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THE EFFECTIVENESS OF LEARNING DEVICE BASED ON SCIENCE, TECHNOLOGY, SOCIETY, AND ENVIRONMENT (STSE) TO IMPROVE STUDENTS' SCIENTIFIC LITERACY

Hafizhah Sri Nugraha[1*], Raharjo[2], dan Fida Rachmadiarti[2]

[1] Pascasarjana Pendidikan Sains, Universitas Negeri Surabaya, Indonesia
[2] Jurusan Biologi, Universitas Negeri Surabaya, Indonesia

*e-mail: hafizhahnugraha16070795033@mhs.unesa.ac.id

Abstract. This research was motivated by the low level of students' scientific literacy due to the lack of learning device designed to train students' scientific literacy. This research aimed to determine the effectiveness of learning devices based on Science, Technology, Society, and Environment (STSE) on biotechnology material which was feasible to improve students' scientific literacy. The learning device which was developed consisted of syllabus, learning implementation plan (RPP), student book, student workheets (LKPD), and learning result test instrument. The developed learning device was implemented to three classes of VIII grade students of SMPN 1 Campurdarat Kabupaten Tulungagung in Second Semester in 2017/2018 Academic Year. The result of this research was level of students' scientific literacy reached level 1b to 3 in pretest and reached level 2 to 5 in posttest. Based on the analysis of research results and discussion, it could be concluded that the learning device based on Science, Technology, Society, and Environment (STSE) was effective to improve students' scientific literacy.

Keywords: *STSE learning device, biotechnology, scientific literacy*

INTRODUCTION

Kemendikbud (2016) stated that Natural Sciences (IPA) education is one aspect of educations that uses science as a way to achieve educational purpose, both education general purpose and science education specific purpose. The education general purpose is the national education purpose. While the science education specific purpose is to improve understanding of natural world so that scientific literacy needs to be mastered by students. Scientific literacy is the ability to engage with issues related to science and with scientific ideas (OECD, 2013). Furthermore, OECD (2013) stated that scientifically literate person able to engage science and technology which needs the competencies to explain phenomena scientifically, evaluate and design scientific inquiry, as well as interpret data and evidence scientifically. A series of those scientific processes can support scientific literacy skill.

Student who has literacy skill is able to participate in social and cultural activities in this modern world (Sang, 2017). One of the purpse of literacy instruction is helping student develop the ability to think deeply about what they have read (Alberta Education, 2008). Keemendikbud (2016) stated that scientific literacy is important to be mastered by student in relation to how student can understand and make decisions regarding the environment, health, economy, and other problems faced by modern society that are highly dependent on technology as well as the progress and development of science. Based on the statements above, it could be concluded that individual who has scientific literacy will be able to use their knowledge in accordance with the context of the situation they are experiencing.

The importance of scientific literacy skill is not comparable to the Indonesians' scientific literacy skill. The results of PISA study in 2012 stated that Indonesians' scientific literacy on the order 63 of 64 countries (OECD, 2013). The results of PISA study in 2015 stated that Indonesians' scientific literacy on the order 62 of 70 countries (OECD, 2016). The pretest results related to scientific literacy in the limited trial that was tested on 18 students got the results that three students reached level 1b, 12 students reached level 1a, and three students reached level 2. The levels achieved by students included low level for the level range 1-6. These data indicated that Indonesians' student scientific literacy needs to be improved.

Aikenhead (1992) stated that the basic purpose of Science, Technology, and Society (STS) is to create a literary society in science and technology as well as be able to make decisions and brave to accept the risks of what they has been done. Ackay & Yager (2010) stated that STS is considered to be important to achieve basic scientific literacy. Over time, some science educators advocated more issues that encouraged STS curriculum changed in the form of Science, Technology, Society and Environment (STSE) (Zeidler, Sadler, Simmons, & Howes, 2005). Lau (2013) stated that scientific literacy has many common purpose with the STSE so that making STSE approach as right way to achieve scientific literacy purpose. Based on this opinion, STSE is believed to be able to train scientific literacy.

