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Training Students' Science Literacy on Biotechnology Using Science, Environmental, Technology, Society (SETS) Visioned Learning Instructional

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Abstrak

Penelitian ini bertujuan untuk mengembangkan perangkat pembelajaran IPA berbasis pendekatan science environment technology society (SETS) yang layak untuk melatih literasi sains siswa. Perangkat pembelajaran yang dihasilkan dalam bentuk RPP, materi ajar siswa, Lembar Kerja Peserta Didik (LKPD) dan instrumen penilaian literasi sains siswa. Metode penelitian ini menggunakan metode penelitian dan pengembangan (R&D) model Dick and Carey dan diujikan pada siswa kelas IX SMPN 4 Langke Rembong di semester genap tahun akademik 2021/2022. Data dikumpulkan dengan menggunakan metode validasi ahli, observasi dan tes. Data dianalisis secara deskriptif kuantitatif dan kualitatif. Hasil penelitian menunjukkan 1) perangkat pembelajaran IPA yang dikembangkan dinyatakan valid setelah divalidasi oleh dua orang guru IPA dan dua orang dosen IPA, 2) kepraktisan perangkat pembelajaran IPA dikategorikan sangat baik, 3) keefektifan perangkat ditunjukkan dengan meningkatnya skor dan tingkat literasi sains dengan n-gain sedang dan respon siswa terhadap perangkat dan pelaksanaan pembelajaran menarik dan mudah dipelajari. Berdasarkan hasil tersebut dapat disimpulkan bahwa perangkat pembelajaran IPA berbasis SETS cocok untuk melatih literasi sains siswa.

Kata Kunci: Perangkat Pembelajaran IPA, Pendekatan SETS, Literasi Sains.

Abstract

This research aims to develop science learning instructional based on Science Environment Society Technology (SETS) approach which can facilitate students' science literacy. Science learning instructional that developed in this research is lesson plans, student teaching materials, student worksheets, and scientific literacy instruments. The method used in this study is the research and development (RnD) using the Dick and Carey model and it was tested on ninth-grade students of SMP Negeri 4 Langke Rembong in the second semester of the 2021/2022 Academic Year. Data were collected using expert validation, observation, and test methods. Data were analyzed descriptively quantitative and qualitative. The results of the research show that 1) the science learning instructional developed was valid after being validated by two science teachers and two science lecturers, 2) the practicality of the learning device was obtained from the implementation of the lesson plan in the very good category, 3) the effectiveness of the device was demonstrated by increasing scores and levels scientific literacy with moderate n-gain and student responses to devices and learning implementation are interesting and easy to learn. Based on these results, it can be concluded that science learning instructional based on the SETS approach is suitable for practicing student scientific literacy.

Keywords: Science Learning Instructional, SETS Approach, Science Literacy

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INTRODUCTION

Science has become an integral part and influencing our economic, social, and political life. Science is not only the factual but also the historical, sociological, technological and humanistic dimensions. Science education has the potential to prepare qualified human resources in the face of globalization. Students should be able to use science to identify and solve problems in the real world also be able to adapt with environmental conditions (Nurkaenah et al., 2019).

The rapid development of science and technology in the 21st century helps humans in establishing what we can do, as well as in providing us with the ability to generate new options (Zoller, 2013). Nevertheless, the rapid advancement of science and technology also increasing public concern on science dimension in every issues.

Most people are aware but unfortunately that awareness is not supported by sufficient knowledge in providing appropriate responses in their resolution. This may be viewed as a lack of people's scientific literacy which has the potential to disengage society from the decision making processes. Consequently, the language of science becomes inaccessible.

This condition is exacerbated by incomplete information that peoples receive from media, resulting in misinterpretation of facts (Johnston, 2012). Only people with sufficient scientific literacy are prepared enough to participate in facing this challenge. So that each decision taken is not based on subjective and emotional criteria, but is based on knowledge.

Scientific literacy is one of the necessary components of education (Ogunkola, 2013). Scientific literacy is defined as the ability of an individual to formulate, use, and interpret scientific concepts in a variety of contexts. This includes reasoning and using concepts, procedures, facts, in explaining and predicting phenomena and making decisions related to the nature and the changes done to the nature by human hand (Johar, 2012). This definition views science literacy as multidimensional, not merely about understanding science knowledge but more than that (Atmojo & Kurniawati, 2018). Student who has literacy skill is able to develop the ability to think deeply about what they have read and participate in social and cultural activities.

One of the goals of science education issued by the Indonesian Ministry of Education and Culture (2016) is to improve understanding of the natural world. Therefore, the most important duty for teachers is to help their students to build a solid ground in science content. Teachers should teach student how to use scientific knowledge to explain phenomena and guide students to apply related knowledge and draw appropriate conclusions based on scientific evidence.

Unfortunately, the importance of scientific literacy skill is not comparable to the Indonesians' scientific literacy skill. Indonesian childrens scientific literacy skills only reaching level 2 in the range of 1-6 scientific literacy level set by the OECD (H. S. Nugraha et al., 2018; Ristina et al., 2019). These results are consistent with the results of the PISA study in 2012, 2015 and 2018. In these three periods the average score of Indonesian students' scientific literacy scores were far below the average score set by the OECD. These results indicate that Indonesia has failed in the International Assessments and student's scientific literacy needs to be improved (Pratama et al., 2018).

