The Development of Scientific Literacy Ecology Worksheet to Improve Student Higher Order Thinking Skills at Senior High School

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ABSTRACT

This study aims to produce a student worksheet (LKPD) based on scientific literacy on ecology topic, to determine the feasibility of the LKPD as learning materials according to expert validators, teachers, and student responses, and its effectiveness in improving student's higher order thinking skills (HOTS). The research development is 4D Thiagarajan model. Product validation is done by content, learning strategy and media validators and also biology teacher assessment and student responses. The effectiveness test of worksheet was carried out at SMA Methodist An Pancurbatu at the X IPA 2 as the experimental class and at the X IPA 1 as the control class. The data were collected by using observation, interviews and student achievement test. The questionnaire instrument used Likert scale. Research result showed that the worksheet feasibility according to content (material), learning strategy and media experts were 92.19%, 92.2% and 94.8%, respectively, with very good category. Teacher's assessment and student responses were 93.24 % and 94.00% also with very good category. Meanwhile, the effectiveness test result showed that the gain score was $0.7 > g > 0.3$ means that developed scientific literacy LKPD was effective in increasing of students' HOTS. The independent sample t-test result showed that there was a very significant differences of learning outcome between the experimental and the control classes (t count= 5.89; P=0.00). In this case, the learning outcome (HOTS) of the students who have used the developed worksheet in the learning process was significantly higher compared to the students who didn't use the developed worksheet. The developed worksheet was effective to improve the student HOT, especially in answering the analytic (C4) and synthetic questions.

Keywords: HOTS, Ecology, Scientific Literacy, LKPD, Development

INTRODUCTION

The learning in twenty first century is intimately related to 4C skills which consist of critical thinking, creativity, collaboration, and communication also in higher order thinking skills (HOTS) which have not been mastered by students. Higher order thinking skills is the ability to find out and to select the truth of information, developing and reconstruct the information into new ideas as innovations or solutions to a new problem, and to declare it clearly both in written and spoken, independently or in groups, to produce a new alternative problem solving [1].

Higher order thinking skills is the most relevant way to reach 21st century skills that can be experienced through a scientific literacy worksheet [2]. According to Poedjiadi, scientific and technological literacy happened when students are be able to think critically, creatively, logically, and take the initiative to respond some issues in society by using scientific concepts that they

obtained in education, utilizing technology, and maintaining it to sufficient their needs during the learning process in the 21st century. This means that scientific literacy supports the growth of higher order thinking skills (HOTS).

Literacy is seen as the ability to produce various ideas in representational media, such as written symbols, images, or anything from objects in the environment around us. Literacy that used in learning biology is scientific literacy. Scientific literacy according to PISA is defined as the ability to apply scientific knowledge, identify questions, and make conclusions based on fact or evidence, to understand and make decisions regarding the natural changes through human activities.

Based on interviews that have been held with biology teachers in SMA Methodist An Pancurbatu, it was found that in order to develop scientific literacy and HOTS skills of the students, teachers have tried to ask students to find out some relevant learning resources as much as possible. Learning resources from the internet contain irregular information are the most favorite choice for students. Learning media as worksheet or LKPD is also needed in regarding to improve the students HOTS. Meanwhile, the LKPD currently used at the school is the same LKPD from year to year, and it is no longer effectively used during the learning process, especially after the Covid 19 pandemic. Due to the situation, the development of new worksheet or LKPD, especially at the ecology topic based on scientific literacy is needed.

In order to develop a learning resource as worksheet, there is some models that could be used. One of the models is the Thiagarajan 4D model [3]. Worksheet or LKPD has components such as titles, learning objectives, materials, student activities, and exercises as assessment tools. According to Umbaryati (2016) [4], a better student worksheet must reach various condition, for example, didactic requirements governing the use of student worksheets, construction requirements regarding language use, sentence structure, word selection, level of difficulty, and clarity which must be appropriate. In the sense that it can be understood by students and the technical requirements that govern writing, pictures, and appearance in LKPD.