The learning based on Science, Technology, Society, and Environment (STSE) is carried out by teachers by connecting between science and technology related to their use in society (Poedjiadi, 2010) and their impact in environment. This learning connects science and its use in everyday life.

One of the Basic Competencies (KD) in the science lessons found at junior high school is to apply the concept of biotechnology and its role in human life (KD 3.7) and to make conventional biotechnology products in the surrounding environment (KD 4.7). This KD create biotechnology material delivered in IX grade.

Biotechnology can be defined as the manipulation of organisms or their components to produce useful products (Campbell et al., 2010). The products produced through biotechnology such as tofu, tempeh, yogurt, transgenic soybeans, transgenic papaya, and vaccines. The use of biotechnology uses technology and sometimes produces wastes where the waste substances usually have an impact in surrounding environment. Biotechnology material is very close to everyday life. Therefore, students need to understand biotechnology material and then use their knowledge in everyday life to improve the quality of life or solve problems.

Biotechnology material is very suitable when taught with learning that connects science with its application in life, including STSE learning. This is because biotechnology material is a complex material that contains the context of science, process, and products.

Science, Technology, Society, and Environment (STSE) is a learning that connects science, technology, society, and environment. Biotechnology material is a material that discusses science so that producing technology which the technology ultimately impacts on society's life and environment. Biotechnology material that is closely related to life if delivered with STSE learning which also connects science with life will make

students easier to train their scientific literacy because students can practice to connect their knowledge that has been learned with life.

Based on that descriptions, the aim of this research was to evaluate the effectiveness of learning device based on Science, Technology, Society and Environment (STSE) on biotechnology material through differences in scores and levels of students' scientific literacy in pretest and posttest.

METHOD

This research is a research and development that developed learning device based on Science, Technology, Society, and Environment (STSE) on biotechnology material that aimed to determine the effectiveness of learning device in improving students' scientific literacy. The developed learning device include: syllabus, learning implementation plans (RPP), student books, student worksheets (LKPD), and learning result test instruments.

The subject of this research was a STSE-based learning device on biotechnology material which was implemented on three classes of VIII grade students of SMPN 1 Campurdarat with 102 students. The research was conducted in Second Semester in 2017/2018 Academic Year. The research design used One Group Pretest-Posttest with the following pattern.

O_1	X	O_2
Pretest	Perlakuan	*Posttest*

(Fraenkel, Wallen, & Hyun, 2012)

Information:

O_1 : initial test to measure student's literacy before treated

X : treatment of the subject, namely learning based on STSE

O_2 : final test to measure student's literacy after treated

The scientific literacy test consisted of thirteen test items with details four test items are multiple choice, four test items are complex multiple choice, and five test items are easy. Scientific literacy tests also consisted of all levels of scientific literacy with details one test item is level 1a, four test items are level 2, three test items are level 3, three test items are level 4, one test item is level 5, and one test item is level 6. The scientific literacy test items are developed based on indicators determined by PISA, they are: 1) explain phenomena scientifically, 2) evaluate and design scientific inquiry, and 3) interpret data and evidence scientifically.

The test results of scientific literacy that were obtained then analyzed by the following steps.

1) Give score of each test item that has a different level.

Table 1 Item Tes Score for Each Level based on PISA 2015

Level	Skor
1b	262
1a	335
2	407
3	480
4	553
5	626
6	698

(OECD, n.d)

2) Determine the student's achievement score using the formula as follows.

$$\text{Score} = \sum \frac{Bi \; x \; bi}{St} \text{ x } 100$$

(Inzanah, 2014)

Information:

Bi : the amount of questions correctly answered by students

bi : score for each question (adapted from PISA)

St : teoritical score (score if the students can answer all questions correctly).

From the calculation, the following categories are obtained.

