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# Development of Integrated Problem-Based Electronic Student Worksheets Local Potential of TPST Piyungan on Environmental Change Material

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**Abstract:** This research aims to determine the characteristics and produce problem-based electronic student worksheets that are integrated with the local potential of TPST Piyungan in appropriate, practical, and effective environmental change material to improve students' problem-solving abilities and environmental literacy. This research is research and development (R&D) using the 4D model (Define, Design, Develop, and Disseminate). A field trial of electronic worksheets was carried out through quasi-experimental research with a pretest-posttest control group design. The field trial subjects were 72 students from two classes. Data analysis was carried out using the MANOVA test to analyze differences in students' problem-solving abilities and environmental literacy. The results of the research show that based on the assessment of expert lecturers, the content of electronic worksheets is very suitable for encouraging problem-solving abilities and environmental literacy, and the MANOVA test results show that there are differences in problem-solving ability and environmental literacy when using electronic worksheets based on problems integrated with the local potential of TPST Piyungan. It can be concluded that the integrated worksheet based on local potential problems at TPST Piyungan is feasible, practical, and effective for use in implementing environmental change materials.

**Keywords:** Electronic Student Worksheet; Environmental Change; Environmental Literacy; Local Potential; Problem-Solving Ability

## Introduction

Education has an important role in developing knowledge, skills, attitudes, and values that enable a person to do everything to contribute and obtain benefits for the future in a sustainable manner (Organization for Economic Co-operation and Development, 2018). Entering the 21st century, human life has experienced fundamental changes and is different from the previous order of life. This is called the century of emergence or the century of dispersal (Khairani & Aloysius, 2023). 21st-century learning enables technology-based learning, which is now growing rapidly (Rosnaeni, 2021).

Preparing human resources capable of mastering 21st-century skills will be effective if pursued through education. One of them is the curriculum change that has been carried out by the government (Redhana, 2019). The 2013 curriculum places greater emphasis on application-based learning in everyday life. One of them is utilizing local potential as a learning resource that can be packaged into teaching materials (Situmorang, 2016).

Local potential is a resource that a region has and can be used as a biology learning resource (Imtihana & Djukri, 2021). In fact, not many schools have utilized local potential. Several factors cause this, namely the difficulty of making teaching materials, the cost of making teaching materials, and determining teaching materials that are relevant to local potential (Prihandono

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et al., 2017). TPST Piyungan is one of the local potentials in Yogyakarta that can be integrated into biology learning.

Based on the results of interviews and preliminary observations on October 25, 2022, it was stated that the TPST Piyungan is an integrated waste disposal site that serves waste from the Sleman Regency area (30%), Yogyakarta City (50%), and Bantul Regency (20%). The volume of incoming waste is around 700–750 tons per day and has increased from year to year. The results of laboratory tests in 2019–2022 show that the TPST Piyungan leachate has not met quality standards, namely mostly the TSS, TDS, BOD, and COD parameters, which are based on DIY Regional Regulation Number 7 of 2016, concerning waste water quality standards (Balai Pengelolaan Sampah Dinas Lingkungan Hidup dan Kehutanan DIY, 2023).

Based on the results of the analysis of the use of local potential, it can be seen that the problems at the TPST Piyungan can be used as an alternative source for studying biology on environmental change material, namely related to waste and leachate management. Class X high school biology material is related to the surrounding environment, one of which is environmental change material. Learning materials sourced from local potential will train students' abilities in identifying problems related to local potential in the students' environment (Vasminingtya et al., 2014).

Utilization of local potential learning resources at TPST Piyungan can be applied in biology learning on environmental change material. Identifying environmental problems is the most difficult thing for students to think about. If students fail to understand their own problems, they will have difficulty taking further action to solve them (Fenny et al., 2019).

The environmental imbalance that occurs in the surrounding environment cannot be overcome simply by improving nature. However, efforts to overcome these problems cannot be separated from the role of environmentally conscious people, or what is usually called environmental literacy. A person can be said to have environmental literacy, measured through four components: environmental knowledge, environmental competence, attitudes that care about the environment (dispositions), and environmentally responsible behavior (NEEF, 2015).

PISA (Program of International Assessment of Students) data reflects that the environmental literacy level of students in Indonesia is relatively low. Indonesian students in the fields of environmental science and geoscience are ranked 51st out of 57 participating countries. Therefore, it is important to make efforts to facilitate students' environmental literacy (Fahlevi et al., 2023).

