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# Developing an e-student worksheet on natural disasters to train elementary school students' scientific reasoning and environmental sensitivity

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4D; scientific reasoning; environmental sensitivity; natural disasters

**Abstract**

An understanding of natural disasters that may occur in the environment around students is expected to facilitate their scientific reasoning by enabling them to explain natural phenomena using knowledge. This study aims to test the effectiveness of Science Student Worksheets on natural disasters in improving scientific reasoning skills and environmental sensitivity among fifth-grade Elementary School students. The research method used is the 4D Research & Development model. The results of the study show that the developed product is valid, effective, and practical in improving scientific reasoning skills and environmental sensitivity. The digital platform is an effective solution for 21st-century learning that focuses on enhancing high-level thinking skills and utilising digital learning technology.

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## 1. Introduction

As a country with a high risk of natural disasters (Suarmika et al., 2022), students need to understand the natural disasters in their environment. Knowledge about disasters is also related to mitigation measures. Disaster mitigation knowledge also includes elements of environmental awareness. Science learning is a way to practice scientific reasoning and ecological sensitivity. Science learning in elementary schools aims to develop science skills, understand scientific concepts, and shape attitudes based on learned values (Anggriani et al., 2024). Understanding natural disasters that may occur in students' environments is expected to facilitate their scientific reasoning by enabling them to explain natural phenomena using knowledge. Scientific reasoning, in

terms of seeking explanations to gain insight into a phenomenon, is related to the construction of models (Belzen et al., 2021).

The 2022 PISA results show that the majority of Indonesian students' abilities in the natural sciences are at level 1 (OECD, 2023). This means that students' ability to explain natural phenomena using scientific principles remains limited to simple phenomena, with complete instructions and direct observation. They still struggle to explain phenomena that require higher-level analytical thinking, such as reasoning. This fact suggests that students' scientific reasoning skills remain low (Harangus & Katai, 2020; Li et al., 2020; Nouri et al., 2020; Zulkipli et al., 2020; Cavojova et al., 2022). This condition results from the science learning process in schools, which remains far from the essence of science, and from limited teaching materials that specifically train specific thinking skills (Kaffa & Miaz, 2022; Syaidah & Faizah, 2021).

In elementary schools, many innovations have been introduced in science instruction, including problem-based learning. This model is widely recommended for use in improving students' science skills (Suryawati et al., 2020; Erlangga et al., 2020; Akhdinirwanto et al., 2020). However, obstacles to implementing this learning are still often encountered, one of which is the use of teaching materials that fail to stimulate students' independent thinking, especially in scientific reasoning. Several other studies suggest the use of technology in science learning (Wahyuni et al., 2022; Sari et al., 2022; Suarmika et al., 2023; Hidayat et al., 2023). The technology used in this learning is the e-Student Worksheet.

The natural disaster-themed e-worksheet developed in this study emphasises the use of natural disaster themes and electronic-based presentations to train students' scientific reasoning and to preserve environmentally sensitive characters. Learning from factual events close to students has been shown to make it easier for them to understand the concepts. In addition, the technology-based presentation of the Student Worksheet makes it easier for students to describe natural phenomena they may have never seen firsthand. Thus, the advantage of the Student Worksheet developed in this study is that, through phenomena presented in electronic form, ordinary students can easily train their scientific reasoning to explain how the phenomena occur based on their existing scientific knowledge or concepts.

Although various e-LKPD have been developed, studies that specifically integrate contextual natural disaster themes into digital platforms to simultaneously train scientific reasoning and environmental sensitivity among elementary students remain limited. The research questions proposed are as follows: a) How is the validity and reliability of the e-Student Worksheet on the theme of natural disasters that has been prepared? b) How are students' scientific reasoning abilities after using the e-Student Worksheet on the theme of natural disasters that has been prepared? and c) How is the environmental sensitivity of students after learning using the e-Student Worksheet on the theme of natural disasters that has been prepared?

## 2. Method

The effectiveness test of the e-worksheet product for students was conducted at three elementary schools: Nurul Anshar Integrated Islamic Elementary School, Dawuhan 6 Elementary School, and Dawuhan 4 Elementary School. These schools are located in Situbondo, East Java. The research subjects were fifth-grade students.