Table 2
Score Category and Literacy Level

Skor	Level
0,0 - 14,2	level 1b
14,3-28,5	level 1a
28,6-42,8	level 2
42,9- 57,1	level 3
57,2-71,4	level 4
71,5-85,7	level 5
85,8-100,0	Level 6

3) Score each student's answer sheet according to the answer key.

4) Calculate the score of each pretest and posttest answer by using the same formula to determine the score and level achieved by students.

To find out whether there are differences in pretest and posttest scores due to the learning that has been implemented, statistic tests are conducted through the SPSS program. The statistic test was paired t-test with a significance level of 0.05 ($\alpha = 0.05$). The hypothesis of paired t-test according Sugiyono (2014) are:

H_0 : After learning, students' pretest score are equal with students' pretest score

H_1 : After learning, students' pretest score are not equal with students' pretest score

H_0 is accepted if the significance value is $\geq \alpha$
H_0 is rejected if the significance value is $<\alpha$
The conditions for the t-test are:

1) Normality Test

The normality test is done to find out whether the data is distributed normally or not. Normality

test was carried out on pretest and posttest scores. Normality test was done by using the Kolmogorov Smirnov Test with a significance level of 0.05 (α = 0.05). The testing hypothesis for normality tests according Sugiyono (2014) are:

H_0 : sample data come from a population that are distributed normally

H_1 : sample data come from a population that are not distributed normally

H_0 is accepted if the significance value is ≥ α
H_0 is rejected if the significance value is <α
Class data that are distributed normally then tested for data homogeneity using the Levene test.

2) Homogenity Test

Homogeneity test is used to find out whether the sample data variant is homogeneous or not. This test was carried out on pretest and posttest scores. Homogeneity test was done by Levene test with a significance level of 0.05 (α = 0.05). The hypothesis of testing for normality tests according Sugiyono (2014) are:

H_0 : sample data comes from a population with the same variants or homogeneous

H_1 : sample data comes from a population with unequal variants or not homogeneous

H_0 is accepted if the significance value is ≥ α
H_0 is rejected if the significance value is <α
If the results of paired t-test state learning based on Science, Technology, Society, and Environment (STSE) can improve students' scientific literacy, then the n-gain is calculated. The amount of n-gain is calculated using the formula:

$$n\text{-}gain = \frac{(Spost)-(Spre)}{Smax-Spre}$$

Information:

Spre : pretest score
Spost : posttest score
Smax : maximum score

(Hake, 1999)

The n-gain classification as follows.

Table 3 N-Gain Classification

Kriteria *N-Gain*	**Skor *N-Gain***
Tinggi	g) >0,7
Sedang	0,7 ≥ g ≤ 0,3
Rendah	(g) < 0,3

(Hake,1999)

The consistency of learning effect on improving scientific literacy scores in the three classes is known by one way ANOVA test (Sugiyono, 2014). The requirement for one way ANOVA test was the n-gain for three classes were distributed normally and n-gain for three classes were homogeneous. The significance level of the one way ANOVA test is 0.05 (α = 0.05). The hypothesis for testing one way ANOVA according Sugiyono (2014) are:

H_0 : There is no significant difference in literacy scores in the three classes

H_1 : There is a significant difference in literacy scores in three classes

H0 is accepted if the significance value is ≥ α
H0 is rejected if the significance value is < α

RESULT AND DISCUSSION

The results of pretest and posttest were analyzed by calculating students' scientific literacy scores and categorized the scores which were obtained based on literacy levels. The results of pretest and posttest scores calculation of students are shown in Figure 1 for class VIII E, Figure 2 for class VIII G, and Figure 3 for class VIII H.

