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Innovation in Science Learning Based on Eco Disaster Literacy through a Design Based Research Approach to Improve Environmental Care Attitudes and Problem Solving Skills of Elementary School Students

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ABSTRACT : This study aimed to develop and evaluate an eco-disaster literacy–based science learning model using a Design-Based Research (DBR) approach to improve environmental awareness and problem-solving skills of elementary school students. The research was conducted at SD Negeri 1 Laousu, Konawe Regency, Southeast Sulawesi, involving 40 fifth-grade students. The DBR process included four stages: analysis, design, implementation, and evaluation. Data were collected through questionnaires, problem-solving tests, observations, and interviews. The findings showed that the learning model was highly valid, with Aiken's V values ranging from 0.85 to 0.89, and highly practical, indicated by 92% implementation and 90% positive student responses. The model was also effective in improving student learning outcomes. Environmental awareness increased in the moderate category (N-Gain = 0.57), while problem-solving ability improved in the high category (N-Gain = 0.70). The t-test results showed significant differences between pretest and posttest scores ($p < 0.05$), indicating the effectiveness of the developed learning model.

Key words: Eco Disaster Literacy, Design Based Research, Science Learning, Environmental Literacy, Problem Solving, Elementary School

INTRODUCTION

Global environmental problems are becoming increasingly complex due to the rise of industrial activities, climate change, and massive ecosystem degradation. This condition requires the education system not only to focus on cognitive aspects, but also on the formation of ecological awareness from an early age. Environmental literacy is an important competency in facing 21st century challenges because it is related to individuals' ability to understand, evaluate, and act on environmental issues. Research in Indonesia shows that environmental literacy and context-based learning can improve elementary school students' environmental care attitudes, as found in a study by Fitriani, Kurnianti, and Hasanah (2023) which shows that science learning models based on the environment can significantly improve students' environmental literacy and environmental care character.

In Indonesia, environmental problems are increasingly evident, especially in regions with extractive industrial activities such as nickel mining. Konawe Regency, Southeast Sulawesi, is one of the areas experiencing ecological pressure due to these industrial activities. The impacts include water pollution, soil degradation, and changes in local ecosystems that affect community life. This condition shows that real environmental context is very important to be used as a learning resource in science learning, because context-based learning has been proven to improve students' understanding of environmental issues around them. This is supported by Fradina, Cahyono, and Sumarni (2022) who found that contextual-based IPAS learning can improve conceptual understanding and problem-solving skills of elementary school students.

Science learning in elementary schools has a strategic role in building scientific literacy and students' environmental awareness. However, in reality, learning is still predominantly theoretical and less connected to real-life situations. This causes students to have difficulty linking science concepts with environmental phenomena around them. A study by Dewi, Dantes, and Gunamantha (2023) shows that Contextual Teaching and Learning (CTL) based on ethnoscience can improve critical thinking skills and science learning outcomes of elementary school students because students are directly involved in meaningful learning experiences, so concepts are easier to understand and apply in daily life.

Environmental literacy is the ability of individuals to understand, analyze, and act responsibly toward environmental problems. This literacy includes not only knowledge, but also attitudes and behaviors that support environmental sustainability. This is supported by Solheri, Azhar, and Yohandri (2022) who found that the integration of ethnoscience based environmental literacy in science learning can improve conceptual understanding as well as shape students' environmental care attitudes through contextual and real problem-based learning.

One relevant approach to improving environmental literacy is eco-disaster literacy, which integrates ecological concepts with environmental disaster potential. This approach emphasizes the relationship between human activities and environmental damage risks. Research by Hurriyah, Lufri, and Asrizal (2023) shows that science learning integrated with natural disasters based on SETS can significantly improve students' disaster awareness and environmental literacy because learning is directly connected to real phenomena in the students' surrounding environment.

Eco disaster literacy based learning can also improve students' problem-solving skills. Students are trained to analyze environmental problems and formulate solutions based on real conditions. This is supported by Lestari and Winanto (2022)

who show that the implementation of Problem Based Learning can significantly improve elementary school students' problem-solving abilities because students are faced with contextual problems that encourage critical, analytical, and problem-solving skills in science learning.

To produce contextual and tested learning innovation, the Design-Based Research (DBR) approach is highly relevant. DBR is an iterative, collaborative, and real context based research approach. This is supported by Rahmawati, Masykuri, and Sarwanto (2021) who show that the development of design-based learning tools, such as discovery learning modules, can improve the quality of science learning because through development, testing, and repeated revision processes, it produces tools that are more valid, practical, and effective in improving students' critical thinking skills.