Based on preliminary results at SMA N 1 Piyungan on 72 students, the results showed that 23.61% of those who had environmental literacy skills were in the low category. Environmental literacy must be possessed by students as agents of change in protecting the environment for the better (Chen et al., 2020). Therefore, efforts are needed to increase students' environmental literacy, namely through the field of education. This is because education is an institution that is considered effective in providing knowledge and competencies (Kamil et al., 2019).

Students' understanding will be gained if the teacher involves students directly in honing their abilities, such as solving problems. PISA (Program of International Assessment of Students) data for 2018 explains that the average student in Indonesia is only able to recognize explanations, identify phenomena, and search for truthful information. Based on the data in this research, it shows that students' problem-solving abilities are still in the low category.

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The results of preliminary research at SMA N 1 Piyungan conducted on 72 students showed that 22.22% of those with problem-solving abilities were in the low category. Students' low problem-solving abilities need to be considered because they are the most important thing in preparing a superior generation in accordance with the demands of 21st century competence (Kurniawati et al., 2019). Increasing students' problem-solving abilities can be done through innovative and effective teaching methods (Darma et al., 2018).

The results of an interview with one of the class X biology teachers stated that the student worksheet used was purchased from the publisher. The student worksheet is printed on opaque paper and is black and white, making students less interested in studying it. The student worksheet contains a description of the material and an assignment of practice questions and does not use a specific learning model. The learning process carried out with the help of student worksheets requires a learning model so that the implementation of learning can run effectively (Sujana, 2023).

Facts and realities of education in the field: many teachers are found who still use conventional teaching materials, namely teaching materials purchased on the market. The risk is very high if the teaching materials used are not contextual, uninteresting, monotonous, and

do not suit the needs of students (Zuriah et al., 2016). Electronic student worksheet is an effort to adapt to technology-based developments in the 21st century (Rahmawati et al., 2022). Innovative electronic student worksheets are very important for students to meet the demands of technology-based 21st-century learning (Suryaningsih & Nurlita, 2021). Electronic student worksheets can simplify and narrow space and time (Syafitri & Tressyalina, 2022). Students can easily access learning repeatedly without having to spend money on printing teaching materials (Sari et al., 2022).

The electronic student worksheet developed is inserted with learning model syntax that suits the characteristics of the material, namely the problem-based learning model (PBL). The PBL model is a learning model that requires students to process actively in solving problems that exist in everyday life by relating the material to be studied (Stankunas et al., 2016). The application of the PBL model is proven to provide good results in research into student learning outcomes (Tiring, 2020). There is an increase in problem-solving abilities because the problem-based learning process involves students directly in the problem-solving process. Students will actively seek information, manage information, and analyze data to solve problems (Permata et al., 2022).

Based on the explanation above, researchers need to carry out research and development regarding an integrated problem-based electronic student worksheet with local potential at TPST Piyungan, which has the potential to improve the problem-solving abilities and environmental literacy of class X high school students.

## Method

This research is research and development (R&D). This development research is used to produce new products in the form of electronic student worksheet. The development model used is a 4D development model, which has four stages: define, design, develop, and disseminate. The framework for this research can be seen in Figure 1.

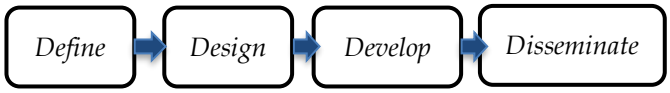


**Figure 1.** Research Framework

The development product is a problem-based electronic student worksheet integrated with the local potential of the TPST Piyungan using Google Sites media. The material in this research is environmental change material for class X high school students. The validation of electronic student worksheet products was carried out by material expert lecturers and biology learning experts. Next, a limited test was carried out on an electronic student worksheet, which was reviewed by class X high school students. The next step, the electronic student worksheet, was tested on 36 class X high school students to see its effect on the students' problem-solving abilities and environmental literacy.