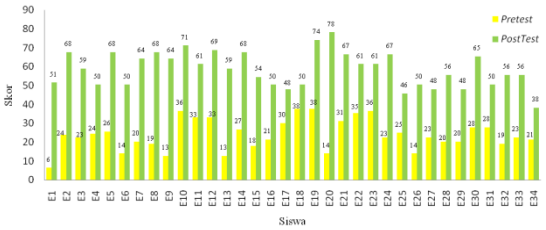


Figure 1. Pretest-Postest Scores of VIII E

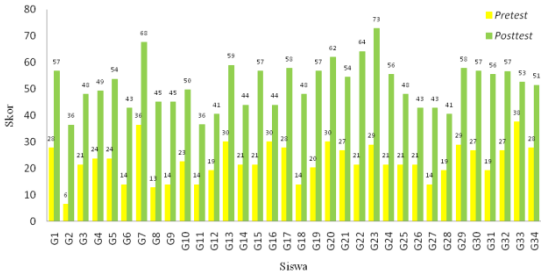


Figure2. Pretest-Postest Scores of VIII G

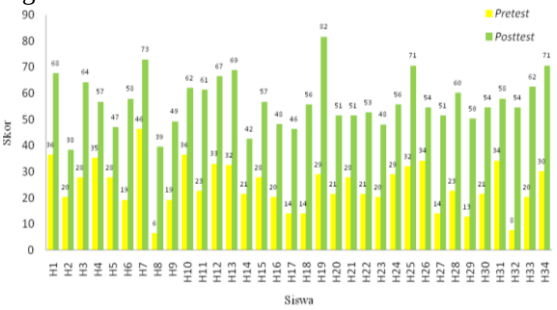
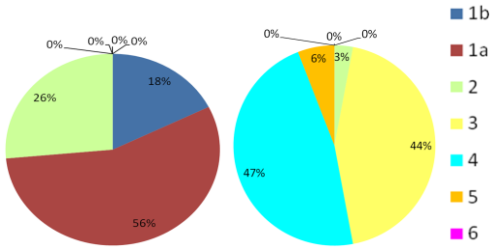


Figure 3. Pretest-Postest Scores of VIII H

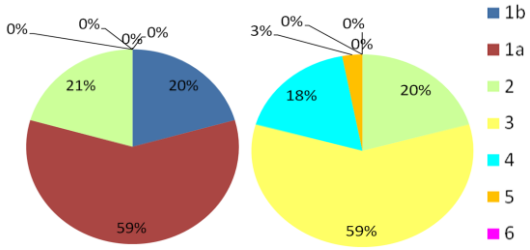
Based on the data in Figure 1, Figure 2, and Figure 3 can be known that there are differences in pretest and posttest scores so there were also differences in the level of student literacy achieved by students in pretest and posttest. Figure 4, Figure 5, and Figure 36 shows the differences of scientific literacy level achieved by students in pretest and posttest.



(a) (b)

Gambar 4. Scientific Literacy Level of VIII E Students in (a) Pretest and (b) Postest

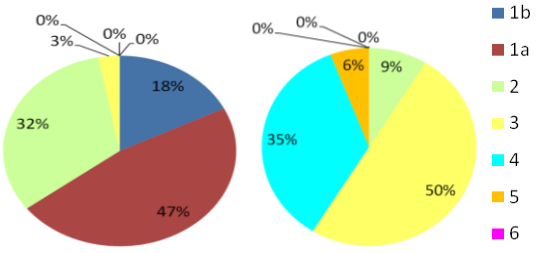
Based on Figure 4 (a), it can be known the level of scientific literacy of VIII E students that 18% of students reached level 1b, 56% students reached level 1a, and 26% of students reached level 2 in pretest. Based on Figure 4 (b) it can be known the level of scientific literacy of VIII E students that 3% of students reached level 2, 44% of students reached level 3, and 47% of students reached level 4, and 6% of students reached level 5 in posttest.



(a) (b)

Figure 5. Scientific Literacy Level of VIII G Students in (a) Pretest and (b) Postes

Based on Figure 5 (a), it can be known the level of scientific literacy of VIII G students that 20% of students reached level 1b, 59% of students reached level 1a, and 21% of students reached level 2 in pretest. Based on Figure 5 (b), it can be known the level of scientific literacy of VIII G students that 20% of students reached level 2, 59% of students reached level 3, and 18% of students reached level 4, and 3% of students reached level 5 in posttest.