This research is a development research with a 4D model (Define, Design, Develop, and Disseminate), with a research flow as shown in Figure 1. Development research is an effort to produce a learning product, namely learning tools (Parinduri et al., 2025; Simorangkir et al., 2025).


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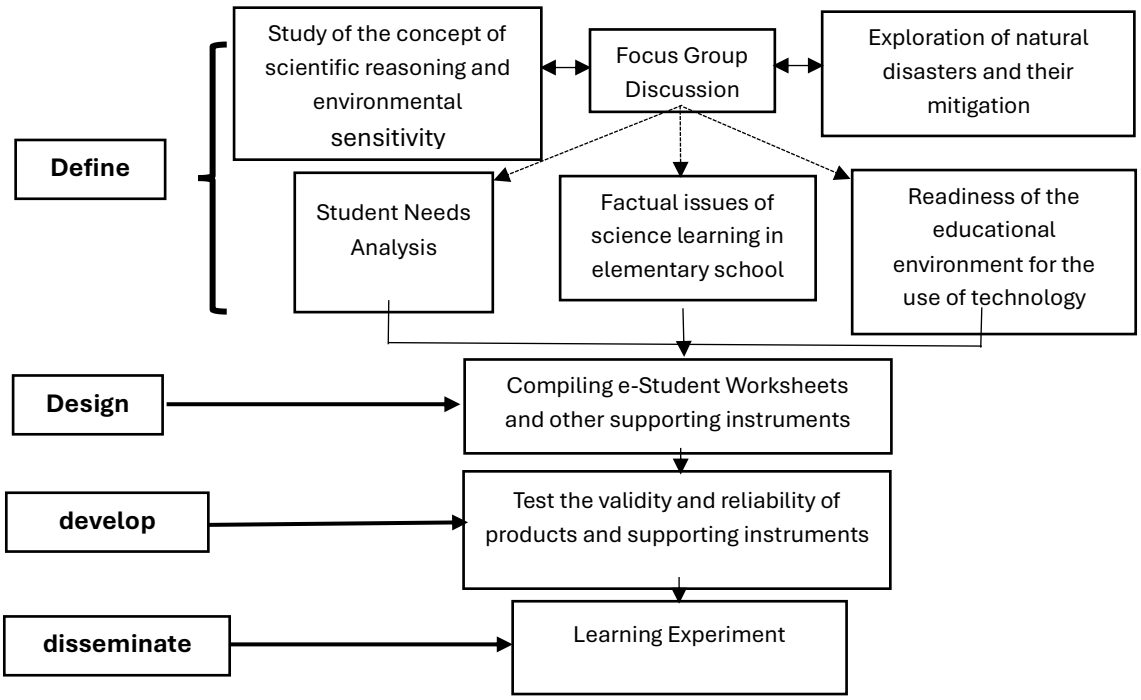


Figure 1. Research flowchart

The steps taken for each stage are explained as follows:

a. Define includes an analysis of student needs, the characteristics of scientific reasoning, an exploration of natural disasters in Indonesia and their mitigation, and other aspects required in preparing electronic student worksheets.
b. Design includes the preparation of e-Student Worksheets based on the results of data analysis in the previous stage and other supporting instruments, such as validation sheets and reliability test tools, scientific reasoning test sheets, and open-ended questionnaire sheets to determine students' environmental sensitivity after learning using the e-Student Worksheets that have been prepared.
c. Development includes validity testing and reliability testing of the e-Student Worksheet product that has been prepared along with its supporting instruments. Validation of the e-Student Worksheets was conducted by science learning, language, and electronic learning media experts. The scientific reasoning and environmental sensitivity tests were tested for validity and reliability using product-moment correlation and Cronbach's alpha.
d. Dissemination/implementation: includes a learning experiment to determine the effectiveness of using e-Student Worksheets through the test results on students' scientific reasoning skills and environmental sensitivity after learning using the prepared e-Student Worksheets. The effectiveness test used a quasi-experimental design with a non-equivalent pretest-posttest. Meanwhile, to observe improvements in scientific reasoning and environmental sensitivity, a normalised gain (N-gain) test was used.

