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Development of E-LKPD Ecology and Biodiversity Using PBL-SSI to Enhance Secondary Students' Environmental Literacy

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ABSTRACT

The lack of material in teaching materials related to the environment around students is one of the causes of low environmental literacy. This results in low student knowledge of environmental issues and solutions to these problems. Problem-based learning is an alternative solution for students to practice analyzing problems using a socio-scientific issues approach. The research on the development of E-LKPD Ecology and Biodiversity by integrating the PBL-SSI learning model aims to enhance secondary students' environmental literacy. The type of research conducted is research and development (R&D) with the ADDIE development model, using a pre-experimental design with a group pretest-posttest design. This research was conducted at SMP N 3 Bawang in class VII using a small-scale test with 9 students and a large-scale test with 120 students. The results of this study were declared valid with high score criteria consisting of a material expert validity value of 0.93 and a media expert validity value of 0.94. This research is also very practical with a value of 98.48%, and very effective, with a value of 84.4%. Based on the results of data analysis, it can be seen that the E-LKPD Ecology and Biodiversity can improve students' environmental literacy.

Introduction

Science learning allows students to understand the impact of human actions on the natural environment, understand the relationship between nature, human social life, and culture. The environmental problems faced are environmental damage caused by climate change, extinction of natural resources, and the most common is environmental damage caused by human activities (Nugroho, 2018). The increasing human population can affect the physical environment, including increased pollution, conversion of forest functions, and excessive use of fossil fuels. Based on this

statement, it can be said that humans are the main factor causing environmental damage (Nasution, 2016). Natural disasters in Indonesia have high potential. Extreme weather and climate are disasters that often occur. This condition requires an attitude of environmental concern and adequate public awareness (Saragih et al., 2021). One of the efforts to deal with environmental problems that occur is to equip the next generation with environmental literacy skills through education (Susanti & Nupus, 2022).

Environmental literacy is part of scientific literacy (Sakti, 2016). Environmental literacy is a person's knowledge, skills and abilities in understanding, analyzing and overcoming problems related to the environment and knowing what actions to take to overcome these problems (Aswita et al., 2022). Environmental literacy skills can develop students' understanding of key concepts related to the environment and can apply the knowledge they have to contribute to solving existing environmental problems (Anggraini et al., 2022). The role of environmental literacy is very much needed in creating problem-solving abilities in students, because the higher the students' environmental literacy abilities, the better the students' environmental problem-solving abilities (Adela et al., 2018). Environmental literacy of Indonesian society is still relatively low. This can be seen from the results of the Survey of the Ministry of Environment which resulted in the conclusion that the index of community behavior towards the environment nationally is still not entirely good. The average index nationally is 0.57. This figure indicates that society has not behaved in an environmentally conscious manner in everyday life (Subhan, 2017). One of the class VII materials related to the environment is Indonesian ecology and biodiversity.

Indonesia's ecology and biodiversity is one of the important main subjects in science subjects. Acoording to Winda (2021) that the material on ecology and biodiversity of Indonesia has a broad scope and the objects in the material are related to things that are often encountered in real life, so it is necessary to have the right learning method for students to understand the material. Ecology is one of the key aspects in achieving sustainable development (Nur & Husen, 2022). The Sustainable Development Goals (SDGs) launched by the United Nations, ecology has a central role in achieving various goals, such as action on climate change (Goal 13), protecting terrestrial ecosystems (Goal 15), and conserving marine ecosystems (Goal 14) (Rohman, 2021). The ecological principles in the United Nations goals can help maintain a balance between human needs and environmental sustainability (Sari & Khomsiyah, 2023; Sujatini, 2018). The learning objectives to be achieved from the material on ecology and biodiversity of Indonesia are that students can identify interactions between living things and the environment, and can design efforts to prevent and overcome pollution and climate change. Success in achieving these learning objectives can be implemented using a learning model. One of the learning models that can be used is Problem Based Learning (PBL).