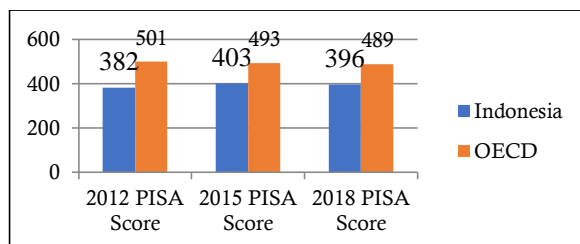


Figure 1. The average scores of Indonesian Students Science Literacy Based on PISA Assessment

Reflect on that, according to many documents there is a strong need to renew science education (Britt et al., 2011) that over the last several decades, have been rather unsuccessful in creating major change in the way science is taught in the classrooms (Autieri et al., 2016). Current science education does not provide adequate inner orientation and bases for students required to their developments, and uphold values and ethics as responsible future citizens. Many school students do not find science as encompassing the world around them (Chowdhury, 2016). Learning science that not associated with real life make students doesn't feel the benefits of it. We need a change in learning to overcome these problems that primarily focused on aspects of science that are important for students in their everyday life (Haglund & Hultén, 2017).

As the spearhead of education, the teacher's preparation also determines the success of learning activities (Nurkaenah et al., 2019). The method and the learning model used by the teacher becomes important and needs to be improved in the learning to facilitate students' science literacy.

But ini reality, most of Indonesian teachers are lacked of innovative teaching ways to develop scientific literacy levels in the school (Sumarti et al., 2015). It is not suprising that science learning had not been integrated, orientation towards the mastery of material and teachers tend to apply conventional learning process or teacher-centered instruction rather than inquiry-based learning and conceptual understanding (Cheung, 2000; Ristina et al., 2019). The result is Indonesian students were very good at memorizing science content/knowledge and possessed very limited skills in transferring their knowledge to novel issues (Pratama et al., 2018).

This also happened at SMPN 4 Langke Rembong, Manggarai Regency, East Nusa Tenggara. The results of observations and interviews conducted by researchers of natural science teachers obtained the fact that learning activities that practice students' scientific literacy are not yet included in the learning design. The literacy abilities of students include knowledge, content, context and attitudes towards science have not been trained in learning activities. In addition, the learning model used is still oriented to the mastery of the material and student achievement in working on test questions, both daily tests, general tests, as well as national exams and school final exams. As a result students are less able to determine and formulate problems in real life related to the concepts they have. According to researchers the main factors that might cause this are the unavailability of learning tools that can be used to train students' scientific literacy and the application of learning strategies that are not yet oriented to the formation of students' life skills.

To train students' science literacy, learning science by using an approach that can form life skills suit the demands of the times is needed. One of approach that can address these demands is the Science, Environment, Technology, and Society (SETS). SETS is an integrated learning approach by integrating the four elements, namely science, environment, technology and society.

SETS approach focuses on the real world (Hairida, 2017). Students are encouraged to using the result of science and technology to recognize the social and physical environment through the socio-scientific context that affects society and the environment in the science lesson. SETS can be used for improving the students' ability to practice asking scientifically valid questions, designing experiments, exploring, analyzing and interpreting data to find solutions to solve the problem in order to comprehend the relationship between what

they learn in the classroom and what occurs in their daily life and also make meaningful scientific learning (Chanapimuk et al., 2018; Pedretti & Nazir, 2011).

SETS approach helps students actively search for information in order to be able to solve given problems related to the development of science and technology by connecting science concepts with environmental concepts, technology and society contextually based on the students experiences in daily life so as to help develop students' process skills while minimizing its negative impact on the environment and society (Eliyanti; et al., 2018; Maknun et al., 2018). Curriculum 2013 expects that learning science can help students associate of science and technology in the environment and society. Biotechnology as one of the materials contained in learning science, as well as its application has been widely encountered in everyday life and has impacted the lives are potential sources of STSE content. Dilemmas related to biotechnology products, environmental problems can produce varied perceptions.

However, learning science will succeed if the learning plan that has been made is well implemented. The plan is implemented in the form of science learning tools that aim to control the direction of the learning process through to assessment. Therefore, for learning outcomes to be as high as expected, learning plans must also be made as well as possible. Thus, the existence of a good learning tool for science educators is essential for its development to be examined (Setiawati & Senam, 2015). A good learning tool is a learning device that not only tends to focus on mastering the concepts of science, but also capable of linking science, technology, environment and society as powerful resources for science education (Calado et al., 2015) in solving problems that faced in everyday life.

METHODS

Research Types and Procedures

This research is a research and development (R & D) by developing science instructional learning in the form of syllabus, lesson plans, teaching materials, Students Worksheet and assessment instruments on biotechnology materials and their role in human life. The purpose of this study was to produce a valid and feasible instructional SETS-based science learning product to train students' scientific literacy. The development procedure used in this study adapted the Dick and Carey development model followed by the implementation of science instructional learning in the classroom (Figure 2). The procedure of this research was carried out in three stages namely need assessment, development and research (Setiawati & Senam, 2015). Furthermore, to find out the increase in students' scientific literacy as a result of the use of the product being developed, researchers conducted a scientific literacy test in the control class and the experimental class using nonequivalent control group design.

