The Effect of STEM-Based Worksheet on Students' Science Literacy

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Abstract: This study aims to improve the students' science literacy through the application of STEM-Based Worksheet (Science, Technology, Engineering, and Mathematics) on sound waves learning the material. The research used mixed-method with exploratory sequential design in the Nonequivalent Control Group Design. Samples were taken using purposive sampling technique. This study involved 25 eighth grade students of class F as the experimental class and 25 eighth grade students of class A as the control class in SMP Negeri 2 Pugung. The data collecting techniques were observation method, questionnaire, and test. The data were analyzed using independent sample t-test to see the effectiveness of the learning in both groups. The questionnaire results were analyzed descriptively. The results showed that the application of STEM-based worksheet could effectively increase the science literacy with N-gain of 0.43 (medium category). The highest increase was in the indicator of "explains the science phenomenon" and the lowest was on the "drawing conclusions" indicator. The results of the students' questionnaire responses after using the developed worksheet was 92,73 (very high category). This means that the developed students' worksheets effective in increasing science literacy.

INTRODUCTION

In essence, education is an effort undertaken by the government to improve the human resource capacity in facing 21st-century challenges (Anwar, 2014; Wijaya, Sudjimat, & Nyoto, 2016). Currently, 21st-century human resources must have life skills and career skills, critical and innovative learning skills and skills in technology, media, and information (Murti, 2013). Learning in the context of preparing for the 21st century refers to the concept of learning that provides experience to learners (Poedjiadi, 2005). 21st-century learning emphasizes learning that teaches the 4C principles (communication, collaboration, critical thinking, and creativity) which use a student-centered learning approach (P21, 2007).

The government is continuously working to improve the quality of education. The government's efforts to improve the quality of education are monitored through curriculum improvements, educational facilities, professionalism of educators, but have not shown maximum results (Zulrahman, 2013). One of the indicators is the students' low achievement in science and mathematics. This can be seen from the report of The Trend in International Mathematics and Science Study (TIMSS) in 2011 that shows the students' low

achievement in the field of mathematics and science (Kemdikbud, 2014).

The result of the Program for International Student Assessment (PISA) study in 2015 argues that the Indonesian students' ability in science is still low. In the report, the average score of Indonesian students' is 403. It is ranked 62 out of 69 countries participating in PISA (Organisation for Economic Cooperation and Development (OECD), 2016). This indicates that the ability of science literacy, creative thinking skills, and the students' science process skills are still low, so they cannot afford to work on higher level issues (Desianti, H., W., Adnyana, B., & Setiawan, I., G,.A., 2015). Desianti further explains that the low science literacy is caused by learning, in general, is still teacher-centered by using lecturing method without connecting learning with problems in real life and between science and technology (Abdurrahman, 2017; Desianti, H., W. et al., 2015).

Learning innovation has been done by many teachers such as the use of science learning model, problem-based learning, discovery and others, but this has not been able to train students' science literacy. In addition, students' worksheets that are used also have not been able to train the science literacy optimally (Pratiwi, Abdurrahman, & Rosidin, 2017). One of the learning innovations that teachers can use is the STEM approach in learning to train the science literacy.

Integrated STEM education is learning where learners use science, technology, engineering, and mathematics in a real context to develop STEM literacy that enables learners to compete in a new economic era (Tsupros, Kohler, & Hallinen, 2009). The goal of STEM education is to ensure that students have science and technological literacy in the future, they will be able to develop the competencies they have to be applied in

facing daily life problems related to STEM science field (Bybee, 2013).

STEM education is developed to produce meaningful learning through the systematic integration of knowledge, concepts, and skills (Tseng, Chang, Lou, & C, 2013). Some research results show that STEM approach can increase science literacy (Ismail, Permanasari, & Setiawan, 2016; Khaeroningtyas, Permanasari, & Hamidah, 2016) and able to increase motivation and provide experience in engineering process and also able to improve student achievement in examination (I.R, Astuti, & Endah, 2015; Syukri, T, & M.M, 2013). In addition, the use of STEM-based worksheet is effective in training students' creative-thinking skills (Aldilla, Abdurrahman, & Sesunan, 2017; Pratiwi et al., 2017).

STEM-based worksheet could be used as an alternative to train the science literacy. STEM-based worksheet serves as a guide for the students to work in groups, interacting with colleagues to manipulate various objects, asking questions, focusing on observation, collecting data and attempts to explain natural phenomena (Satterthwait, 2010).

Although the STEM approach plays a significant role in improving students' conceptual mastery, the impact of the STEM approach to science literacy has not been much expressed. Therefore this study attempts to explore the impact of the STEM approach on the science literacy of junior high school students.

METHOD

The research method used was mixed-method, with exploratory sequential design in the Non-equivalent Control Group Design (Table 1). The study was conducted at SMP Negeri 2 Pugung in May-June 2017. The population of this study was all students of the eighth grade. Samples were taken through purposive sampling technique. Two classes were obtained for research

that was class VIII F as the experimental class and class VIII A as control class.