PBL is a learning model that helps students learn how to solve problems and think critically using real-world problems (Herawati et al., 2024). The advantages of the PBL model include making education in schools more relevant to life outside of school, encouraging students to solve real-life problems, and students being able to build their own knowledge through learning activities (Masrinah et al., 2019). The PBL model also has weaknesses, namely that students often find it difficult to determine problems that are appropriate to the students' level of thinking and the time is relatively longer than conventional learning and it is not uncommon for students to face difficulties in learning because in problem-based learning students are required to learn to find data, analyze, formulate hypotheses and solve problems (Masrinah et al., 2019). The problems presented in the PBL model are general in nature, so they are not specific to certain areas that are close to students. Problem-based learning is very appropriate if it is based on social issues (Socio Scientific

Issues) that are directly related to students' daily lives (Wilsa et al., 2017).

Socio-scientific issues (SSI) is an active learning approach, placing science content in a social context by providing motivation and interest in learning to students through the introduction of contextual problems (Zeidler & Sadler, 2023). The criteria for social issues that can be raised are that they have a scientific basis, there is opinion formation, they are often highlighted by the media, and they involve ethical, social, cultural and political values (Siska et al., 2020). The goal of the problem is to be meaningful and interesting for students, so that there is a need for the use of reasoning and providing context in finding out scientific information (Zeidler & Sadler, 2023). One of the focal points of science learning is to improve students' ability to participate in discussions about SSI in their daily lives.

Based on the results of observations and interviews with science teachers, the learning process carried out at SMP N 3 Bawang is still dominated by teachers using the lecture method. In addition, the form of LKPD used is less interesting for students, because the writing and pictures are not colored and learning activities on the ecology and biodiversity material have not been linked to issues in the students' environment. This causes a lack of understanding of the material in depth, comprehensively, and meaningfully.

One of the learning activities that can make students interested is using electronic-based learning devices. The development of the era is always accompanied by the development of advanced technology according to needs, especially in the field of education. Technology is always needed or required by educators to support the learning process. Effective learning can be seen from the ability of students to master learning materials, so E-LKPD is needed to support a better learning process.

Based on the description above, it is necessary to develop E-LKPD which is used for the science learning process for ecology and biodiversity material to improve environmental literacy.

Method

This type of research is research and development (R&D). R&D research is a type of research used to develop a particular product. The development model used in this research is ADDIE, which consists of Analysis, Design, Development, Implementation, and Evaluation. The trial subjects were divided into two, namely small-scale and large-scale trials. Small scale trials involving 9 class VII students of SMP N 3 Bawang based on level ability. The large-scale trial involved all class VII of SMP N 3 Bawang, totaling 120 students in the even semester of the 2023/2024 academic year as an experimental class. The research design adopted was a pre-experimental design with a one group pretest-posttest design as shown in Table 1.

Table 1. Research Design

Pretest	Treatment	Posttest
O_1	X	O_2

This research uses two data collection techniques, namely test and non-test. Tests are used to measure environmental literacy skills in knowledge aspects, using multiple choice questions as a measuring tool. Meanwhile, non-test techniques used to evaluate the validity and practicality of E-LKPD Ecology and Biodiversity as well as environmental care attitudes using a questionnaire. Validity test data was obtained from media expert and material expert validation sheets. Practicality test data was obtained from teacher response questionnaires and student responses.

The data analysis techniques used in this research include: First, the data used is descriptive data sourced from comments and suggestions from material experts and media experts during product development and the testing process. Second, validation and assessment of media quality is carried out based on the results of assessments by media experts and material experts and student readability. Analysis of the validity of the E-LKPD Ecology and Biodiversity was obtained from assessments given by several experts which were then processed using the V-Aikens. The following is the Aiken Coefficient Category in Table 2.