## 3. Results

### 3.1 Defining stage

This activity began with direct observation at partner schools to obtain a clear picture of learning conditions, infrastructure, and the readiness of teachers and students to integrate digital-based learning media. During the observation, the research objective was clearly conveyed: to develop an e-Student Worksheet-based learning tool that supports student competency achievement while increasing their active engagement in the learning process. We also communicated follow-up actions with the school, particularly regarding implementation stages, product trials, and partner collaboration. After completing the series of observations and initial discussions with the school, the next step was to hold a Focus Group Discussion (FGD).

The next stage involves the FGD with participants, including the principal and 5th-grade teachers of the elementary school where the research was conducted, as well as alumni, students, and lecturers from the Primary Teacher Education Study Program at Abdurachman Saleh University, Situbondo. This activity involved three resource persons accompanying the researcher. The results of this FGD can be formulated essential points as a basis for designing e-Student Worksheets with a disaster theme to improve scientific reasoning and environmental sensitivity: 1) the material in the e-Student Worksheets is adjusted to learning outcomes; 2) the instructions for the e-Student Worksheets are easy and can be understood by students and teachers; 3) hands-on activities are prioritised; and 4) assessment (scientific reasoning and environmental sensitivity) in the form of descriptions.


Figure 2. FGD activities

### 3.2 Designing stage

The subsequent stage is to design e-Student Worksheets based on the results of the needs analysis, 1) Grade V science learning outcomes related to disasters, the relationship between biotic and abiotic components and their effects on the ecosystem, the water cycle and its relationship to efforts to maintain water availability, Utilization of alternative energy sources from surrounding resources as an effort to mitigate climate change, 2) Contextual disaster themes (adapted to Situbondo conditions); and 3) Essay-based question formats (scientific reasoning and environmental sensitivity).

The indicators of scientific reasoning achievement used are 1) problem identification (recognising, identifying problems in depth including indications of emerging variables that influence them), 2) making hypotheses (building possible answers to a question in accordance with scientific standards based on known models, frameworks, or evidence), 3) conducting experiments

(testing the proposed hypothesis), and 4) making conclusions (analysing experimental data to establish logical relationships between variables).

Meanwhile, to measure the achievement of students' environmental sensitivity, the following indicators are used 1) knowing the impact of human behaviour on the environment (students can explain the effects of pollution, deforestation, waste plastic, global warming), 2) understanding the concept of environmental conservation (students understand the 3R principles (reduce, reuse, recycle), water and energy conservation, and reforestation), 3) understanding the reciprocal relationship between humans and the environment (students can explain that environmental damage has an impact on human health and quality of life), and 4) recognising the potential and problems of the surrounding environment.

### 3.3 Development stage

This stage refines the student e-Worksheet's initial design. This product uses the lkpdsd.com domain to prioritise ease of use (adapted for elementary students). The material covers the types and potential of disasters in Situbondo, as well as national disasters correlated with science learning. The student e-Worksheet consists of 32 descriptive questions to measure the level of scientific reasoning skills and environmental sensitivity, with the following steps for use.