Table 1. Research Design

Group	Pretest	Treatment	Postest
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Both sample groups had homogeneous variants (both sample groups had the equivalent capability). The control group was treated with learning using an existing textbook in the school, while the experimental group was given a treatment using a the STEM-based worksheet with project learning model. After that, both groups were given the same tests/question to measure science literacy. The data in this research were in the form of quantitative and qualitative data. Quantitative data was in the form of students' science literacy obtained from the pretest and post-test. Qualitative data was in the form of students' responses obtained from questionnaires and interview toward the learning through the STEM-based worksheet. Students' science literacy is reviewed based on a normalized gain or *N-gain* ratio using the following formula.

$$g = (S_{post} - S_{pre}) / (S_{max} - S_{pre})$$

Description:
g = average *N-gain,*
S_{post} = average post-test score
S_{pre} = average pretest score
S_{max} = score maximum
Criteria *N-* High if $g > 0.7$, mean if $0.7 > g > 0.3$, and low if $g < 0.3$.

Students' science literacy ability data was obtained through the tests. Qualitative data was in the form of student responses obtained through questionnaires and interviews with students after learning. Qualitative data were analyzed descriptively. Quantitative data were taken from pretest and post-test, and the *N-gain* values in the experimental and control classes were then analyzed using the *T-test*. To test the hypothesis the differences between two means and the equality of two means tests were used.

RESULT AND DISCUSSION

The results of data analysis showed that STEM-based worksheet influenced student learning outcomes on sound wave material (Table 2).

Table 2. T-test Results of N-Gain of Science Literacy

Classes	Pretest (x ± sd)	Posttest (x ± sd)	*N-gain* (x ± sd)	Criteria	*T-test*
Control	36.96 ± 13.77	54.88 ± 10.17	0.28 ± 0.07	Low	.000
Experimental	37.92 ± 14.05	64.64 ± 9.50	0.43 ± 0.08	Average	.000

Table 2 shows that the control class has *N-gain* value = 0.28 (low criterion), while the experimental class has then the *N-gain* value of 0.43 (medium criterion). Based on these data in the experimental class there is a significant increase in student science literacy. The result of the *T-test* analysis, the sig value (0.00) < 005 which means there a significant increase in student science literacy. Thus, there is a significant difference of *N-gain* between the control class and the experimental class. There is an increase in the students' science literacy on each indicator.
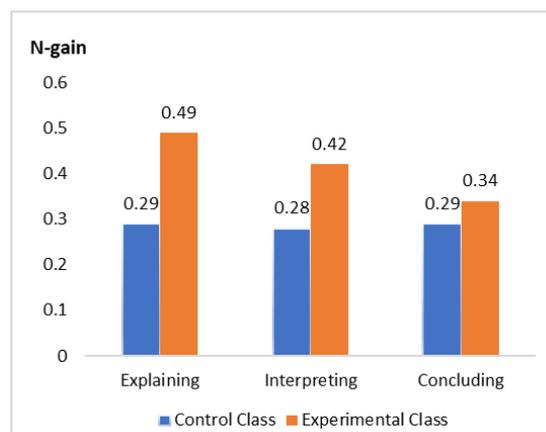
Figure 1. Science Literacy Ability

Based on Figure 1, it appears that the science literacy indicator that experienced the highest increase in the experimental class is "explaining scientific phenomenon" and "interpreting data or scientific evidence". The lowest indicator is "concluding or evaluating conclusions".

When learning using the STEM-based worksheet, the students looked more motivated, more active, and more confident. In general, student response toward the worksheet is very high (Table 3). Interviews show that almost all students enjoy learning through the STEM-based worksheet.

Table 3. Results of Student Response toward STEM-based Worksheet

No.	Assessed Aspects	Percentage %	Criteria
1.	Motivation to learn	91,39	Very High
2.	Interested to learn using the worksheet	94,82	Very High
3.	Fostering confidence	92,00	Very High
Average		**92,73**	**Very High**

Based on research results and data analysis, it can be seen that the use of STEM-based worksheet could effectively improve students' science literacy. This increase occurs because the STEM-based worksheet was used to guide students to do the science process by conducting experimental activities. The science process undertaken by students was the ability to use technology in assembling an experiment about vibration, wave, and sound in order to prove a concept of science. The stem-based worksheet also trained the students in mathematics in problem-solving activities, thus helping them to interpret solutions based on calculations and mathematical data. Students used mathematics when calculating wave frequencies and rapid wave propagation after experimenting

with vibrations and waves as shown in Figure 2.
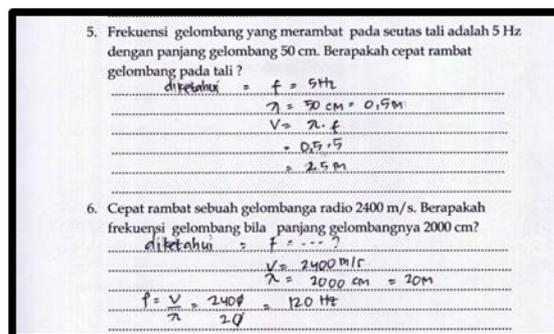
Figure 2. Examples of Student Answers in Using Mathematics