Table 2. Aiken Coefficient Category

Range	Category
0.68 < X ≤ 1.00	High
0.34 < X ≤ 0.68	Medium
0 ≤ X ≤ 0.34	Low

(Oktaviani et al., 2020)

The practicality of E-LKPD Ecology and Biodiversity was obtained by analyzing teacher and student response questionnaires. Practicality data is analyzed by percentage (%), using the following formula:

$$P = \frac{\text{Total score on the instrument (f)}}{\text{The total value of the highest score (N)}} \times 100\%$$

After the percentage is obtained, grouping is carried out according to the product assessment criteria, as can be seen in Table 3.

Table 3. Practical Results Criteria

Valuation Percentage	Interpretation
75% < X ≥ 100%	Very practical
50% < X ≥ 75%	Practical
25% < X ≥50%	Less practical
0% ≥ 25%	Not practical

Modified from Kumalasani (2018)

The environmental literacy studied consists of two domains, namely the domain of knowledge and environmental care attitudes. The N-Gain test is used to analyze pre-post environmental literacy data on the knowledge domain. This test aims to determine the difference in scores before and after treatment using E-LKPD Ecology and Biodiversity. The following is the N-gain formula used:

$$g = \frac{\text{Sposttest} - \text{Spretest}}{\text{Smax} - \text{Spretest}}$$

After the calculation is carried out, the average results are interpreted based on the N-Gain score criteria in Table 4.

Table 4. N-Gain Score Criteria

Score Interval	Criteria
⟨g⟩ ≥ 0.7	High
0.3 ≤ ⟨g⟩ > 0.7	Medium
⟨g⟩ < 0.3	Low

(Hake, 1999)

Data on students' environmental care attitudes were taken using initial and final questionnaires. The questionnaire results were analyzed using the following formula:

$$P = \frac{F}{N} \times 100\%$$

Environmental care attitudes are described using the criteria intervals presented in Table 5.

Table 5. Environmental Care Attitude Percentage Criteria

Score Interval	Criteria
81%-100%	Very caring
61%-80%	Caring
41%-60%	Caring enough
21%-40%	Care less
0%-20%	Don't care

(Amnah & Ferazona, 2021)

The effectiveness of E-LKPD Ecology and Biodiversity can be seen from the students' learning completion. The product is declared effective if the analysis of student learning outcomes yields an individual learning completion score of at least 75 (according to KKTP) and a class score of at least 85%. The interpretation of effectiveness is presented in the Table 6.

Table 6. Interpretation of Effectiveness

Score Interval	Criteria
P > 80%	Very effective
60 % ≤ P < 80%	Effective
40% ≤ P < 60%	Quite effective
20% ≤ P < 40%	less effective
P ≤ 20%	Very ineffective

(Putri et al., 2024)

Results and Discussion

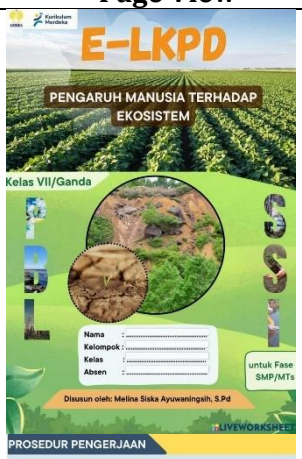
The following are the results of research and development of E-LKPD Ecology and Biodiversity Using PBL-SSI with ADDIE steps. The analysis stage consists of learning analysis, E-LKPD needs analysis by teachers, student needs analysis, and concept analysis. Learning analysis is carried out through observation and interviews with teachers. Based on the results of observations and interviews with the science teacher for class VII of SMP N 3 Bawang, information was obtained: (1) learning sources come from printed books and printed LKPD, (2) environmental literacy skills have never been measured specifically, and (3) students get bored easily and are not focused on learning. Based on the E-LKPD needs questionnaire filled out by science teachers, information was obtained that teachers had linked

ecology and biodiversity materials to real global problems, but not to environmental issues around students, had never made LKPD/E-LKPD, had never used E-LKPD, and the LKPD used so far had not been specifically based on PBL-SSI to improve environmental literacy. Based on the results of the student needs analysis questionnaire, information was obtained that the ecology and biodiversity material was considered difficult, the learning resources used were only textbooks and LKPD, the learning resources used were ordinary so that they were boring, and students were interested if there were learning resources that raised environmental issues around students with material that included images or videos. Concept analysis is carried out by analyzing learning achievements, learning objective flows, and ecology and biodiversity materials.