Based on the literature review, there are several research gaps that still need to be addressed. First, the development of eco-disaster literacy-based science learning models in elementary schools is still limited, so innovation is needed that integrates environmental issues and disaster potential in a contextual way. Second, there is still a lack of research that uses industrial mining areas as learning resources, even though the surrounding environment can be used as meaningful learning media. Third, the integration between environmental care attitudes and problem-solving skills in science learning is not yet optimal. Therefore, this study develops a science learning model based on eco-disaster literacy through a Design-Based Research approach to empirically and contextually address these gaps.

METHODS

This study uses a Design-Based Research (DBR) approach that is both developmental and evaluative in nature. DBR was chosen because it is able to produce contextual learning products that are iterative and based on real problems in the field. This approach does not only focus on testing theory, but also on developing practical solutions that can be applied in science learning in elementary schools. This is in line with McKenney and Reeves (2022), who state that DBR is a systematic approach that connects theory and practice through cycles of design, implementation, and repeated evaluation to produce effective learning innovations.

The subjects of this study were 40 fifth-grade students of SD Negeri 1 Laousu, Konawe Regency, Southeast Sulawesi. The selection of subjects was carried out purposively by considering the characteristics of the area located around a nickel mining industrial zone. These environmental conditions are relevant to the development of eco-disaster literacy in science learning because they provide a real context for students to understand the relationship between human activities and

their environmental impacts. Thus, students do not only receive abstract concepts, but also learn through phenomena occurring in their surrounding environment.

The DBR research stages consist of four main phases, namely analysis, design, implementation, and evaluation and reflection. In the analysis stage, environmental problems around the school are identified, along with analysis of student and teacher needs, and a review of the elementary science curriculum. This stage aims to determine competencies that are relevant to environmental literacy and problem-solving. The results of the analysis become the basis for designing learning tools that match student characteristics and the local environmental context so that learning becomes more meaningful and relevant to daily life.

In the design stage, learning tools were developed in the form of an eco-disaster literacy module, problem-based worksheets (LKPD), and learning evaluation instruments. These instruments include aspects of environmental care attitudes, knowledge, and students' problem-solving skills. Furthermore, the implementation stage is carried out through learning based on real environmental cases occurring around students. Learning activities include group discussions, simple experiments, and the integration of science content with local environmental phenomena to increase students' active engagement in the learning process.

The evaluation and reflection stage is conducted to test the effectiveness of the developed learning tools. The evaluation includes analysis of student learning outcomes, measurement of environmental care attitudes, and reflection on the learning process for improvement of the design in the next cycle. The data analysis techniques used include validity testing of the instruments using Aiken's V, practicality analysis based on learning implementation, and effectiveness testing using N-Gain and paired sample t-test to determine the improvement of learning outcomes before and after the implementation of the learning model.

RESULTS AND DISCUSSION

Results

1. **Analysis Stage**

   In the analysis stage, identification of environmental problems around the school, analysis of student and teacher needs, and a review of the elementary science curriculum were conducted. The results of the analysis showed that students still had a moderate level of environmental care, and their problem-solving skills were not yet optimal. In addition, ongoing science learning in the classroom was still theoretical and had not yet connected to local phenomena, particularly the impacts of nickel mining industrial activities in the surrounding

environment. This condition caused students to have difficulty linking science concepts with real-life situations. Based on these findings, the development of eco-disaster literacy-based learning tools that are contextual, interactive, and grounded in real environmental problems is needed.

Table 1. Results of Initial Needs Analysis of Students and Learning

Aspect Analyzed	Findings	Category	Development Implications
Environmental Care Attitudes	Most students show concern for the environment, but are not yet consistently involved in activities to maintain cleanliness and environmental sustainability at school.	Moderate	Strengthening environmental literacy is needed through learning activities that involve direct experience and reflection on environmental issues.
Problem-Solving Skills	Students still experience difficulties in analyzing and solving science problems related to environmental phenomena.	Low–Moderate	It is necessary to implement problem-based and project-based learning models that can train critical thinking and problem-solving skills.
Science Learning in Class	Learning is still dominated by theoretical concept delivery with limited connection to students' real-life experiences.	Not Contextual Enough	A contextual and experience-based learning approach is needed to improve meaningful concept understanding.
Integration of Local Environment	Learning materials have not accommodated local environmental issues, including the impacts of industrial activities in students' surrounding area.	Not Optimal	Development of eco-disaster literacy-based learning is needed to integrate local environmental issues into the learning process.
Teacher Needs	Teachers require innovative learning tools that are aligned with the local environmental context to support more effective learning.	High	Development of teaching modules, worksheets (LKPD), and project-based learning tools is needed to support the improvement of students' ecoliteracy.