A product feasibility analysis is carried out to determine the feasibility of the product. The data collected is in the form of assessment scores obtained from experts. After obtaining the data, the data is then analyzed quantitatively using Formula 1.

$$M = \frac{\Sigma fx}{N} \quad (1)$$

Information:
M = Average per aspect
$\sum fx$ = Total score per aspect
N = Number of components

After obtaining the average data per aspect, convert the average score to a value of 100 by means of:

$$\text{Value per aspects} = \frac{\text{Average score}}{\text{Max score}} \text{ x } 100 \quad (2)$$

Next, the interpretation of each aspect is categorized according to the value categories conveyed by (Riduwan, 2013). Eligibility categories can be seen in Table 1.

**Table 1.** Product Eligibility Categories

| Score | Category |
|---|---|
| 81 – 100 | Very Good |
| 61 – 80 | Good |
| 41 – 60 | Enough |
| 21 – 40 | Less |
| ≤ 20 | Not Good |

Analysis of product practicality, calculated using data from biology teacher assessments and student responses to an electronic student worksheet. After getting the average assessment data for each aspect, convert the average score to a value of 100 by means of:

$$\frac{\text{The average score obtained}}{\text{Total score}} \text{ x } 100 \quad (3)$$

Next, the interpretation of each aspect is categorized according to the value categories conveyed by (Riduwan, 2013). The practicality category can be seen in Table 2 as follows:

Effectiveness analysis uses pretest and posttest data on students' problem-solving abilities and environmental literacy. The data analysis technique used is multivariate analysis with the Multivariate

Analysis of Variance (MANOVA) technique with a significance level of 0.05.

**Table 2.** Product Practicality Interpretation Criteria

| Value | Category |
|---|---|
| 87.51 – 100.00 | Very practical |
| 74.51 – 87.50 | Practical |
| 61.51 – 74.50 | Enough |
| 48.51 – 61.50 | Less |
| 0.00 – 48.50 | Not practical |

## Result and Discussion

The product designed and developed in this research is a problem-based electronic student worksheet integrated with the local potential of the TPST Piyungan in environmental change material. The teaching materials developed are an alternative teaching material for the 21st century in the industrial era 4.0 (Ismathulhuda et al., 2022). The electronic student worksheet is an innovation in learning that has the advantage of being able to be accessed anytime and anywhere (Magdalena et al., 2021). The product development results have been implemented and achieved in accordance with the 4D research and development procedures described as follows:

*Define*

The definition stage is the first step to determining and formulating needs during the biology learning process. The initial analysis was carried out with student character analysis and competency analysis. In interviews with biology teachers, data was obtained that the student worksheet used presented a form of assignment of practice questions and did not contain learning activities that support the achievement of problem-solving abilities and environmental literacy. Students' problem-solving abilities and environmental literacy are still relatively low. Apart from that, the potential that exists at the TPST Piyungan regarding environmental change is waste and leachate management. There are 3 types of environmental change material, namely environmental change, pollution, and waste recycling (Nuriyah et al., 2020). Students who study environmental change material can obtain information about problems in the surrounding environment (Azrai et al., 2022).

*Design*

The first step is selecting media that are adapted to the material. The media used is an electronic student worksheet using Google Sites. This is in line with students' smartphone ownership reaching 100% and the demands of 21st century technological developments, so that electronic student worksheet takes the form of a website, which is expected to be able to be used by all Android and iOS users. Technology makes a major contribution to the development of more effective and efficient teaching materials to support better learning (Rahmi, 2023). The existence of interactive student worksheets that utilize technology is very necessary so that students are technologically literate. A student worksheet that is packaged interactively can provide a learning atmosphere that is not boring, fun, and has a positive influence on the learning process (Suwastini et al., 2022). Next, an initial design for making an electronic student worksheet is carried out. The electronic student worksheet design can be seen in Figure 2.