The second step is the design stage, by designing E-LKPD Ecology and Biodiversity Using PBL-SSI. The design process includes the preparation of learning instruments, materials, and research instruments. Learning instruments consist of teaching modules and pretest, and posttest questions. The teaching module is compiled based on the PBL learning model with the SSI approach, including student orientation to problems, organizing students, guiding investigations, developing and presenting work results, and analyzing and evaluating problems. The pretest was conducted before using E-LKPD, while the posttest was conducted after learning to use E-LKPD was completed. The material contained in E-LKPD Ecology and Biodiversity Using PBL-SSI is in the form of environmental issues in Banjarnegara based on internet news sources, YouTube, and research articles. The tools used to develop E-LKPD are Microsoft Word, Canva and Liveworksheet. Microsoft Word is used for designing E-LKPD. Canva is used to create cover designs, pages, and learning activities, and Liveworksheet to add interactive tools and publications to E-LKPD. E-LKPD can be accessed via smartphone or PC with screen size adjustments. The E-LKPD assessment instrument is intended for material experts, media, and teacher and student responses to E-LKPD. The assessment instrument is used to assess the feasibility of E-LKPD.

The third step is the development of E-LKPD Ecology and Biodiversity Using PBL-SSI. The following are the results of the development of E-LKPD Ecology and Biodiversity Using PBL-SSI.

Table 7. Development Research of E-LKPD Ecology and Biodiversity Using PBL-SSI

No	Page View	Description
1		The first page is the cover. The cover page created using Canva is equipped with images that are relevant and related to the material.
2		This page contains the procedures for completing E-LKPD, to make it easier for students to use E-LKPD.
3		This page contains PBL-SSI-based learning activities that are packaged with the features let's read, let's answer, let's discuss, let's create, let's express, and let's reflect. Learning activities are equipped with reading sources from news or research articles, images, video materials from YouTube, and quizzes.

Before the E-LKPD was tested, the E-LKPD was first validated by material experts and media experts. Validity is a standard measure that indicates the accuracy and legitimacy of a product. Validity testing is conducted to determine the degree of correctness of a product used. A product is considered valid if it can measure what is intended and can accurately reveal data from the variables being studied. The testing is carried out by comparing the questionnaire responses regarding the evaluation of the product (Putra et al., 2022). The following presents the validation results by 5 experts along with the Aiken's V value.

Table 8. Material Expert Validation Results

No	Aspect	V	Category
1	Content Suitability	0.91	High
2	Presentation Eligibility	0.93	High
3	Language Eligibility	0.87	High
4	Characteristics of E-LKPD	0.97	High
	Average	**0.93**	**High**

Based on table 8, there are 4 aspects assessed to determine the feasibility of the material, namely the content suitability, presentation eligibility, language eligibility, and characteristics of E-LKPD. Thus, a material validation expert is needed to determine the suitability of the material. The aspect of content suitability obtained an Aiken's V value of 0.91, the aspect of presentation eligibility obtained 0.93, language eligibility obtained 0.87, and E-LKPD characteristics 0.97. Presenting interesting material in E-LKPD Ecology and Biodiversity can make it easier for students to understand the material (Ardiansah & Zulfiani, 2023). Based on the obtained values, an average of 0.93 was obtained with a high category, so the material used is very feasible.