Time and Place of Research

This research was conducted in the second semester of academic year 2021/2022. The research development of SETS-based science learning tools was conducted at SMPN 4 Langke Rembong, Manggarai Regency, East Nusa Tenggara.

Subject and Object of Research

Subjects in this study were class IX student of SMPN 4 Langke Rembong. Class IX A is used as a subject test. Class IX B as a control class and Class IX C as an experimental class. Science learning instructional developed in this research consist of syllabus, lesson plans, teaching materials, Students Worksheet and science literacy instruments test. In addition, the subject of this research also the score and level of student scientific literacy.

Data Collection Techniques

Data were collected through interviews, observations, questionnaires, and the provision of scientific literacy tests. Interviews were conducted at the need assessment stage. Observation was carried out to determine the implementation of the lesson plan that was applied by using an observation sheet in the form of a check list. The questionnaire was used to obtain information or data on the appropriateness of the developed learning tools which consisted of a validation questionnaire for the appropriateness of the instrument, an observation sheet for the implementation of the lesson plan. The questionnaire is also used to obtain data about student responses during the learning process that is useful for identifying obstacles encountered and finding alternative solutions to overcome these obstacles.

The test instrument is used to determine the score and level of scientific literacy of students before and after participating in learning by using a product that was developed. Lattice of test material given before and after learning made by researchers with reference to the scientific literacy test instruments in PISA. Likewise, the minimum score given for each level refers to the minimum score found at the 2013 PISA expertise level, which is then processed and formulated using a weighting formula with a weighting formula. Thus, a range of values is obtained for each category of scientific literacy level.

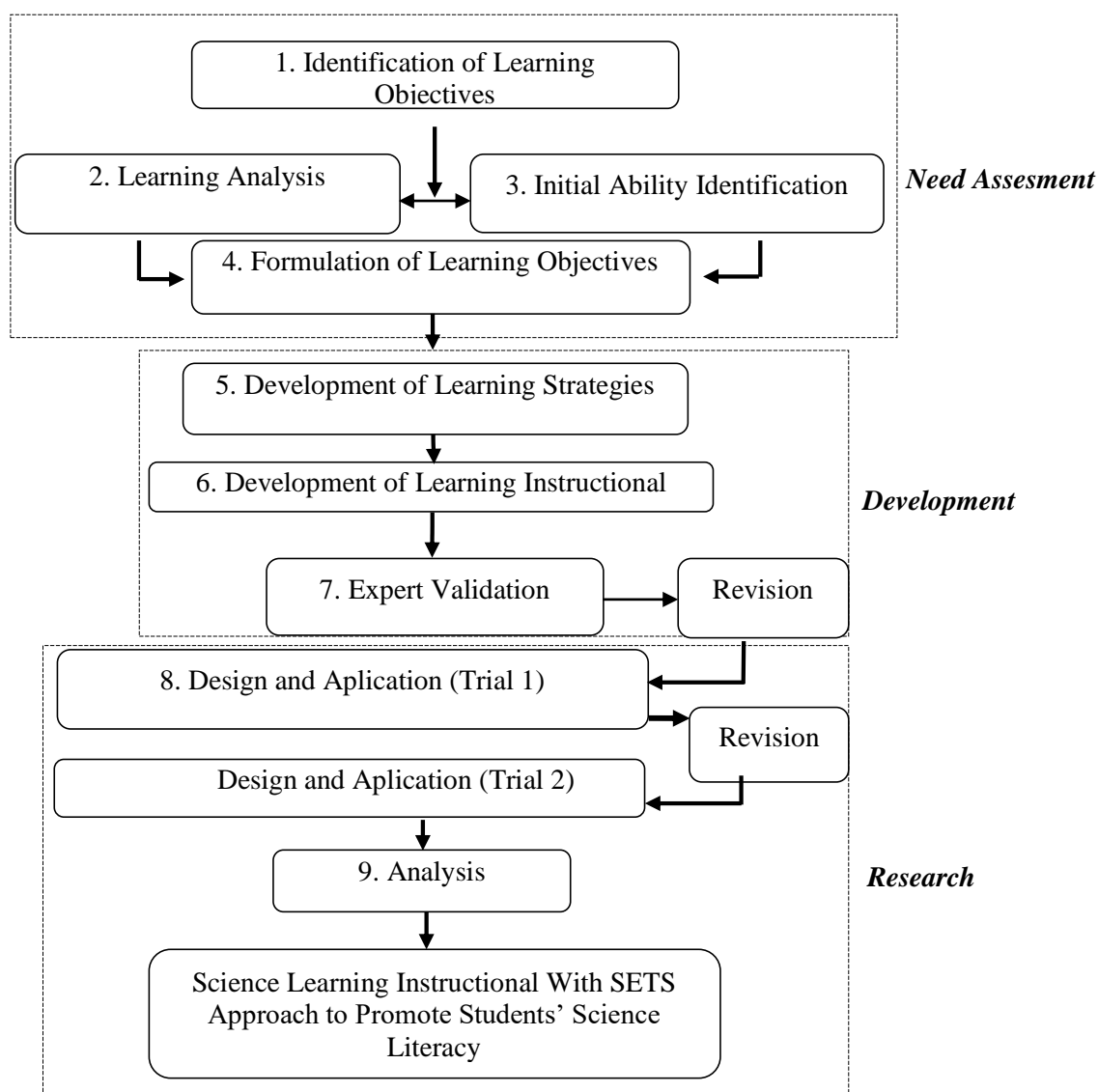


Figure 2. Research Design and Science Learning Instructional Developmental Procedure

Analysis of the data used in the study is divided into three: 1) an analysis of the feasibility of the learning instructional, 2) analysis of the enforceability of the lesson plan and 3) analysis of increasing of students' science literacy.