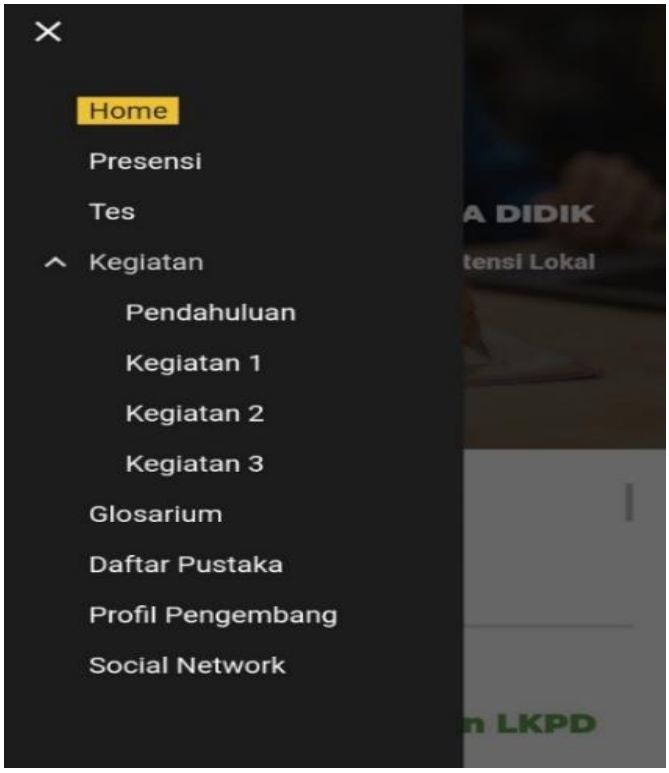


**Figure 2.** Electronic Student Worksheet Design

*Develop*

The development stage consists of expert validation, limited trials, and field trials. The validation stage is used to determine the feasibility of the electronic student worksheet product that has been developed. Validation was carried out by biology learning experts and material experts. The quality of a product developed can be seen from one of the criteria, namely validity (Hulu & Dwiningsih, 2021). The results of the product feasibility test by biology learning experts can be seen in Table 3.

The results of the biology learning expert's assessment showed that the final average score was 88.13 in the very appropriate category. This aspect is very important because good biology learning can improve students' abilities. Overall, it can be concluded

that the problem-based electronic worksheet integrated with the local potential of the TPST Piyungan, assisted by Google Sites, is suitable for use in learning biology from a learning perspective. The assessment of product suitability in terms of material can be seen in Table 4.

**Table 3.** Biology Learning Expert Validation Results

| Assessment aspects | Score | Criteria |
|---|---|---|
| Learning | 80.00 | Good |
| Presentation | 85.00 | Very good |
| Language | 87.50 | Very good |
| Graphics | 100.00 | Very good |
| Average | 88.13 | Very good |

**Table 4.** Material Expert Validation Results

| Assessment aspects | Score | Criteria |
|---|---|---|
| Material feasibility | 50.0 | Enough |
| Accuracy of materials | 100.0 | Very good |
| Didactic | 79.5 | Good |
| Construction | 80.0 | Good |
| Technical | 100.0 | Very good |
| Average | 81.9 | Very good |

The results of the assessment by material experts showed that the average score was 81.9 in the very appropriate category. Overall, it can be concluded that the problem-based electronic student worksheet integrated with the local potential of TPST Piyungan, assisted by Google Sites, is suitable for learning in terms of material. The teaching materials used in the learning process that can develop students' abilities as a whole are student worksheets (Yulkifli et al., 2019). Students can use the student worksheet to better understand the material (Fitri et al., 2019).

As a result of revisions based on suggestions or input from expert lecturers, the practicality test of the electronic student worksheet is then carried out. The practicality test was carried out by two biology teachers and class X MIPA students. The results of the practicality assessment by the biology teacher can be seen in Table 5.

**Table 5.** Biology Teacher Practicality Test Results

| Assessment aspects | Score | Criteria |
|---|---|---|
| Software engineering | 96.00 | Very practical |
| Visual communication | 100.00 | Very practical |
| Material feasibility | 93.75 | Very practical |
| Accuracy of materials | 96.88 | Very practical |
| Sophistication of material | 100.00 | Very practical |
| Didactic | 100.00 | Very practical |
| Construction | 96.25 | Very practical |
| Technical | 97.50 | Very practical |
| Average | 97.20 | Very practical |

Based on the table of practicality test results by two biology teachers, the electronic student worksheet developed is included in the very practical category with an average score of 97.20. Overall, it can be concluded that the electronic student worksheet that has been developed is very practical to use in biology learning. Teaching materials are said to be practical if the product produced is easy for users to use (Kurniasih & Rahayu, 2017). The practical criteria for an electronic student worksheet are that it is easy to learn and easy to understand (Magdalena et al., 2021).

The electronic student worksheet product was tested on a limited basis, involving 36 class X MIPA students. This trial aims to obtain data regarding the practicality of electronic student worksheets. The results of the analysis of electronic student worksheet readability tests by students can be seen in Table 6.