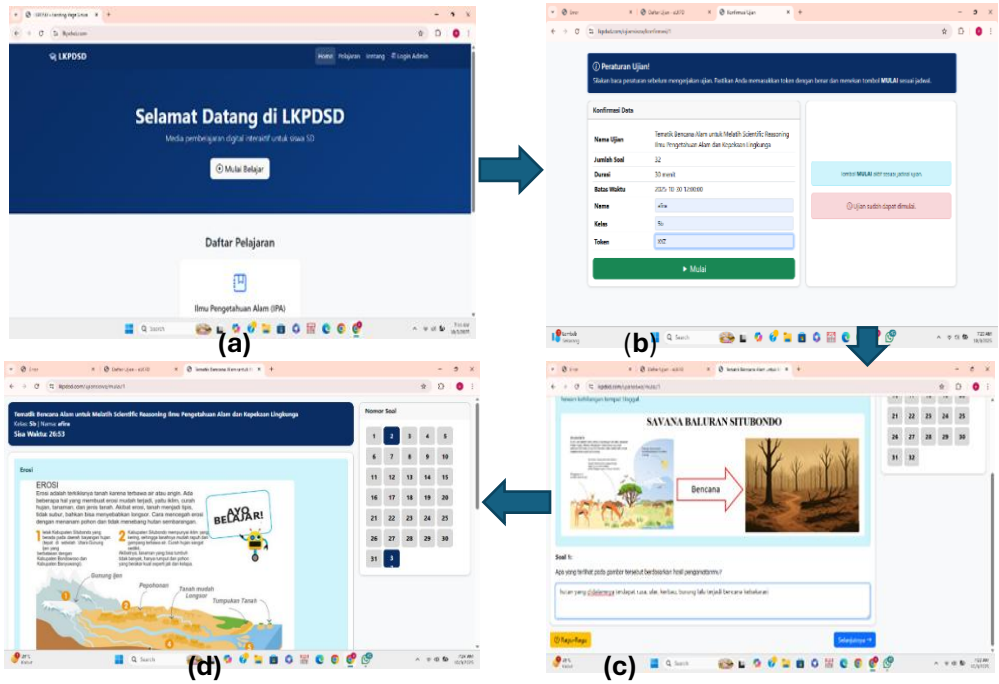


Figure 3. Steps for using e-student worksheets

#### 3.3.1 Open menu

Here you will find the title and a brief explanation of the e-Student Worksheet. Students can proceed directly to the next step by clicking "*Ikuti Ujian*".

#### 3.3.2 Registration menu

This menu displays instructions for completing the exam, including the exam name, number of questions, duration, deadline, student name, class, and token. Students must fill in the blanks to proceed to the next step.

### 3.3.3 Solving the problem

The menu in this section is the core component of the Student Worksheet, which contains material and images about natural disasters and questions that students answer by typing their responses into the answer menu. Students' answers are recorded after pressing Enter until all questions have been answered. The administrator saves the answers for assessment.

### 3.3.4 Log out

After students have answered all questions, the final stage is to exit the e-Student Worksheet menu.

To ensure the product's suitability, the student e-Worksheet was tested by experts. The aspects tested included language, learning content, and technology. The experts included those in Indonesian language education, elementary science education, and learning media. To validate the product, a validation sheet was used by converting the average score to the ideal reference assessment category. To determine the score category, first calculate the Ideal Mean (Mi) = ½ x (*Ideal maximum score* + *Ideal minimum score*) and the Ideal Standard Deviation (SDi) = 1/6 x (*Ideal maximum score – Ideal minimum score*). The calculated score is adjusted according to the number of statement items.

**Table 1.** Theoretical ideal reference assessment category

| No | Categories | Criteria |
|---|---|---|
| 1 | Mi + 1,5SDi - Mi+3SDi | Very suitable |
| 2 | Mi + 0,5SDi - Mi+1,5SDi | Suitable |
| 3 | Mi -0,5SDi - Mi+0,5SDi | Quite suitable |
| 4 | Mi -1,5SDi - Mi-0,5SDi | Not suitable |
| 5 | Mi -3SDi - Mi-1,5SDi | Very unsuitable |

The feasibility test by the language validator at Malang State University uses a validation sheet covering aspects of language use, communicativeness, and the usability of the Student Worksheet e-sheet. The validation sheet contains 10 statements, divided into three aspects. The minimum total score is 10, and the maximum total score is 50. Mi is 30, and SDi is 6.7. Therefore, the score range for the very feasible category is 39.6-50; the feasible score range is 33.35-39.59; the quite feasible score range is 26.65-33.34; the not feasible score range is 19.95-26.65; and the very inadequate score range is 10-19.94. The feasibility test results from the validator yield a total score of 40 (5 out of 5 statements and 4 out of 5), which places it in the very suitable category. This means that, from a linguistic perspective, the e-Student Worksheet is ideal for use with elementary school students.