1. Analysis of the Feasibility of Learning Instructional

The products were tested for feasibility learning device is lesson plan, student worksheet and science literacy instrumnet. The feasibility of the learning instructional was analyzed qualitatively and quantitatively. Qualitative assessment aims to get suggestions and criticisms from the validator of the device that has been developed for later improvement. While the quantitative appropriateness assessment is done in two ways namely a) the validity of the learning instructional and b) the reliability of the learning instructional.

The validity of the learning instructional is using an assessment questionnaire that is filled out by the validator and then the results are analyzed by calculating the average rating score of the validator. The validators in this study were expert lecturers and science teachers. The average score acquisition is converted using the following conditions (Ratumanan and Laurens, 2011):

Table 1
Learning Instructional Validity Criteria

Interval Score of Validation	Category Ratings	Description
$3,6 \leq SV < 4$	Very Valid	Used without revision
$2,6 \leq SV < 3,5$	Valid	Used with a slight revision
$1,6 \leq SV < 2,5$	Less Valid	Used with many revisions
$1,0 \leq SV < 1,5$	Invalid	Can't be used

Description: SV = Validation Score

Meanwhile, to measure the reliability of the learning instructional products, researchers used the Percentage of Agreement (PoA) were calculated as follows (Borich, 1994):

$$PoA = \left(1 - \frac{A - B}{A + B}\right) \times 100\%$$

Description:

A: The highest frequency of assessment

B: The lowest frequency of assessment

The learning instructional that have been developed are said to be reliable if the compatibility between the validators gets a Percentage of Agreement value ≥ 0.75 or $\geq 75\%$.

2. Analysis of Enforceability of The Lesson Plan

The effectiveness of the lesson plan is analyzed by calculating the results of observations of learning activities (observed by observers) using the calculation of the percentage of lesson plan implementation as follows (Riduwan, 2010):

$$P = \frac{\text{Stages that was successfully implemented}}{\text{Total of overall stages}} \times 100\%$$

The percentage of lesson plan implementation during the learning process is guided by the following table:

Table 2
Criteria for Implementation of Learning Plans

Interval	Category
$0\% \leq P < 25\%$	Not implemented
$25\% \leq P < 50\%$	Poorly implemented

$50\% \leq P < 75\%$	Well done
$75\% \leq P < 100$	Done very well

3. Analysis of Science Literacy Tests

Analysis of science literacy test used to determine the score and the level of scientific literacy of students. The questions used to measure scientific literacy are multiple choice questions to measure the mastery of scientific literacy competencies. 12 items with 5 levels of scientific literacy are used to measure students' scientific literacy. Analysis of students' scientific literacy is carried out through several stages as follows:

a. Sensitivity of Science Literacy Test Items

The sensitivity of the item uses the following formula (Gronlund & Linn, 1995):

$$S = \frac{R_A - R_B}{T}$$

Description:

S = items sensitivity index

R_A = Students answer correctly after learning

R_B = Students answer correctly before learning

T = Overall students

Test items are sensitive (sensitive) if the S value ≥ 0.30 .

b. Data analysis of scientific literacy test

The results of students' scientific literacy tests were analyzed by giving a score that refers to the minimum score at the 2013 PISA expertise level on each question. The score of each level can be seen in the following table:

Table 3
Science Literacy Rating Level Score

Level	Score
1	335
2	409
3	484
4	559
5	633
6	708

Furthermore, each student's achievement score for each level is determined using the following formula (Yuliantika, 2012):

$$Skor = \sum \frac{B_i - b_i}{S_t} \times 100\%$$

Description:

B_i = test items answered correctly

B_i = weighted assessment of each item (adapted from PISA)

S_t = theoretical score (score when students answer all the items correctly)

After calculating, the level of students' literacy scores is categorized as follows:

Table 4
Criteria for Student's Literacy Level Based on Scores

Range of Scores	Level Category
0 – 3	Below Level

4 – 18	Level 1
19 – 45	Level 2
46 – 60	Level 3
61 – 79	Level 4
80 – 90	Level 5
91 – 100	Level 6

To determine the increase in students' scientific literacy, the researcher calculates the Normalized Gain (%) by using a gain score (overall improvement score) on the overall scientific literacy of students. The amount of increase or gain is analyzed using the following formula (Hake, 1999):

$$g = \frac{(S_{\text{post}}) - (S_{\text{pre}})}{\text{skor max} - (S_{\text{pre}})}$$

Description:

G (gain) = Increased level of scientific literacy

Spre = Pretest score (initial literacy level)

Spost = Posttest score (final literacy level)

The gain classification is as follows:

g-high : $(g) > 0,7$

g-moderate : $0,7 \geq (g) \leq 0,3$

g-low : $(g) < 0,3$

RESULTS AND DISCUSSION

The learning instructional developed in this study is a science learning product that has a SETS vision on material about biotechnology and its role in human life. The issue that became the topic of SETS visionary learning activities in this study was the availability of food and processing organic waste into natural preservatives. The learning instructional developed in this study include lesson plans, teaching materials, students worksheet and scientific literacy instruments. The entire products are developed based on the curriculum 2013.