The results of the analysis indicate that there is a gap between the current learning conditions and the demands of 21st-century learning. Students do not yet fully possess critical thinking skills and adequate environmental awareness. In addition, science learning has not yet integrated local context as a learning resource. Therefore, the development of eco-disaster literacy-based learning tools is highly relevant to bridge this gap through a more contextual and experience-based approach.

2. Design Stage

In the design stage, the development of eco-disaster literacy-based learning tools was carried out, consisting of a learning module, problem-based worksheets (LKPD), and assessment instruments covering environmental care attitudes, science knowledge, and students' problem-solving skills. The development of these learning tools was designed based on the results of the previous needs analysis so that learning could be more contextual, interactive, and relevant to the environmental conditions of students living around the mining industrial area.

After the learning tools were developed, validity testing was conducted by experts, including material experts, media experts, and language experts. This validation aimed to ensure that the learning tools were suitable for use in the classroom implementation process. The validation results showed that all components of the learning tools were in the very valid category, indicating that they could be used without major revisions in the field trial stage.

Table 2. Results of Learning Media Validation (Design Stage)

Assessed Aspect	Aiken's V Score	Category
Material	0.89	Very Valid
Media	0.87	Very Valid
Language	0.85	Very Valid

The results in Table 2 show that the material aspect obtained the highest score, 0.89, indicating that the content of the learning tools is in line with elementary school science competencies. The media aspect obtained a score of 0.87, indicating that the appearance and design of the learning tools are appropriate for classroom use. Meanwhile, the language aspect obtained a score of 0.85, indicating that the language used in the learning tools is appropriate for the cognitive development level of elementary school students.

Overall, the validation results show that the developed eco-disaster literacy-based learning tools have met the validity criteria and are suitable for use in the implementation stage. Thus, this learning product is ready to be tested in

real classroom learning to examine its practicality and effectiveness in improving students' environmental care attitudes and problem-solving skills.

3. Implementation Stage

The implementation stage was carried out by applying the eco-disaster literacy-based learning tools in fifth-grade science learning activities at elementary school level. Learning was conducted using a real environmental case-based approach that was relevant to the students' surrounding conditions, particularly issues related to the environment in the mining industrial area. In the learning process, students were actively involved through group discussions, simple experiments, and problem-solving activities related to everyday environmental phenomena.

During the implementation process, students' activities were observed to examine their engagement in learning. The observation results showed that students were active, enthusiastic, and able to work collaboratively in groups. In addition, students also began to be able to connect science concepts with real environmental phenomena they encountered in their surroundings. This indicates that eco-disaster literacy-based learning is able to create more meaningful and contextual learning experiences.

Table 3. Learning Practicality at the Implementation Stage

Indicator	Percentage	Category
Learning Implementation	92%	Very Good
Student Response	90%	Very Positive
Average	91%	Very Practical

The results in Table 3 show that learning implementation reached 92%, which is classified as very good. This indicates that the learning tools were implemented very well according to the lesson plan that had been prepared. In addition, students' responses to the learning reached 90%, which is in the very positive category. This indicates that students felt interested, motivated, and found it easier to understand science material through an environment-based and real-problem approach.

The results of the implementation stage show that the eco-disaster literacy-based learning tools are not only practical for teachers to use, but also able to increase students' active engagement in the learning process. Thus, this learning tool can be considered suitable to proceed to the evaluation stage to more deeply measure its effectiveness.

4. Evaluation Stage

The evaluation stage is the final stage in Design-Based Research (DBR), which aims to measure the effectiveness of the eco-disaster literacy-based learning tools that have been developed. Evaluation was conducted by administering pretests and posttests to students to measure improvements in environmental care attitudes and problem-solving skills. The collected data were then analyzed using N-Gain to determine learning gains and a paired sample t-test to examine the significance of differences before and after treatment.

The analysis results show that there was an improvement in both research variables, namely environmental care attitudes and problem-solving skills. This improvement indicates that eco-disaster literacy-based learning provides a more meaningful, contextual learning experience and encourages students to be more active in understanding and solving environmental problems around them.