Table 9. Media Expert Validation Result**s**

No	Aspect	V	Category
1	Product quality	0.93	High
2	Graphics eligibility	0.95	High
3	Usage/operation	0.93	High
	Average	**0.94**	**High**

Based on Table 9, there are 3 aspects assessed to determine the feasibility of the media, namely the product quality, graphics eligibility, and usage/operation. Thus, a media validation expert is needed to determine the suitability of the media. The aspect of product quality obtained an Aiken's V value of 0.93, the aspect of graphics eligibility obtained 0.95, and usage/operation obtained 0.93. Based on the obtained values, an average of 0.94 was obtained with a high category, so the media used is very feasible. In addition to the assessment, the validation of E-LKPD also contains suggestions and input from expert validators that are used for improvements before being implemented for students. The validated E-LKPD Ecology and Biodiversity Using PBL-SSI was tested on students.

The E-LKPD Ecology and Biodiversity was developed to be a solution to the lack of knowledge about environmental literacy. The E-LKPD Ecology and Biodiversity developed consists of 4 sub-materials, and the E-LKPD displayed is one of the sub-materials about the influence of humans on the ecosystem. This is supported by the results of research Saraswati & Suhartini (2024) which states that PBL-based E-LKPD can improve students' environmental literacy. PBL-SSI-based e-LKPD can also improve students' problem-solving abilities and environmental literacy (Chomsun et al., 2025; Septiani et al., 2025). Then, according to research Remindima et al (2024), which stated that the development of teaching materials on biodiversity can improve environmental literacy.

The implementation stage is carried out by applying E-LKPD Ecology and Biodiversity Using PBL-SSI to learning. E-LKPD was tested in class VII of SMP N 3 Bawang. The learning process is divided into four meetings with sub-chapters of material consisting of the influence of the environment on organisms, interactions between components of an ecosystem, the influence of humans on ecosystems, and biodiversity and conservation. Students were given a pretest in the form of multiple-choice questions to measure environmental literacy before using E-LKPD Ecology and Biodiversity Using PBL-SSI. Learning is continued with the distribution of E-LKPD access links and the introduction of E-LKPD Ecology and Biodiversity Using PBL-SSI. PBL-SSI-based activities in E-LKPD are described as follows. The orientation stage towards the problem is presented with images/articles, then students create temporary questions and answers from the results of observations. In the student organizing stage, the teacher helps students with the problems observed by providing supporting materials. In the investigation guidance stage, the teacher encourages students to discuss within their respective

groups to solve problems. In the development and presentation stage of the work results, students present the results of the discussion. In the analysis and evaluation stage, students make learning conclusions and work on quizzes. If students have finished working on the E-LKPD, students click finish at the bottom of the last page. The second meeting and so on are carried out with the same learning stages as the first meeting. After all activities are completed, at the fourth meeting students will be given posttest questions to measure environmental literacy.

The development of E-LKPD Ecology and Biodiversity needs to undergo a practicality test. The purpose of the practicality test is to determine the practicality and ease of use of the developed product (Ayu & Dharmono, 2020). The stages of the practicality test involve asking students and teachers to fill out a response questionnaire. The results of the analysis of the student response questionnaire are presented in table 10 as follows.

Table 10. Results of The Students Response Questionnaire

No	Aspect	Number of Questionnaire Scores	Average Percentage (%)	Category
1	Attractiveness of Presentation	360	100	Very Practical
2	Ease of Use	789	93.93	Very Practical
3	Usefulness	582	97	Very Practical
Average			**96.97**	**Very Practical**

Table 10 shows the average percentage for the attractiveness aspect of presentation of 100% with a very practical category, the ease of use aspect of 93.93% with a very practical category, and usefulness of 97% with a very practical category. The average percentage obtained is 96.97%, with a very practical category. E-LKPD Ecology and Biodiversity is designed using an electronic system so that students are more flexible and practical. Fitriati et al., (2023), states that the use of E-LKPD which utilizes technology is not hampered by time and place. The same opinion was expressed by Cahyani & Jati (2023), E-LKPD is practical to use via smartphone and makes it easier for students to study independently in class because it can be carried anywhere.