The Feasibility of the SETS Vision Science Learning Kit

The product that was developed was validated by two science education lecturers and two science teachers by giving scores to the products that had been developed. The Lesson Plan developed is designed according to the STS learning syntax with the STSE approach. Syntax consists of four stages namely Introduction / Invitation (Invitation) includes exploring the issues or problems brought by students at the initial meeting. The exploration phase of students conducting experiments to collect data. The proposal and explanation submission stage (the proposal of explanation and solution), students discuss discussing the results of the activity. The follow-up stage for students connects the four components of science, environment, technology and society. Learning activities also use a scientific approach (Scientific Approach) as one of the curriculum 2013 demands.

After validation, Percentage of Agreement of lesson plan developed reached 97.32% and the Percentage of Agreement of student worksheet reached 93.8% (Figure 3). Quantitatively, these results indicate that the product developed have fulfilled all the components and principles in developing the lesson plan and students worksheet so that they are feasible to use, but qualitatively the lesson plan and students worksheet that have been developed still need to be revised, especially in grammar and examples used.

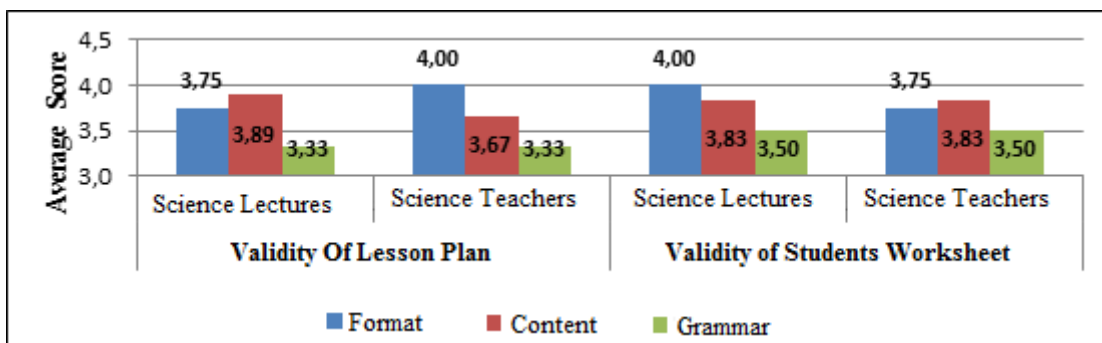


Figure 3. Lesson plan and student worksheet validation results

In addition to the lesson plan and students worksheet, other science learning instructional that need to be validated after being developed are Student Teaching Materials (STM). Teaching materials are arranged with a certain flow and logic adapted to basic competencies, and learning indicators contained in the curriculum 2013. Teaching materials developed contain several concepts about biotechnology and its role in human life in accordance with the development of science and technology. These concepts consist of the basic concepts of modern and conventional biotechnology, the application of biotechnology in agriculture, health, and the environment. Components in teaching materials support in practicing scientific literacy, such as issues of biotechnology products, phenomena that occur are related to the role of biotechnology such as genetically modified organisms.

STM validation is carried out on: format, presentation of material, grammar and physical. Quantitatively, after validation (Figure 4), student teaching materials are declared valid with a Percentage of Agreement reaching 92.06%. This result means that the STM that has been developed can be used in the learning process because it is in accordance with the guidelines for the preparation of teaching materials by the Indonesian Ministry of National Education. But qualitatively, it still needs to be improved, especially by adding more scientific literacy features in the form of information about scientific activities.