As regards the aspect of science learning materials related to the variables measured, namely scientific reasoning and environmental sensitivity, it uses experts or validators in the field of science learning from the State University of Malang. The validation sheet consists of 15 statements with indicators: the relevance of the material to the curriculum; the feasibility of the content, language, and assessment; the significance of the material to Scientific Reasoning and Environmental Sensitivity; the feasibility of implementation; and the feasibility of evaluation. The maximum score is 75, and the minimum total score is 15. The ideal mean (Mi) is 45, and the Ideal Standard Deviation (SDi) is 10. The score range for the very suitable criteria is 60-75; suitable with a score range of 50-59.9; quite suitable with a score range of 35-49.9; the category of not ideal with a score range of 30-34.9; and the category of very unsuitable with a score range of 15-29.9. Based on the validation sheet


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analysis by material experts, a total score of 67 was obtained (7 items are very feasible and eight are viable), indicating it falls in the very feasible category.

The feasibility test of the media aspect uses a validator or expert in Information Technology-based learning media from the State University of Malang. To determine feasibility, a validation sheet containing 13 statements on product appearance, product quality, and product usability is used. Based on the analysis results, the maximum score is 65, and the minimum score is 13, with an Ideal Mean (Mi) of 39 and an ideal standard deviation (SDi) of 8.7. While the score range for the very suitable category is 52.05-65, the appropriate category with a score range of 43.35-52.04, the reasonably feasible category with a score range of 34.65-43.34, the score range of 25.95-34.54 is included in the not suitable category, and the very unsuitable category is in the score range of 15-29.94. Based on expert assessment, a total score of 59 is obtained, placing it in the very feasible category for the media aspect. This means that the e-Student Worksheet, given its quality of IT-based learning media, is very suitable for elementary school students in science learning.

The dependent variable in this study is scientific reasoning and environmental sensitivity, measured using a descriptive test instrument. To determine the instrument's accuracy and consistency, empirical tests were conducted, namely, validity and reliability tests. The validity and reliability test of the instrument used a sample of 76 sixth-grade students from SDIT Nurul Anshar, assuming that the students had received the material in fifth grade. The test consisted of 16 questions to measure scientific reasoning skills and 16 questions to measure environmental sensitivity. Data analysis for both tests used Microsoft Excel 2013, with the research results for all valid test items (r-count) greater than the r-table (≥ 0.2287 with DF = 76 at a significance level of 5%). The reliability test using Cronbach's Alpha yielded a coefficient of 0.8, which falls within the firm category.

To ensure that the e-Student Worksheet on natural disasters trains scientific reasoning and environmental sensitivity, a readability test was conducted. The readability test used a questionnaire administered to a sample of three teachers and 30 sixth-grade elementary school students, consisting of 16 statements to measure aspects of construction, technical content, material content, and presentation. The results of the readability test analysis from technical aspects (accuracy in the use of language, student abilities in activities, and having complete objectives and identities), technical (writing, use of supporting images, colour display, and attractiveness of the display), as well as material content and presentation (completeness of material, presentation techniques, arousing learning motivation and improving learning outcomes) showed the very appropriate category.

### 3.4 Dissemination/Implementation Stage

The final stage of product finalisation is the effectiveness test. This test is used to measure 1) the effect of the natural disaster-themed e-Student Worksheet on scientific reasoning skills and environmental sensitivity (t-test), and 2) the improvement in scientific reasoning skills and environmental sensitivity (normalised gain test).

Table 2. N-Gain category

| Range of values | Categories |
|---|---|
| >0.7 | High |
| 0.3-0.7 | Medium |
| <0.3 | Low |

The selected sample consists of two experimental and one control group, using the simple random sampling technique.

Table 3. Sample distribution

| Schools | Classes | Number of students | Groups |
|---|---|---|---|
| SDN 6 Dawuhan | 5 | 22 | Experiment |
| SDN 4 Dawuhan | 5 | 31 | Experiment |
| | 5 Tahfidz | 21 | Experiment |
| SDIT Nurul Anzhar | 5 A | 32 | Control |
| | 5 B | 32 | Control |

### 3.4.1 e- Student Worksheet on Scientific Reasoning Ability

The testing was conducted using pre-tests and post-tests with descriptive questions. The summary of the data analysis is presented in the following table.