Table 4. N-Gain Results (Learning Evaluation)

Variable	Pretest	Posttest	N-Gain	Category
Environmental Attitude	65	85	0.57	Medium
Problem-Solving Skills	60	88	0.70	High

The results in Table 4 show that environmental care attitudes increased with an N-Gain value of 0.57, which is in the medium category. Meanwhile, students' problem-solving skills showed a higher improvement with an N-Gain value of 0.70, which is in the high category. This indicates that the learning tools were more effective in improving students' higher-order thinking skills compared to attitude improvement, although both variables showed positive gains.

Table 5. t-Test Results (Paired Sample t-Test)

Variable	t-value	Sig. (p)
Environmental Attitude	6.12	0.000
Problem-Solving Skills	7.45	0.000

The results of the paired sample t-test in Table 5 show that the significance value for both variables is 0.000, which is less than 0.05. This indicates that there is a significant difference between pretest and posttest results in both research variables. Therefore, it can be concluded that the implementation of eco-disaster literacy-based learning is significantly effective in improving students' environmental care attitudes and problem-solving skills.

Overall, the results of the evaluation stage prove that the learning tools developed through the Design-Based Research approach are not only valid and practical, but also effective in improving the quality of students' learning outcomes in elementary science education.

5. Reflection Stage

The reflection stage is the final stage in the Design-Based Research cycle, which aims to comprehensively evaluate the effectiveness, strengths, and weaknesses of the eco-disaster literacy-based learning tools that have been implemented. Reflection is conducted based on classroom observation results, student learning outcomes, and students' responses during the learning process. The results of this reflection are used as the basis for improving the learning design in the next cycle so that it becomes more effective and adaptive to students' needs.

The reflection results show that the implementation of eco-disaster literacy-based learning is able to increase student engagement in science learning. Students become more active in group discussions, more enthusiastic in participating in learning activities, and more able to connect science concepts with real environmental problems around them. In addition, this learning approach also improves students' understanding of science concepts and their awareness of environmental issues, particularly those related to the impacts of human activities on the environment.

However, the reflection results also indicate several aspects that still need improvement, especially students' ability in reflective discussion and scientific argumentation. Some students are still not optimal in expressing critical and systematic opinions when asked to formulate solutions to environmental problems. Therefore, it is necessary to strengthen learning strategies that place greater emphasis on developing students' critical and reflective thinking skills.

Table 6. Reflection Results of the DBR Stage

Aspect Reflected	Findings	Category	Improvement Follow-up
Student Engagement	Students show active participation in discussions, group work, and project-based learning activities.	Good	Maintain and continue to encourage through varied collaborative activities.
Understanding of Science Concepts	Students' understanding of science concepts improved after participating in learning.	Good	Maintain by increasing exploration and scientific investigation activities.
Environmental Awareness	Students show higher concern for environmental issues around them.	Good	Improve through strengthening local environmental context and real environmental action activities.

Reflective Discussion Skills	Some students still experience difficulties in delivering scientific arguments logically and evidence-based.	Not Optimal	Strengthen reflective strategies, structured discussions, and scientific argumentation training.
Problem-Solving Skills	Students' problem-solving abilities improved, but have not yet reached optimal results across all indicators.	Fairly Good	Provide further practice through case studies and more complex environmental problems.

The results in Table 6 show that, in general, eco-disaster literacy-based learning has a positive impact on students' learning processes and outcomes. Aspects of student engagement, understanding of science concepts, and environmental awareness are in the good category, indicating that the developed learning model is effective in creating meaningful and contextual learning. However, weaknesses were still found in reflective discussion skills, which need to be improved through learning strategies that emphasize critical thinking skills, scientific argumentation, and systematic problem-solving.

Overall, these reflection results serve as an important basis for improving the Design-Based Research learning design so that in the next cycle the learning tools can become more effective, adaptive, and better able to enhance students' 21st-century skills.

Discussion

Eco-literacy-based learning in science shows an important role in improving students' critical thinking skills and environmental awareness. This is in line with the study by Pursitasari, Rubini, and Firdaus (2022) which found that interactive and contextual eco-literacy-based teaching materials are feasible to be used in science learning because they are able to improve students' critical thinking skills through the integration of real environmental issues into the learning process. In addition, Syafi'atun, Saptono, and Putra (2022) showed that the implementation of Project-Based Learning using household waste media can improve elementary students' eco-literacy through direct learning experiences that connect science content with daily life. Thus, these studies confirm that the integration of eco-literacy in science learning not only improves conceptual understanding but also develops environmental care attitudes and students' problem-solving skills in a more meaningful way.