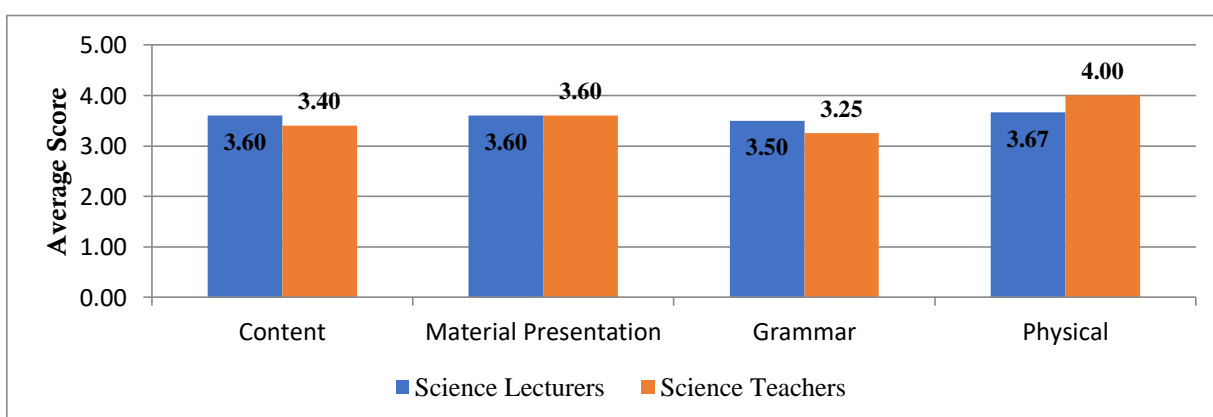


Figure 4. Student teaching material validation results

Also developed in this study is the assessment tool in the form of students' science literacy test to find out the achievement score and level of students' scientific literacy. 12 items were tested consisting of five levels of literacy that refer to the competence of scientific literacy from PISA. Test items developed based on the competence of scientific literacy capabilities set by PISA in the field of biotechnology with three (3) indicators namely identifying scientific issues in the field of biotechnology, explaining scientific phenomena in the field of biotechnology, explaining scientific evidence in the field of biotechnology. After validation, it was found that the matter of scientific literacy developed both in terms of content and grammars was categorized as very valid with a Percentage of Agreement between validators reaching 97.62% (Figure 5).

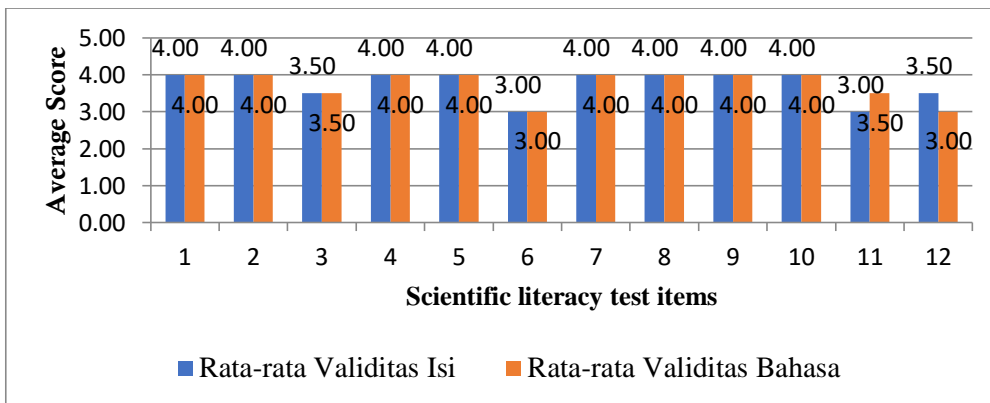


Figure 5. Scientific literacy instrument validation result

The Implementation of Lesson Plan

The implementation of the lesson plan during the learning process was observed by two science teachers as observers. The observations are documented in the observation sheet. The learning activity begins with exploring information related to students' daily life experiences and issues that are close to students' lives such as tempeh as food and cabbage waste treatment. This is in accordance with the characteristics of SETS-based learning that students are brought to the situation to utilize the concept of science into technology for the benefit of society (D. A. Nugraha et al., 2013). Poedjiadi (2005) states the benefits of raising issues or problems at the beginning of learning (introduction), can invite pros and cons so that students require to think and analyze the issue. Based on observational scores, it is known that the implementation of lesson plan is 100% for three meetings with very good criteria and with an average Percentage of Agreement (%) reaches 89.49%.

Assessment of Science Literacy Tests

Before conducting learning activities based on the SETS approach, students are given a preliminary test (pretest) to find out the initial ability of students scientific literacy with reference to the achievement indicators developed from the 2013 PISA indicators. The test results are represented in the form of scoring and leveling. After the pretest, the results obtained by students indicate that the ability of scientific literacy in students is categorized as low. The maximum score obtained by students is 39, 17 with an average score of 22.04 and the level of scientific literacy of students only reaches level 2 of 5 level set by PISA (Figure 6).

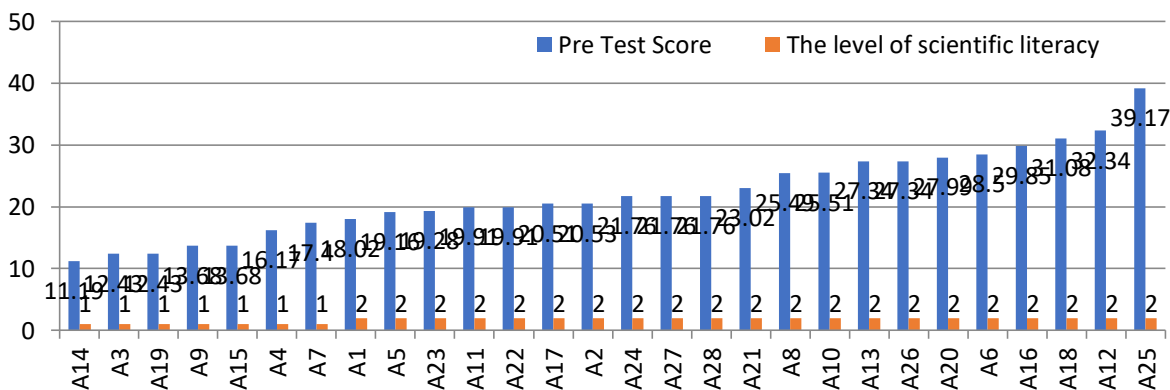


Figure 6. Students pretest

Reflecting on the pretest results, the researcher then conducts learning activities using the SETS vision science learning instructional that has been developed. The SETS approach stems from the belief that there is a relationship between students and the real world. This process will cause students to be required to recognize