Table 11. Results of The Teacher Response Questionnaire

No	Aspect	Number of Questionnaire Scores	Average Percentage (%)	Category
1	Attractiveness of Presentation	4	100	Very Practical
2	Ease of Use	5	100	Very Practical
3	Usefulness	6	100	Very Practical
	Average		**100**	**Very Practical**

Table 11 shows the average percentage for the attractiveness aspect of presentation of 100% with a very practical category, the ease of use aspect of 100% with a very practical category, and the usefulness of 100% with a very practical category. The average percentage obtained is 100%, with a very practical category. The average percentage of student and teacher response questionnaire results was 98.48%, so that the E-LKPD Ecology and Biodiversity that was developed is practical for use in learning. According to Habiba et al., (2023), conveyed that in developing learning tools, what needs to be considered is practicality.

Effectiveness is a measure of the success of E-LKPD Ecology and Biodiversity using PBL-SSI to improve students' environmental literacy through field trials. The field trials consist of one group, which

is the experimental group, also referred to as the one-group pretest-posttest design. The advantage of the one-group experimental design is that it is practical and efficient to implement, as well as having a high level of homogeneity in the research sample (Saifuddin, 2020).

Effectiveness testing was carried out by giving a pretest and posttest with a total of 18 multiple-choice questions to students. The average pretest is 67.96 and the posttest is 93.8. The N-Gain value aims to compare the difference between pretest and posttest scores. The N-Gain value obtained is 0.81 in the high category.

The results of the pretest and posttest will be tested with the Wilcoxon Non-Parametric Test. This test is conducted to obtain the results of the effectiveness of E-LKPD Ecology and Biodiversity with non-normally distributed data. Calculation of the Effectiveness Test with the Wilcoxon Non-Parametric Test with 2 paired data with non-normal distribution using SPSS as follows.

The sig. value is 0.000, which means it is less than 0.05. Thus, Ho is rejected and H1 is accepted. Ho, there is no difference in students' environmental literacy scores before and after being given treatment, is declared rejected. While H1, there is a difference in students' environmental literacy scores before and after being given treatment, is declared accepted.

Based on the results of the descriptive analysis, the average positive rank value is 60.50, and the negative rank is 0.00. This shows an increase in students' environmental literacy values after receiving treatment. Contextual learning of the surrounding environment can improve students' environmental literacy (Dwianto et al., 2017; Setiawan et al., 2017). E-LKPD that utilizes the environment around students makes learning activities more interesting and meaningful (Istiliana, 2016). Students can relate the material to everyday life because the material and problems presented are in accordance with real life, so it will be easier for students to accept. Therefore, it can be concluded that the use of E-LKPD Ecology and Biodiversity using PBL-SSI has a significant effect on improving the environmental literacy of junior high school students.

Environmental literacy is not only measured by knowledge of the environment, but also by caring about the environment. Yaumi (2014), explains that an attitude of caring for the environment is an exemplary attitude that aims to create harmony, compatibility and balance between humans and the environment. Students' environmental care attitude was measured from a questionnaire before and after using E-LKPD Ecology and Biodiversity.

The average pretest is 63.69 and the posttest is 95.47. The N-Gain value aims to compare the difference between pretest and posttest scores. The N-Gain value obtained is 0.88 in the high category. The results of the pretest and posttest will be tested with the Wilcoxon Non-Parametric Test. This test is conducted to obtain the results of the effectiveness of E-LKPD Ecology and Biodiversity with non-normally distributed data. Calculation of the Effectiveness Test with the Wilcoxon Non-Parametric Test with 2 paired data with non-normal distribution using SPSS as follows.

The sig. value is 0.000, which means it is less than 0.05. Thus, Ho is rejected and H1 is accepted. Ho, there is no difference in students' environmental literacy scores before and after being given treatment, is declared rejected. While H1, there is a difference in students' environmental literacy scores before and after being given treatment, is declared accepted.

