC conducted in one or more than one meeting.

Based on the interview result with the classroom teacher, Lesson Plan is individually compiled by teacher, still, after getting training and discussion in Teacher Work Group (TWG) on how to compile a good lesson plan, as well as guide from higher education institutions. Besides, the interview result of the headmaster shows that lesson plan is individually compiled by teacher. The compilation of LP must contain some components. According to Savage & Amstrong (1996: 152), Lesson plans often feature the following categories of information: Instructional objectives, teaching approaches, organizing and managing learners. Concerning on this study, the teacher has compiled learning objectives that will be achieved, learning approaches or methods that will be used, learning activity management. However, these components are not provided in detail.

Technical Guide for Compiling LP in Elementary Schools contains some components [6], including: 1) school identity referring to the name of educational institution; 2) subject or theme/sub-theme identity; 3) grade/semester; 4) main materials; 5) time allocation; 6) main competence (MC); 7) Basic Competence (BC) and competence achievement indicators; 8) learning goals formulated from BC; 9) learning
materials; 10) learning methods; 11) learning media, tool, and sources; 12) learning activity steps; 13) evaluation. Fortunately, lesson plan compiled by the teacher has stated the achievement of BC/MC 1, 2, 3, and 4. It implies that the specific skills in terms of affective, knowledge and psychomotoric that have to be achieved by students have stated.

The result of analyzing the lesson plan document by the teacher indicates that developed indicators correspond with the teacher book. Competence achievement indicators are explained into learning goals. The learning goals has contained ABCD (Audience, Behaviour, Condition, and Degree). However, learning steps are not fully conducted in the learning process, but the teacher generally has allocated time for pre-activity, whilst activity, and post-activity. According to Regulation of the Ministry of Education and Culture number 81 A on the implementation of Curriculum, LP minimally contains: (i) learning goals, (ii) learning materials, (iii) learning methods, (iv) learning sources, and (v) evaluation. Henceforth, the lesson plan complied by the teacher has been appropriate with the principles of compiling LP. However, it is lack of description about learning steps, which are not organized in detail.

3.2 Implementation of STEAM Learning

The integrated thematic learning conducted by the teacher uses five themes with STEAM method, including Bangga sebagai Bangsa Indonesia (Proud as Indonesian People). STEAM learning has been carried out by teacher by combining BC in some subjects, and all combined BC has no overlapping materials. It is emphasized by Fogarty, who states that webbed curricula represent the thematic approach to integrating subject matter [7]. Multidiscipline integration is conducted without combining basic competence of each subject since each subject has its own basic competence.

The result of learning observation reflects that teacher has been able to carry out learning with using multidiscipline approach, for the teacher has referred to and used the teacher book. It indicates that this multidiscipline approach has embedded to teacher books. If teachers have been able to do what is in the book, they have been able to apply multidiscipline approach. The implementation of STEAM learning activity needs clear stages. In accordance with the 2013 curriculum socialized by the Ministry of Education and Culture, there are 4 stages of integrated thematic learning as the followings. (1) The first is determining themes that are possibly compromised with students. It is found that the teacher has carried out theme-based learning, namely Bangga sebagai Bangsa Indonesia (Proud as Indonesian People). For this theme, the teacher carries out learning for eight times to complete three sub-themes. (2) The second is integrating themes in accordance with the applied curriculum by prioritizing attitudes, knowledge, and skills. The teacher has facilitated learning activities by prioritizing these aspects. In the third meeting, the aspect of attitude visibly demonstrated is the spiritual attitude in terms of praying at the beginning and at the end of learning activity, and nationalist attitude by singing the Indonesian national anthem before starting the learning activities. For the knowledge aspect, the teacher provides learning materials about the benefits of hydropower weir, natural features. For the psychomotoric aspect, the teacher facilitates students to read, write and ask question. (3) The third is designing a lesson plan accommodating the scope of the theme. The teacher has compiled a lesson plan based on 5 themes, which accommodates the basic competencies related to the theme. (4) The fourth is to carrying out learning activities that enable students to actively learn. The teacher carries out learning by stimulating students with questions, allowing students to actively answers look for the answer and to answer questions, and
facilitating students in discussion activities. Henceforth, the teacher has carried out the stages of integrated thematic learning.

The implementation of STEAM learning is inseparable from the application of scientific approach. This study also observes the application of scientific approach in the integrated thematic learning. The observation results on the scientific approach are the followings.

3.2.1 Observing

In this observing activity, students are more encouraged to seek and deeply comprehend the knowledge through reading. This knowledge is acquired by students by reading books and listening material given by the teacher. For example, in the learning activity 4, students listen to materials about benefit and function of coconut trees given by the teacher. This is undeline by Settlage & Southerland (2007: 31) who stated that observing is the most fundamental of basic science process skills and includes sight and the other sense [8]. This study shows that students use not only one sense (eyes) in observing activity but also other senses. However, reading and observing pictures showed through projector are most frequent activities conducted, so the teacher tends to focus on one sense. As a conclusion, the teacher has encouraged students to do one the activities in scientific approach in terms of observing. This observing activity exists in learning activity 1 until 8.