the possibility of the problems they have (Yörük et al., 2010). In the learning process students are invited to collect data from activities that have been compiled so that they can answer the problem formulation found in the student activity sheet. Students also ask to connect science and technology and the impact it has on society and the environment. By applying the SETS approach students can realize that on the one hand technology is needed by humans and on the other hand it has adverse side effects. This awareness makes students more motivated to learn more about science and technology (Asy'ari, 2006: 35).

After being given three treatments using the SETS visionary learning instructional that was developed, students are given a final test (posttest) to find out the score and level of students' scientific literacy. Based on the posttest results, the average value of students' scientific literacy scores is 68.85. This shows that there was an increase in literacy score of 46.81 points after the implementation of the science learning instructional based on the SETS approach.

The effect of the SETS approach on the results of students' scientific literacy tests can be observed from the difference in the results of the posttest and pretest (Figure 7) measured using N-Gain analysis. The results of the N-Gain analysis show that there is an increase in scores on students' scientific literacy tests. The average increase in the gain score on the scientific literacy test before and after being given treatment was 0.60 and categorized as moderate. This is consistent with the statement that the application of the SETS approach in learning has a dramatic effect on increasing students' scientific literacy (Avci et al., 2014).

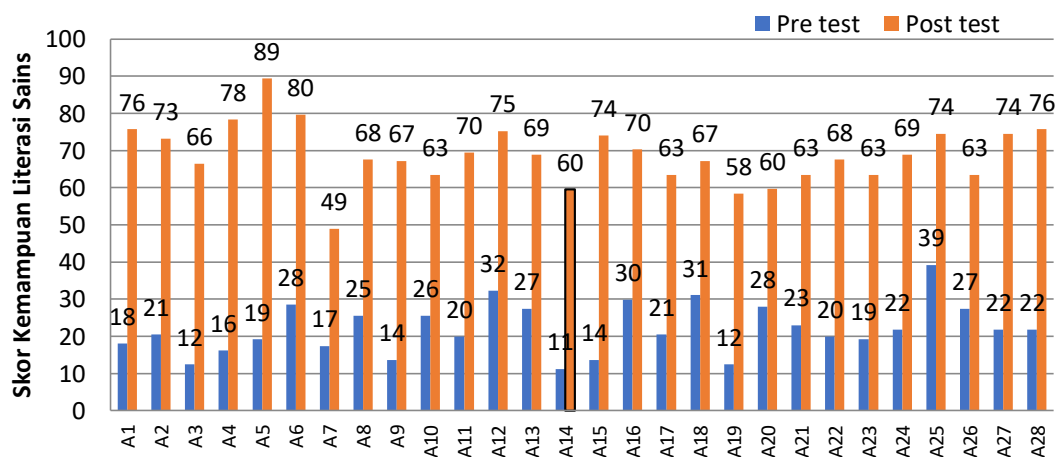


Figure 7. Student literacy ability score

Posttest result also indicated that there was an increase in the average score of scientific literacy skills in the three competencies developed (Figure 8). The posttest results showed that before the learning process using the SETS approach the average score of each indicator ranged from 14.29 to 39.29 and after the learning process the average score of each indicator reached 54.46 to 83.04. After participating in learning by applying the SETS-based learning instructional, 74.11% students have been able to answer large questions with the competence to identify scientific issues in the field of biotechnology, 83.04% of students have been able to answer correctly questions with the competence to explain scientific phenomena, and 54.46% of students have been able to answer correctly questions with competency using scientific evidence.

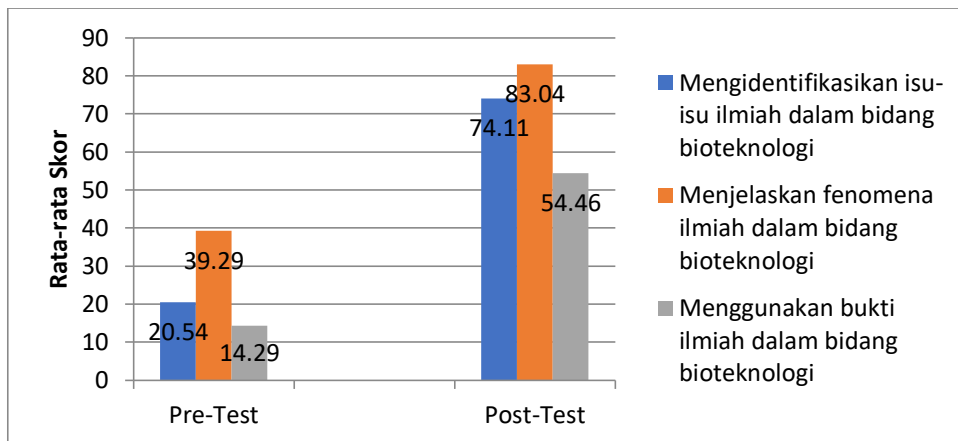


Figure 8. Average score for science literacy indicators

In addition to an increase in the ability of science literacy of students, the level of students science literacy also increased (Figure 9). This shows that there is an increase in students' science literacy on biotechnology materials through learning activities based on the SETS approach.