**Table 6.** Student Readability Test Results

| Assessment aspects | Score | Criteria |
|---|---|---|
| Presentation | 94.50 | Very practical |
| Language | 95.50 | Very practical |
| Visual communication | 97.50 | Very practical |
| Expediency | 95.50 | Very practical |
| Average | 95.75 | Very practical |

The results of the recapitulation of the electronic student worksheet readability test by students showed that it was included in the very practical category with an average score of 95.75 in terms of presentation, language, visual communication, and usefulness aspects. Next, a field trial was carried out to implement the electronic student worksheet product, which had previously been feasible, and tested in the field to determine the effectiveness of the electronic student worksheet product on students' problem-solving abilities and environmental literacy. The implementation of the electronic student worksheet product developed in this research uses a nonequivalent quasi-experimental (pretest-posttest) control group design. The field trial subjects were 72 SMA class X MIPA students, each divided into treatment (experimental) and comparison (control) groups.

The effectiveness of electronic student worksheet products in learning was analyzed using MANOVA test statistical analysis. Before statistical tests are carried out, prerequisite tests are carried out first. The following are the results of the prerequisite tests: Two dependent variables are measured at the interval or ratio level, namely data on problem-solving ability and environmental literacy, including interval data; the independent variable is composed of two or more categories, namely using two independent variables: an electronic student worksheet based on problems integrated into the local potential of TPST Piyungan and a printed student worksheet based on the 5M model; independence of measurements; the two groups are in different classes with different treatments, namely the

control class and the experimental class; and it has an adequate sample size of 72 students.

Apart from that, there are no univariate or multivariate outliers. There are no outliers, the scatterplot graph tends to be in the form of a straight line upwards with one plot; the data is normally distributed. It is stated that it is normally distributed, as seen from the scatterplot graph showing a straight line, and more than 50% of the Mahalonobis distance values are less or equal to the qi value; there is linearity obtained. Deviation from linearity (sig > 0.005) means that the data shows significant linearity between students' problem-solving abilities and environmental literacy; there is homogeneity of variance and covariance (sig value). In the pretest-posttest, each variable exceeds 0.05, so the conclusion is that there is the same variance in each research variable, and there is no multicollinearity because the tolerance value is > 0.1 and the VIF value is < 10 so that the multicollinearity assumption test can be exceeded.

After fulfilling the nine MANOVA prerequisite tests, proceed to carry out the MANOVA hypothesis test analysis. The results of the MANOVA test analysis can be seen in Table 7.

**Table 7.** Multivariate MANOVA Test Results

| Effect | Sig. | Partial eta squard |
|---|---|---|
| Hotelling's trace | .00 | 0.89 |

Based on table 7, it can be concluded that the significance value is <0.05 (p <0.05), so Ho is rejected and Ha is accepted. If Ha is accepted, then it can be stated that there is a difference in the problem-solving abilities and environmental literacy of students who take part in learning using problem-based electronic student worksheets integrated with the local potential of TPST Piyungan and students who do not use problem-based electronic student worksheets integrated with the local potential of TPST Piyungan. This significant difference means that the problem-based electronic student worksheet product integrated with the local potential of TPST Piyungan is effective in improving students' problem-solving abilities and environmental literacy. Web-based learning media is able to improve students' learning outcomes. This is due to the learning process being student-centered and using many sources, complete with pictures and videos (Jusriati et al., 2021).

The percentage effect or contribution provided by the electronic student worksheet towards increasing problem-solving abilities and environmental literacy can be seen in the partial eta square value, which is multiplied by 100% to obtain an effect percentage of 88.5%. A problem-based student worksheet is effective in improving students' problem-solving abilities. This is because the student worksheet can guide students in solving problems, have their own problem-solving strategies, use problems as starting points, and stimulate students' participation abilities in groups (Marhaeni et al., 2021).

Further analysis of this MANOVA test is the Test of Between Subjects test to determine the effect of the integrated problem-based electronic student worksheet on the local potential of TPST Piyungan on each variable, namely problem-solving ability and environmental literacy. The results of the test of problem-solving ability between subjects can be seen in Table 8.