3.2.2 Questioning

The questioning activity is carried out not only by the teacher as a stimulation to make students active, but also students who have been actively asking questions, both about material that is difficult to understand and other materials. According to the Regulation of the Minister of Education and Culture Number 81 A Year 2013, competencies that can be developed in the scientific approach for the questioning aspect are developing creativity, curiosity, ability to formulate questions in the need of forming critical thinking for smart life and lifelong learning [9]. Developing creativity, as in the learning 4, is conducted by asking question, such as "why does the earth rotate but we don't feel it?". Students' curiosity starts to rise in the learning activity 2. Students want to know the meaning of quality and prime numbers. Critical thinking is constructed in the learning 8. Students formulate questions about the application of prime numbers in daily life. The questioning activity has existed in each learning passages (eight times). It is carried out by both the teacher and students related to questionn words of 'what' and 'who' but occasionally 'how' and 'why'.

3.2.3 Trying

The trying activity is always identical with Science subject, but the application also occurs in other learning activities [10]. It is conducted in the learning activity 4, namely pojok beteng game include as an art field. This study determines pojok beteng game as the trying activity because it has the following stages: students read pojok beteng text in the book, the teacher explains the stages of pojok beteng game, students are divided into some groups, each group does pojok beteng game, and after all group play the game, each group is given a chance to explain their experience in playing pojok beteng game. Based on the observation result, the trying activity has been conducted once.

3.2.4 Inferring

Concluding the results of an observation is carried out by inferring what is obtained in the observation. Settlage & Southerland argues that inferring is to explain the reason or cause for what has been observed [11]. This argument can give an explanation that the inferring activity is an attempt to explain the reason of why is observed or explanation of what has been observed. The inferring activity occurs in the learning activity 3. The teacher makes an activity description, that is people can walk well without interruption
even though the earth rotates. By giving such questions, students will infer or draw conclusions by linking that this phenomenon is related to God, has a relationship with God and can be scientifically explained. This activity is included to the inferring activity to find the conclusion in terms of gravity force and science[12].

3.2.5 Communicating

The communicating activity is fully conducted in the learning activity 8. It is implemented by individually presenting or explaining the result of group work in terms of small and large group in written (writing in the board) and spoken forms. This is pointed out by Nasution who stated that communication is explaining the observation result that is successfully obtained or explaining the investigation result [13]. This result is explained in the class and evaluated by the teacher as individual or group learning result.

3.3 Authentic Assessment of STEAM Learning

Authentic assessment utilized by teacher in this STEAM learning include process assessment, performance assessment, portofilio assessment, and written test. Based on the interview result with teacher, the process assessment deals with assessing if students are skilled or not, brave or not, and then giving them marks. At the group discussion, the teacher also assesses students by taking note or marking students who actively express their opinion.

The portofolio assessment is conducted twice in the learning activity 2 and 3. In the learning activity 2, the teacher gives a homework to make telescope from carton. In the learning activity 3, the teacher gives a homework to make 5 questions and answers about natural features and 5 sentences of conclusion. These portofolio are collected in the indivual map saved in teacher cabinet. At giving school report card, the results of portofilo are given to parents to make them know of what their children have done. This is in line with Genesee and Upshur who stated that portofolio is a collection of students’ works that can show them (also others) about their effort, improvement, and achievement in a certain subject [14]. The written test is conducted every day at the end of learning activity. As suggested by Majid that written test is a test in term of written form (both questions and answers) [15]. This written test forms are brief answer and essay. This formative written test has some contents adjusted to the materials having been taught in that day [16].

4. Conclusion

Based on the results and discussion, it is concluded that the lesson plan of the STEAM learning has already contained the minimum criteria for a lesson plan, which includes a) learning objectives, b) learning material, c) learning methods, d) learning resources, and e) assessment. However, this lesson plan has not been described the steps of learning and the type of assessment used in detail. In the implementation of STEAM learning, there is a subject that cannot be integrated, namely Religious Education and Character and Sport. Nevertheless, the implementation of STEAM learning has raised to the characteristics of integrated thematic learning, including using the Basic Competency (BC) combination of some subjects, in which each BC has its own material. In the learning activities, the scientific approach has been carried out. Observing, questioning, trying activities, inferring activities, and communicating activities have emerged in the implementation of integrated thematic learning. In fact, there is a scientific activity less implemented, namely the trying activity. The trying activity was only conducted once. The authentic assessments have also been carried out in terms of process assessment, performance assessment, portfolio assessment, and written tests.
Moreover, this study suggests that teachers should develop and increase their knowledge on the implementation of STEAM learning, scientific activities, and authentic assessments through Teacher Group Work, or learning innovation seminars. Headmasters should motivate teachers to develop and implement the STEAM learning better, especially with regard to assessment activities.

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