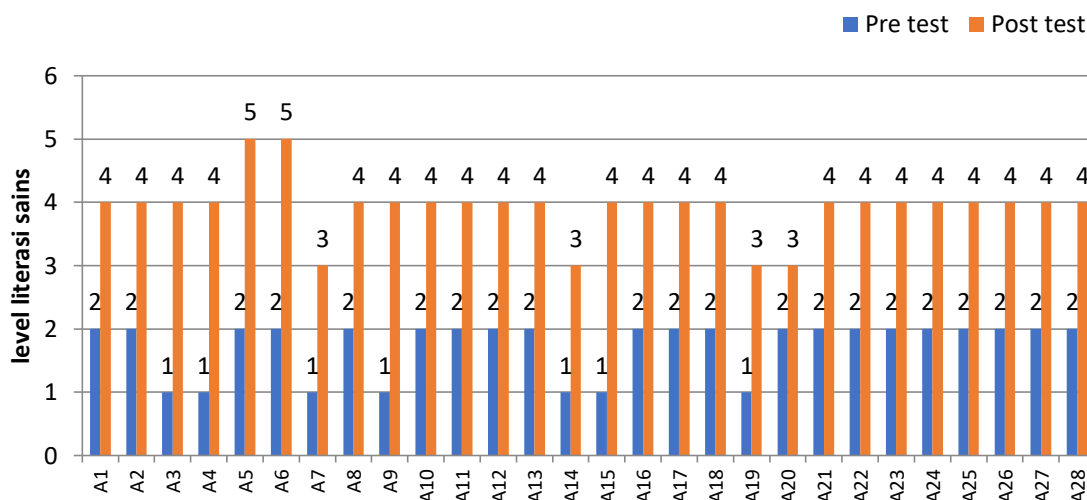


Figure 9. Average score for science literacy indicators

In addition to an increase in the ability of science literacy, the results of posttest data analysis also showed that the overall level of sensitivity of the developed scientific literacy instruments was above 0.30 (Figure 10). This means that the instruments developed are very sensitive to the effects of learning and can be used to measure students' scientific literacy abilities.

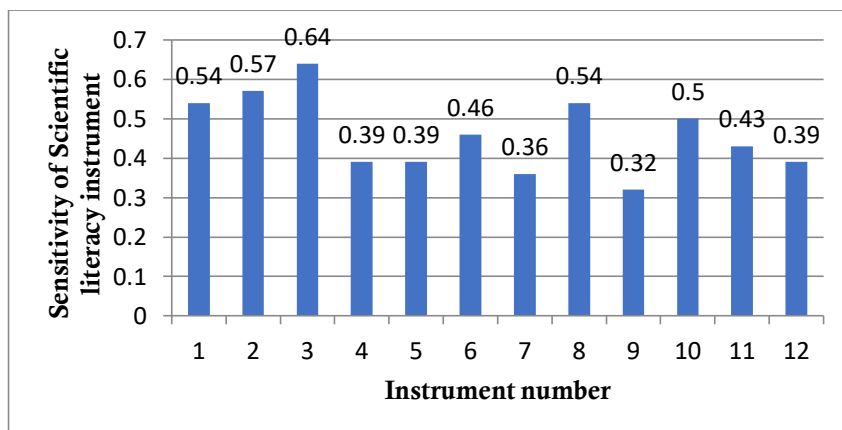


Figure 10. Sensitivity of Scientific Literacy Instruments. Constraints during the Teaching and Learning Activities

Although there is an increase in students' scientific literacy skills, but in the implementation of learning activities there are several obstacles such as students who are not familiar with learning to use the SETS approach and as a result students find it difficult to conduct investigative activities to collect data and analyze data to draw conclusions. Another obstacle is that the fermentation process requires optimal temperature and environment, and the observation process that takes several days so that it requires additional time and is forced to be done at additional study hours or rest periods with supervision from researchers to prevent errors in the process of observation and data collection.

There is also an awkward feeling experienced by students which makes it difficult for students to ask questions so that the presence of a facilitator is needed in order to provide guidance and facilitate students to focus on the subject matter. It takes longer so students can get used to the SETS approach in the learning process. But it does not rule out the possibility that learning science using the SETS approach can increase student interest in science which ultimately affects student participation in the classroom.

CONCLUSION

Based on the findings of the study it can be concluded that the science learning instructional materials based on the science environment technology society (SETS) approach is feasible to train students' science literacy in order to have life skills that are in line with the demands of the 21st century. The development of science learning tools by integrating the SETS approach can help students find positive things from the application of science and technology so that they can benefit human life without damaging environmental conditions.

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4938 *Training Students' Science Literacy on Biotechnology Using Science, Environmental, Technology, Society (SETS) Visioned Learning Instructional – Zephisius Rudiyanto Eso Ntelok, Ni Wayan Putri Resnasari, Yohannes Marryono Jamun*
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