Literacy is the ability to acquire and develop meaning based on events that occur in everyday life through critical and creative thinking activities. Literacy learning is learning that requires students to examine and apply information from various sources, which serves as a mediating tool to learn various cross-curriculum concepts. The scope of learning scientific literacy includes science as a body of knowledge, science as a process or as way of investigation, requires students to answer questions based on experiments to prove theories through practical activities, science as a way of thinking and the interaction of science, and technology with society [5, 6].

Higher order thinking skills (HOTS) are the ability to connect, manipulate, and change the knowledge and experience already possessed critically and creatively in making decisions to solve problems in new situations [7]. Higher order thinking skills will occur when a person begins to relate new information into already information that be stored in his memory and to relates it or to rearranges and develops it to achieve a goal or find out a solution toward a difficult situation. Indicators to measure Higher Order Thinking Skills include analyzing, differentiating, organizing, connecting, evaluating, and creating.

Meanwhile, in the line with the development of worksheet or LKPD at ecology topic, the best source of ecological material is the natural environment that very closely to everyday life of the students. By this approach, students can learn about the closest environmental conditions, be more familiar with the various characteristics of the environment in Indonesia, care about environmental conservation and be able to creatively think about environmental conservation efforts and to design some solutions to overcome the environmental

problems around them. Ecological materials based on local potency can also to support the scientific literacy and higher order thinking skills of the students as the aim of this study [8]. Therefore, finding out the effectiveness of worksheet or LKPD based on scientific literacy in order to improve the higher order thinking skills of the students is very much needed.

RESEARCH METHOD

This research was held in the SMA Methodist An Pancurbatu at Jalan Jamin Ginting No. 36, North Sumatera-Indonesia. This research was held from March to April 2022. The subjects in this study were biology lecturers as learning strategists, material (content) experts as well as HOTS question validators, media expert, biology teacher at SMA Methodist An Pancurbatu and 24 students in X IPA 2 as the experimental class and 28 students in X IPA 1 as control class at SMA Methodist An Pancurbatu. The object of this research is scientific literacy-based worksheets that have been made by researchers.

The steps in the research and development procedure are the defined stage or the initial step in research in the form of interviews with biology teachers and students to find out the obstacles experienced by both teachers and students in the process of achieving ecological material competence. The second step is designed, where the researcher makes 10 HOTS questions, consisting of 4 analytical questions (C4), 3 synthetic questions (C5), and 3 evaluation questions (C6). Researcher also make LKPD at this stage starting with determining the title of the Ecology LKPD based on scientific literacy, making covers with green landscape images, making instructions for using LKPD for teachers and students, making material concept maps, setting 2 basic competencies and 20 indicators, preparing LKPD with components of scientific literacy, namely science as a body of knowledge in the form of theories and concepts of ecological material equipped with interesting and

contextual pictures, science as a way of thinking in the form of presenting environmental problems that students must solve by applying the concept of ecosystems, environmental change, and waste, science as a process or as a way of investigation namely simple waste recycling activities carried out by students to better understand ecology material, then the interaction of science, technology, and society as a forum for students to express ideas related to solving environmental problems around where they live [5, 6] The researcher also inserts practice questions related to ecology material and a reflection column at the end of the learning activities in the science literacy worksheets. The third step is LKPD development which begins with LKPD validation using a validated questionnaire and ends with LKPD trials through HOTS-based pre-test and post-test work [3, 6]. The obtained data from the questionnaires were analyzed using the feasibility formula and then be interpreted with qualitative statement [9]. The fourth step is to disseminate, namely processing pre-test and post-test data obtained from the experimental class and control class at SMA Methodist An Pancurbatu using the t-test to know the difference in post-test scores between the experimental class and the control class and followed by the N-gain test for knowing the effectiveness of scientific literacy worksheets in improving students' HOTS [10]. The analysis of all data was carried out by using the SPSS v.23 software.

RESULTS

The result of the validity test of developed worksheet (LKPD) according to experts, teacher assessment and student responses are presented in Table 1. The mean score of validity was 92.2-94.0% and therefore the developed worksheet has very good feasibility. Based on this validity result, it can be concluded that the developed ecology worksheet based on scientific literacy are feasible to be tested in learning

activities and in order to improve the students' thinking skills.