At the design stage, the developed learning tools obtained a very valid category with an Aiken's V value of 0.85–0.89. This result indicates that the module,

worksheets (LKPD), and evaluation instruments are in accordance with the needs of science learning. This finding is consistent with Noviana et al. (2023) who explain that validation using Aiken's V is an important stage to ensure instrument feasibility before classroom implementation, especially in the development of environment-based teaching materials. Furthermore, Pursitasari, Rubini, and Firdaus (2022) emphasize that context based instructional design can improve the relevance of science materials to students' real life experiences and strengthen critical thinking skills. Therefore, the high validity scores indicate that the eco-disaster literacy based learning tools are ready to be effectively implemented in the learning process.

The implementation results show that learning implementation reached 92% with a very positive student response of 90%. This indicates that the learning tools are practical to be used in the classroom. This finding is in line with Ruswanto and Atmojo (2023) who found that context-based science learning related to environmental and disaster issues can increase students' active engagement through more meaningful and contextual learning approaches. In addition, Syafi'atun, Saptono, and Putra (2022) also showed that problem-based learning can improve students' collaborative activities and engagement through real-life learning experiences. Thus, eco-disaster literacy implementation is proven to create an active, interactive, and meaningful learning environment for elementary students.

The evaluation results show a significant increase in environmental care attitudes (N-Gain 0.57) and problem-solving skills (N-Gain 0.70). This improvement indicates that eco-disaster literacy-based learning is effective in enhancing both cognitive and affective aspects of students. This is consistent with Fetiana, Permanasari, and Permana (2022) who stated that students' environmental literacy can be improved through context-based science learning, thereby strengthening ecological awareness. In addition, Hidayat and Nuraini (2022) also showed that Problem-Based Learning can significantly improve students' higher-order thinking skills through contextual problem-solving activities. Therefore, the Design-Based Research approach has a positive impact on improving students' science learning outcomes.

The t-test results show a significance value of 0.000 (< 0.05) for both variables, indicating a significant difference between pretest and posttest results. This means that eco-disaster literacy-based learning has a strong influence on improving student learning outcomes. This finding is consistent with Rahayu, Sudarmin, and Dewi (2023) who stated that local wisdom-based science learning can improve students' critical thinking skills and engagement through learning that is closely related to real-life contexts. Furthermore, Puspitasari and Subali (2022) also found that the integration of local context in science learning significantly improves students' scientific literacy

because concepts are easier to understand through meaningful experiences. Thus, eco-disaster literacy-based learning has a significant effect on improving student learning outcomes.

The reflection stage shows that eco-disaster literacy-based learning can improve student engagement, science concept understanding, and environmental awareness. However, reflective discussion skills still need improvement. This is in line with Maulana and Fitriyani (2023) who found that students' reflective thinking skills in science learning still need to be strengthened through structured and discussion-oriented learning strategies. In addition, Hidayat and Nuraini (2022) also emphasized that although Problem-Based Learning can improve higher-order thinking skills, scientific argumentation and reflection remain challenges that must be continuously trained. Therefore, strengthening reflective learning strategies is essential to further enhance students' critical thinking skills.

Overall, the results of this study show that the eco-disaster literacy learning model based on Design-Based Research (DBR) is valid, practical, and effective in improving students' environmental care attitudes and problem-solving skills. This finding is consistent with Fetiana, Permanasari, and Permana (2022) who emphasized that environmental literacy in science learning can significantly enhance students' ecological awareness through context-based approaches. Furthermore, Pursitasari, Rubini, and Firdaus (2022) also showed that eco-literacy integration in science learning can improve students' critical thinking skills through interactive teaching materials based on real environmental issues. Therefore, this learning model is feasible to be used as an innovation in elementary science education because it significantly improves both the learning process and learning outcomes.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the eco-disaster literacy learning model based on Design-Based Research (DBR) has been proven to be valid, practical, and effective in improving elementary school students' environmental care attitudes and problem-solving skills. The validity of the learning tools is categorized as very valid based on expert judgment, while practicality is indicated by high learning implementation and very positive student responses.

In terms of effectiveness, there was a significant improvement in both environmental care attitudes and problem-solving skills, as shown by N-Gain scores in the medium to high category and t-test results indicating a significant difference between pretest and posttest scores. In addition, this model was able to enhance

students' active engagement, science concept understanding, and awareness of local environmental issues relevant to mining industrial areas.

Students reflective discussion skills still need to be improved through strengthening learning strategies that emphasize scientific argumentation and reflection. Therefore, this learning model is suitable to be used as an innovation in elementary science learning because it is able to integrate cognitive, affective, and 21st-century skills in a balanced and contextual manner.

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