**Table 8.** Results of the Test of Between Subjects Problem Solving Ability

| Dependent variable | Sig. | Partial eta squard | Information |
|---|---|---|---|
| Problem-solving skills | .00 | 0.89 | There is a difference in the donation value of 89% |

This significant difference means that this electronic student worksheet product is effective in improving students' problem-solving abilities. The large percentage effect or contribution provided by the electronic student worksheet towards improving problem-solving abilities can be seen in the partial eta square value, which is multiplied by 100% to obtain an effect percentage of 88.5%. In environmental change material, students are not only required to understand the material. However, students are also required to be able to play an active role in creating solutions to problems based on issues of environmental change that are occurring (Nisak & Susantini, 2023). Problem-based learning creates a learning environment where students can be involved in analyzing real-life problems (Gok & Boncukcu, 2023).

The syntax in the problem-based electronic student worksheet is a learning model that uses real-world problems as a context for students to learn how to think and problem-solve skills and gain knowledge and concepts from learning material. This is in line with research Argaw et al. (2016), problem-based learning can increase motivation so that it has an impact on increasing problem-solving abilities. Problem-based learning is an innovation in learning because students' thinking abilities are optimized through a systematic group or team work process so that students can empower, hone, test, and develop their thinking abilities continuously (Febriasari & Supriatna, 2017). By utilizing local potential, students can understand learning objects related to daily life that they study, which has a positive impact on their interest in learning and helps them achieve learning goals (Tyas et al., 2020). The results of

the test of environmental literacy between subjects can be seen in Table 9.

**Table 9.** Results of the Test of Environmental Literacy Between Subjects

| Dependent variable | Sig. | Partial eta squard | Information |
|---|---|---|---|
| Environmental literacy domain knowledge | .00 | 0.50 | There is difference with donation value 50 % |
| Environmental literacy domain competencies | .00 | 0.87 | There is difference with donation value 87 % |
| Environmental literacy domain disposition | .00 | 0.91 | There is difference with donation value 91 % |

This significant difference means that this electronic student worksheet product is effective in increasing students' environmental literacy. The percentage effect or contribution provided by the integrated problem-based electronic student worksheet on the local potential of the TPST Piyungan in increasing environmental literacy can be seen in the partial eta square value, which is multiplied by 100% to obtain a percentage effect of environmental literacy domain knowledge of 50%, domain competencies of 87%, and disposition domain of 91%.

The percentage of effect or contribution made by the electronic student worksheet on environmental literacy skills in domain knowledge or environmental knowledge is low compared to other aspects of environmental literacy. This is because the provision and delivery of material related to environmental knowledge on the electronic student worksheet is still lacking, causing students' environmental knowledge to be less than optimal. According to Risanatul & Junaidi, (2022), through the support of various reading sources, it can provide knowledge and shape students in responding to questions from teachers related to learning. Knowledge is very necessary to create standards of behavior that are able to maintain and protect the environment and improve the quality of human life. Problem-based learning can be used as an important tool in environmental education (Rachman et al., 2020).

Students who have environmental literacy will behave responsibly towards the environment through knowledge, skills, and awareness of environmental problems (Febriasari & Supriatna, 2017). This is supported by research Suryawati et al., (2020), The use of learning resources in the form of student worksheets strengthens students' literacy in identifying, analyzing, evaluating, and planning actions, as well as their sensitivity to environmental problems, both local and global. The use of local context or potential in presenting learning will be better understood by students than the national context, which is not recognized by students as they usually encounter it in school textbooks (Sriyati et al., 2022). An electronic student worksheet that uses real problems can potentially increase students' motivation because they can find out and learn the meaning of material life in real life (Isma et al., 2021).

## Conclusion

Based on the results of data analysis and discussion, it can be concluded that a problem-based electronic student worksheet integrated with the local potential of TPST Piyungan in environmental change material is stated to encourage students to actively seek their own knowledge in accordance with the stages of the problem-based learning model. Electronic student worksheet content is very suitable for encouraging students' problem solving and environmental literacy abilities based on assessments from expert lecturers; suitable for use in learning based on assessments from biology learning experts and material experts; has been tested for practicality and is included in the very practical category based on teacher and student assessments as well as observations of learning implementation; effective for improving problem solving abilities and environmental literacy of class X high school students.

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**Conflicts of Interest**
The authors declare that there is no conflict of interest regarding the publication of this paper.

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