Table 1. Results of validity

Expert Validator	Mean Score (%)	Feasibility
Material expert	92.2	Very good
Learning strategies expert	92.2	Very good
Media expert	94.8	Very good
Biology teacher	93.24	Very good
Student responses	94	Very good

The developed LKPD has been tested at class X IPA 2 as an experimental class and class X IPA 1 as a control class. Before entering the learning process, a pretest was conducted to measure the students' initial higher order thinking skills. At the end of the learning process, a post-test is given at the both classes to measure the students' HOTS. The result of student achievement or HOTS in pretest and posttests both at experimental and control classes are presented in Table 2.

Table 2. Student achievement of HOTS in Pretest and Posttests

Descriptive Statistics					
	N	Min	Max	Mean	Std. Dev
Pretest experiment class	24	23	65	40.33	10.154
Pretest control	28	20	70	44.32	13.306
Posttest experiment class	24	50	88	71.71	11.893
Posttest control	28	35	70	53.93	9.865

Based on obtained students HOT scores both in pretest and posttest at the control and experimental classes, it was found that the increasing of the pre-test and post-test scores in the experimental class was higher than in the control class. This result showed that the using of scientific literacy worksheets plays a significant role in improving students' higher order thinking skills (HOTS). In order to confirm this statement by using t-test, the normality and homogeneity testing on obtained data have been done. The result of normality and homogeneity testing on HOTS data for both classes were displayed in Table 3 and Table 4.

Table 3. Normality Test Pretest and Posttest Data

Class	Kolmogorov-Smirnov[a] (P)	Shapiro-Wilk (P)
Pretest experiment	0.134	0.402
Posttest experiment	0.200	0.167
Pretest control	0.177	0.299
Posttest control	0.105	0.234

The result of normality testing by using the Kolmogorov-Smirnov and Shapiro Wilk formula showed that the pretest and posttest data for both classes were normal (P= 0.105-0.200: P>0.05) (Table 3). The result of homogeneity testing also showed that the HOTS data were normal (P= 0.149-0.195: P>0.05) (Tabel 4).

Table 4. Homogeneity Test of Postest Data

Class	Probability	Description
Pretest	0.195	Homogen
Posttest	0.149	Homogen

Furthermore, the t-testing result on student higher order thinking skill in the pretest between experimental and control classes of both are presented in Table 5.

Table 5. Independent sample t test of Pretest data of Experimental and Control Classes

Class	Mean	t count (n=52)	t table (n=52)	Sig. (2-tailed)
Pretest experiment class	40.33	1.199	2.008	0.236
Pretest control class	44.32			

Based on the above t test result, it showed that t-count score was lower than t table (1.199 < 2.008; P= 0.236), and this finding means that there was no significant difference of student HOTs in Pretest between experimental and the control classes. It could be stated that there were no significantly differences in the HOTS initial ability between experimental and control classes.

The result of the independent sample t test of posttest data of experimental and control classes are presented in Table 6.

Table 6. Independent sample t test of Post test data of Experimental and Control Classes

Class	Mean	t count (n=52)	t table (n=52)	Sig. (2 tailed)
Posttest experiment class	71.71	5.894	2.008	0.000
Posttest control class	53.93			

Based on the above result, it is known that there were the significant differences of student HOTS between experimental class and control class (t-count= 5.894; P= 0.000). This means, the students HOT of the class that using of developed ecology worksheet was significantly higher compare to the students who did not use the developed ecology worksheet in learning process. In this case, the developed ecology worksheet has significant contribution in order to improve or to increase the students higher order thinking skills (HOTS).

Furthermore, the result of the N-gain testing of posttest data of experimental and control classes are presented in Table 7.

Table 7. N-Gain of Post Test data of Experimental and Control Classes

Class	Mean of gain score	Mean of gain score (%)	Category
Experiment	$0.30 \leq 0.53 \leq 0.70$	53.00%	Moderate (Effective)
Control	$0.16 < 0.30$	15.95%	Low (Not Effective)

Based on the results of above N-gain score, it was found that the average N-gain score for the experimental class using the ecology LKPD based on scientific literacy in the learning process was 0.53 or 53% and therefore belongs to moderate category, whereas, at the control class (without using the scientific literacy worksheets) was 0.16 or 15.95% belongs to low category. The result of the gain test for C4, C5 and C6 of experimental and control classes are presented in Table 8.