Based on the results of the descriptive analysis, the average positive rank value is 60.50 and the negative rank is 0.00. This shows an increase in students' caring about the environment after receiving treatment. Developing an attitude of caring for the environment at a young age is expected to produce people who behave positively towards the environment in the future (Susilo et al., 2016). The number of categories of environmental care attitudes before and after the use of E-LKPD Ecology and Biodiversity experienced changes and increases. The frequency of pretest and posttest results can be seen in Figure 1.

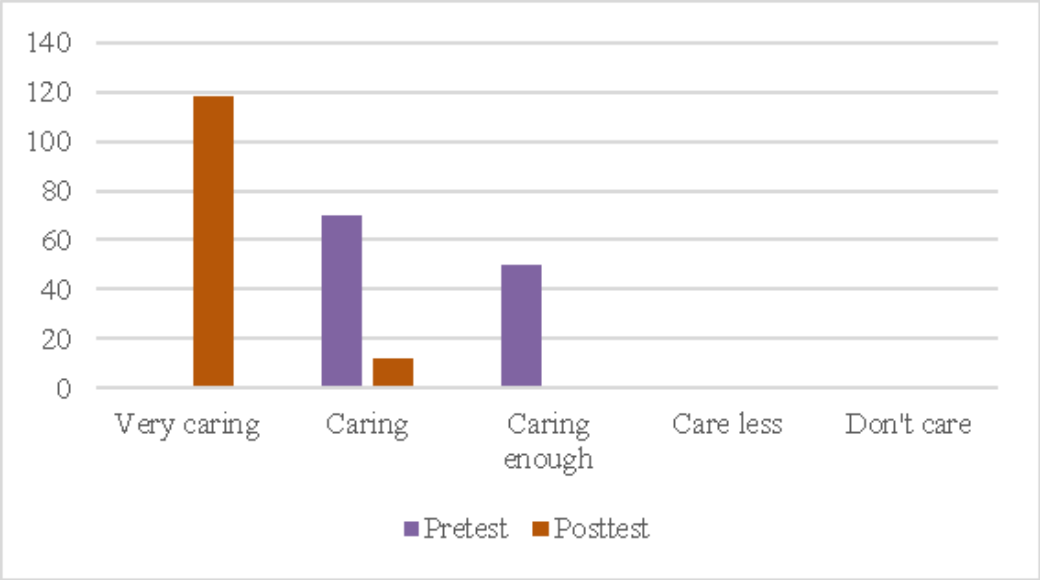


Figure 1. Results of Pretest-Posttest Frequency

Based on Figure 1, it shows that the frequency of environmental care attitudes during the pretest obtained the caring category of 70 students and quite caring of 50 students. While during the posttest obtained the very caring category of 118 students and caring of 12 students. Therefore, it can be concluded that the use of E-LKPD Ecology and Biodiversity has a significant effect on improving the environmental literacy of junior high school students. A sense of concern for the environment must be instilled in students from an early age, considering that current technological advances are threatening the state of the environment (Rakhmawati et al., 2016). Instilling an attitude of caring for the environment to shape students' mentality and develop knowledge and skills so that their future is more focused (Lubana et al., 2013).

Table 12. Effectiveness Results

N-Gain percentage		Average	Category
Knowledege	Attitude		
80.89%	88%	84.4%	Very effective

Table 12 shows the percentage of N-Gain in the knowledge aspect, which is 80.80% with a very effective category and the attitude aspect, which is 88% with a very effective category. The percentage of N-Gain environmental literacy is obtained from the average value, which is 84.4% with a very effective category. From the results of the analysis above, it can be concluded that the E-LKPD Ecology and Biodiversity is very effective for implementation in junior high school students.

Conclusion

Based on the results and discussions that have been presented above, it can be concluded that the E-LKPD Ecology and Biodiversity that was developed is classified as valid, very practical, and very effective in improving students' environmental literacy. These results are based on validity tests by material and media experts, practicality tests with student and teacher response questionnaires, and effectiveness tests with pretests and posttests on aspects of knowledge and attitudes of caring for the environment. Therefore, it is recommended to develop E-LKPD on other materials or to use other models and approaches, and to add features to learning activities.

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