(a) (b)

Figure 6. Scientific Literacy Level of VIII H Students in (a) Pretest and (b) Postest

Based on Figure 6 (a), it can be known the level of scientific literacy of VIII H students that 18% of students reached level 1b, 47% of students reached level 1a, 18% of students reached level 2, and 3% of students reached level 3 in pretest. Based on Figure 6 (b), it can be known the level of scientific literacy of VIII H students that 9% of students reached level 2, 50% of students reached level 3, and 35% of students reached level 4, and 6% of students reached level 5 in posttest.

Level 1b students are able to identify simple patterns in data, recognize basic scientific terms and follow explicit instruction to carry out a scientific procedure. Level 1a students areable to select best scientific explanation for given data in familiar personal, local, and global contexts. Level 2 students demonstrate basic epistemic knowledge by being able to identify question that can be investigated scientifically. Level 3 students are able to distinguish between scientific and non scientific issues and identify the evidence supporting a scientific claim. Level 4 students are able to interpret data drawn from a moderately complex data set or less familiar context, draw appropriate conclusion that go beyond the data and provide justifications for their choices. Level 5 students are able to evaluate ways of exploring a given question scientifically and identify limitations in interpretations of data sets including sources and the effects of uncertainty in scientific data. Level 6 students are able to evaluate competing designs of complex experiments, field studies or simulations and justify their choices (OECD, n.d).

Based on Figure 4 (a), 5 (a), and 6 (a) the students' scientific literacy level reached level 1b to 2 in pretest. These data show that students' scientific literacy skills are still low. These data are in line with the results of PISA study in 2015 which stated that Indonesians' scientific literacy on the order 62 of 70 countries, average score of scientific literacy was 403, and 42.3% of students are below level 2 (OECD, 2016) that indicated scientific literacy of Indonesian students are still low.

Based on Figure 4 (b), 5 (b), and 6 (b) the students' scientific literacy level reached level 2 to 5 in posttest. These data show that after implementing the learning based on Science, Technology, Society, and Environment (STSE) students' scientific literacy levels improved and got on reaching the basic level of scientific literacy established by OECD. OECD (2013) established that level 2 is the basic level of scientific literacy because students can begin to demonstrate scientific knowledge and skills that enable students to participate actively in life situations related to science and technology.

The proof that there were differences in literacy scores achieved by students in pretest and posttest was reinforced by the results of paired t-tests. The requirements for paired t-test were the data of three classes were distributed normally and homogeneous so they had to be carried out by normality test and homogeneity test first.

Normality test was done to find out whether the data were distributed normally or not. The results of

normality tests of three classes using the Kolmogorov Smirnov Test are shown in Table 4.

Table 4. The Result of Normality Test for Paired T-Test

Class	Score	α	Sig.	Hint.
VIII E	Pretes	0.05	0.200	Normal
	Postes	0.05	0.108	Normal
VIII G	Pretes	0.05	0.200	Normal
	Postes	0.05	0.200	Normal
VIII H	Pretes	0.05	0.200	Normal
	Postes	0.05	0.200	Normal

Based on the testing hypothesis, Table 4 shows that the data for three classes are distributed normally. The next statistic test was homogeneity test. Homogeneity test was done to find out whether the sample data were homogeneous or not. The results of homogeneity test using the Lavene test are shown in Table 5.

Table 5. The Results of Homogeneity Test for Paired T-Test

	Levene Statistic	df1	df2	Sig.	Hint.
VIII E	2,014	1	66	0,161	Homogeneous
VIII G	2,373	1	66	0,128	Homogeneous
VIII H	0,57	1	66	0,812	Homogeneous

Based on the testing hypothesis, Table 5 shows that the sample data comes from a population with the same variants or homogeneous. Thus, the students had the same abilities.