Table 8. N-Gain Test of C4, C5, C6 of Experimental and Control Classes

Group	Mean Pretest	Mean Posttest	N Gain	%N Gain	Category
C4 Experiment	6.92	11.79	0.54	54	Moderate
C5 Experiment	5.00	8.71	0.53	53	Moderate
C6 Experiment	3.82	7.58	0.46	46	Moderate
C4 Control	11.21	12.79	0.33	33	Low
C5 Control	3.71	4.86	0.14	14	Low
C6 Control	2.71	3.83	0.12	12	Low

Based on above N-gain value, it was found that the average N-gain score for the experimental class using the ecology LKPD based on scientific literacy in the learning process on category C4, C5 and C6 questions were from 0.46 until 0.54. These values belong to moderate category, whereas in control class (just from 0.12 to 0.33) belongs to low category. These results confirmed that the using of ecology LKPD based on scientific literacy was proven to be effective in improving the students' higher order thinking kills (HOTS) at ecology subject matter at senior high school. In contrary, the using of conventional worksheet (without based on scientific literacy) was not effective in increasing of students' higher order thinking skills.

DISCUSSION

The final product of the LKPD based on validity and effectiveness testing included to feasible category as supporting material for ecology learning. In the first validation process, the validation is done by instrument validator who assessed the validity of the questionnaire instrument. The researcher then corrected the entire questionnaire according to the suggestions and remarks that be given by the validator in order to obtain the very good category. This is following Haradhan (2017) [11] who wrote that the validity of a research instrument is seen based on the assessment score and the opinion of an expert. In addition, Adib (2017) [12] in her research also said that the instrument's feasibility category can be met when the instrument has instructions, clarity

aspect and indicators to be achieved and use th language that is easy to understand.

In the second and third validation process, the validations were done by material or content, learning strategy and media experts who assessed the validity of the material or content, language, design and also to assess the validity of the HOTS questions on ecology material before being used for pretest and posttest data collection. The researcher then corrected the scientific literacy worksheets and HOTS questions according to the suggestions and notices that be given by the validators. Due to this action, Fitrihidajati *et al* (2021) [13] stated that the selection of ecological materials is a suitable means to improve critical thinking skills through the use of the surrounding environment.

In the fourth validation process, the validation was done by biology teachers at SMA Methodist An Pancurbatu who assessed the validity of the material and presentation of the worksheets in terms of cover display design, content presentation, aspects of scientific literacy and language. These activities are similar to research that be done by Huda *et al* (2019) [14] regarding the development of scientific literacy worksheets. At that research Huda stated hat scientific literacy worksheet or LKPD was very suitable to be used as one of the learning media in order to increase the HOTS of the students. In line with that finding, research result by Rahayuni (2016) [15] stated that scientific literacy is very closely related to students' higher order thinking skills (HOTS). These results are also following Prastowo's theory about the benefits of LKPD and the results of Afifah's *et al* (2020) research that showed that scientific literacy-based teaching materials developed can be used properly, generate interest, and interest in learning and can increase students' HOTS [16].

Based on the independent sample t-test was proven that there was a significant different between experimental class which use an ecology LKPD based on scientific literacy and the control class who studied ecology topic without an ecology LKPD based on scientific literacy. Furthermore, based on the gain test is also proven that ecology LKPD based on scientific literacy is effective to improve students' higher order thinking skills especially in C4 and C5 category of HOTS on ecology subject matter at senior high school. Meanwhile, the using of worksheet without scientific literacy worksheets is not effective in increasing students' higher order thinking skills. The results of this study are supported by Afifah's *et al* (2020) which showed that developed scientific literacy-based teaching materials are effective in increasing students' HOTS [16]. In line with that result, Juhji's (2020) also stated that scientific literacy was very influential on student higher order thinking skills (HOTS) [17].

CONCLUSION

Based on the results of the research and discussion that have been described, it can be concluded that the feasibility of developed ecological worksheet (LKPD) based on scientific literacy was very feasible according to material (content), learning strategy and media experts and also according to responses of biology teachers and students. The developed worksheet can improve and effective in increasing of student higher order thinking, especially in answers the analytic (C4) and synthetic (C5) questions.

Conflict of Interest: None

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