The implementation of engineering aspects in the STEM-based worksheets in the form of a project to make simple tools provided to students. The project of creating a simple tool in STEM-based worksheet aims to help the students to understand the concept of science applied in the tool and to involve the students to actively build the learning experience. In line with the principle of constructivism learning theory that centralizes the learning process experienced directly to form the concept of learning and understanding (Sulaeman, Indrawati, & Noeraida, 2017). Furthermore, the concept of experiential learning proves that learning by experiencing itself in real conditions and controlling the learning process is a better fulfillment of learning experiences than learning by observing so that knowledge gained will last longer in memory (Triyono, B., 2011). Activities in the STEM-based worksheet help the students to be able to solve problems and make a scientific conclusion. STEM project-based learning invites the students to make meaningful learning in understanding a concept (Tseng et al., 2013). Students are invited to explore through a project activity, so students are actively involved in the process. It fosters students to think critically, creatively, analytically (Capraro & Slough, 2013).

STEM learning applies problem-based learning that deliberately places

science inquiry and application of mathematics in the context of designing technology as problem-solving (William, 2011). By applying such learning, then the students' science literacy can be improved. Based on the results of the increase in science literacy indicators in the experimental class, the highest indicator was "explaining the science phenomenon", while the lowest was "to draw or evaluate conclusions".

The indicator "explains the science phenomenon" had the highest increase because in the STEM-based worksheet the students are given contextual problems in life, students are invited to do the process of science in learning by experimenting and collecting data then processing the data to generate conclusions. Through the contextual problems in life, students are required to learn to construct their own knowledge. This will encourage students to seek information from various sources in order to solve the problems presented. Bruner states that students should actively seek concepts through experiments to construct the knowledge it acquires (Bruner, 1966). In addition, the ability to "explain the science phenomenon" can also be increased through class discussion activities (Asyhari & Hartati, 2015).

In this study, the indicators "draw or evaluate conclusions" get the lowest results, although at the time of the learning process, the students directly performed the process of science by experimenting, collecting data, and processing data to produce conclusions. In reality, the students were not skilled to make conclusions. This is caused by the lack of reading skill. The students are not used to express their ideas and to do the practicum. In addition, students are still familiar with memorization (Rusilowati, Kurniawati, Nugroho, & Widyatmoko, 2016).

The improvement of the students' literacy in this research is caused by the

application of STEM-based worksheet that gives them the maximal chance to train their science literacy. Nevertheless, the increase in science literacy in this study is said to be not optimal because it only reached the moderate criteria. The important factor that becomes a constraint is the time spent in the learning process because previously the students have not been accustomed to using STEM-based worksheet and the science literacy have not been trained.

Students' responses were obtained by providing a questionnaire containing several statements. The result of students' response after using STEM-based worksheet was 92,72% which is in the very interesting category. In the learning activities, the students looked more active in the discussion, more motivated to learn the sound wave material and they think that the STEM-based worksheet can foster self-confidence.

The interview result shows that most of the students felt happy to learn by using the STEM-based worksheet, motivated to learn sound wave material and more motivated to finish every activity in the worksheet. Here are some excerpts of interviews to students after the use of STEM-based worksheet.

Table 4. The Interview Result

Student A:
"I feel happy to learn using the worksheet. It helps me to do a lot of activities in understanding the sound wave material".

Student B:
"Learning by using worksheet is fun because many of the experiments of sound waves are done in groups".

Student C:
"Learning by using worksheet makes it easy for me to understand the sound wave material".

Based on the results of the interview, the students felt happy to learn by using the STEM-based worksheet. It helps them to gain a better understanding

of the sound wave material. The worksheet presents pictures, phenomenon, and discourse related to daily life and the activities in the worksheet are also arranged in sequence. With the STEM-based worksheet, the students' understanding of the sound wave material being taught becomes increased because the sound wave material taught is related to daily life.

In addition to the duration problem, the number of concepts taught is also influential. In order to increase science literacy, the students should be trained through several concepts. While in this study, the students were only trained through a single concept, so that the increase is not optimal. Mastering multiple and interdisciplinary relationships increase science literacy (Silaban, 2014).

CONCLUSION

Based on the results of the research and discussion it can be concluded that the STEM-based worksheet could effectively improve the students' science literacy. The indicators show that the science phenomenon has the highest value and the conclusion drawing indicator has the lowest value. In addition, the students have a good or positive response toward the learning using the STEM-based worksheet.

Recommendations for further research are: (1) other prospective researchers should pay attention to the management of time at the time of learning because the activities performed relatively complex, (2) The concept of learning should be more than one in order to optimally increase the science literacy.

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