The next statistic test was paired t-test. Paired t-test was done to find out whether there were differences in pretest and posttest scores due to the learning based Science, Technology, Society and Environment (STSE) that have been implemented. The results of paired t-tests are shown in Table 6.

Table 6.The Results of Paired T-Test

Class	t	df	α	Sig.
VIII E	-18.745	33	0,05	0,00
VIII G	-25.909	33	0,05	0,00
VIII H	-22.852	33	0,05	0,00

Based on the testing hypothesis, Table 6 shows that there are differences scientific literacy scores in pretest and posttest after implementing STSE-based learning. The difference in scientific literacy scores in pretest and posttest was determined by calculating n-gain. Figure 7 shows the average n-gain achieved by students of each class.

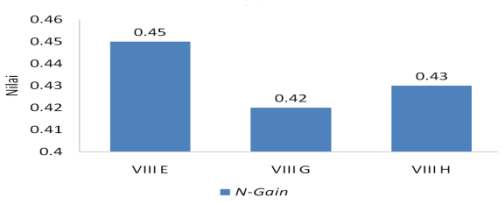


Figure 7. *N-Gain*

Based on Figure 7, it can be known that the n-gain of class VIII E, VIII-G, and VIII-H is respectively 0.45; 0.42; and 0.43 which show medium category.

The consistency of learning effect on improving scientific literacy scores in three classes was known by doing one way ANOVA test (Sugiyono, 2014). The requirements for one way ANOVA test were n-gain for three classes distributed normally and homogeneous. The results of n-gain normality test for three classes are shown in Table 7.

Tabel 7. The Resultsof Normality Test for One Way ANOVA

Kelas	α	Sig.	Hint.
VIII E	0.05	0.200	Normal
VIII G	0.05	0.102	Normal
VIII H	0.05	0.200	Normal

Based on the testing hypothesis, Table 7 shows that the n-gain of three classes are distributed normally. The next statistic test was homogeneity test. The results of the n-gain homogeneity test are shown in Table 8.

Table 8
Test Results of Homogeneity Test for One way ANOVA

Lavene Statistic	α	Sig.	Hint.
0,322	0,05	0,726	Homogen

Based on the testing hypothesis, Table 8 shows that n-gain for three classes are homogeneous.

The next statistic test was one way ANOVA test. The results of one way ANOVA test are shown in Table 9.

Table 9. The Results of One Way ANOVA N-Gain

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.024	2	0.012	0.821	0.443
Within Groups	1.450	99	0.015		
Total	1.474	101			

Based on the testing hypothesis, Table 9 shows that there are no significant difference in increase of literacy scores in three classes.

The increase scores obtained by students showed that the implementation of STSE learning was successful in improving students' scientific literacy. The results of this study are in accordance with those stated by Cepni & Lee (in Avci, Onal, & Usak, 2014) that the implementation of STSE learning has a dramatic effect on increasing students' level of scientific literacy. Karademir & Ulucinar (2017) stated that students' scientific literacy can be improved if students have interest, enthusiasm, and participation during the science learning process. In addition, if seen from the students response questionnaire's answer, students gave a very good

response which meant students had interest, enthusiasm, and participation in the learning process.

The increasing scientific literacy level achieved by students also proved that STSE learning which was implemented was effective to improve students' scientific literacy. This is in line with the adventages of STSE according to Predeti & Little (2008) that STSE is able to cover scientific literacy. This is also in line with Lau's (2013) statement which stated that scientific literacy has many common purpose with the STSE so making STSE approach as right way to achieve scientific literacy purpose. Furthermore, Lau's research (2013) stated that learning with the STSE approach can improve students' scientific literacy in the aspects of application of scientific concepts, scientific inquiry skills, as well as science, technology, society and environment awareness.

CONCLUSION

Learning device based on Science, Technology, Society, and Environment (STSE) effectively improve students' scientific literacy.

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