Table 4. Analysis of pre-test and post-test data for scientific reasoning

| Groups | Measure | Treatments | | |
|---|---|---|---|---|
| | | Pre-test | Post-test | Difference (gain) |
| Experiment | N | 74 | 74 | - |
| | Minimum value | 16 | 32 | 16 |
| | Maximum value | 30 | 48 | 18 |
| | Mean | 23.68 | 40.75 | 17.07 |
| | Standard deviation | 3.23 | 4.21 | 5.313 |
| Control | N | 64 | 64 | - |
| | Minimum value | 16 | 27 | 11 |
| | Maximum value | 28 | 38 | 10 |
| | Mean | 20.96 | 32.79 | 11,83 |
| | Standard deviation | 4.13 | 2.76 | 4.965 |

Table 5. t-test for equality of means

| | F | Sig. | t | df | Sig.(2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|
| Equal variances assumed | .031 | .860 | 5.954 | 136 | .000 | 5.239 | .880 | 3.499 | 6.980 |

Based on Table 4, it is seen that there is an increase in scientific reasoning skills (in the experimental group) by using the e-Student Worksheet for fifth-grade students. The ideal maximum score is 48 (16 questions, utilising a score criterion of three for correct and comprehensive answers, two for less correct answers, and one for incorrect answers). The N-gain score is 0.73 in the high category. It can be concluded that the e-Student Worksheet on natural disasters is highly effective in improving scientific reasoning skills. Table 5 presents that there is a significant difference in scientific reasoning skills between those who use the e-Student Worksheet and those without the e-Student Worksheet (sig. 0.000). This means that the development of the e-Student Worksheet is proven to be valid, practical, and effective in improving scientific reasoning skills in science subjects for fifth-grade elementary school students.


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### 3.4.2 e- Student Worksheet on Environmental Sensitivity

The testing was conducted using pre-tests and post-tests with descriptive questions. The summary of the data analysis is presented in the following table.

Table 6. Analysis of pre-test and post-test data for environmental sensitivity attitude

| Groups | Measure | Treatments | | |
|---|---|---|---|---|
| | | Pre-test | Post-test | Difference (gain) |
| Experiment | N | 74 | 74 | - |
| | Minimum value | 16 | 31 | 16 |
| | Maximum value | 24 | 46 | 22 |
| | Mean | 18.25 | 35.32 | 17.27 |
| | Standard deviation | 2.684 | 3.655 | 0.971 |
| Control | N | 64 | 64 | - |
| | Minimum value | 18 | 28 | 3 |
| | Maximum value | 27 | 40 | 21 |
| | Mean | 22.15 | 33.95 | 11.83 |
| | Standard deviation | 2.27 | 3.78 | 4.541 |

Table 7. T-test for equality of means

| | F | Sig. | t | df | Sig.(2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|
| Equal variances assumed | 98.407 | .000 | 15.743 | 136 | .000 | 8.523 | .541 | 7.453 | 9.594 |

Table 6 describes that there is an increase in environmental sensitivity attitude (in the experimental group) by using the e-Student Worksheet for fifth-grade students. The ideal maximum score is 48 (16 questions utilising a score criterion of three for correct and comprehensive answers, two for less correct answers, and one for incorrect answers). The N-gain score is 0.573, placing it in the moderate category. As such, the use of the e-Student Worksheet on natural disasters is effective in increasing environmental sensitivity, but some students may still benefit from further development, such as improved learning methods or additional support. Table 7 displays that there is a significant difference in ecological sensitivity attitude between those who use the e-Student Worksheet and those without the e-Student Worksheet (sig. 0.000). This implies that the development of the e-Student Worksheet is proven to be valid, practical, and effective in environmental sensitivity attitude in science subjects for fifth-grade elementary school students.

## 4 Discussion

This study demonstrates that the e-Student Worksheet (e-LKPD), a learning tool with a natural disaster theme, is highly effective in science education. e-LKPD helps students develop problem-solving and literacy skills in learning (Winarto et al., 2025). The use of virtual media in learning stimulates curiosity, increases motivation, and improves learning outcomes (Mitrakas & Tsihouridis, 2026). The flexible and adaptive nature of e-LKPD allows students to learn independently and at their own pace (Wiratama et al., 2025). This indicates that combining real and virtual media can significantly impact the science learning process.


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Incorporating natural disasters into science learning can provide knowledge about the importance of disaster risk reduction. Disaster risk reduction can be effectively implemented or integrated into both formal and non-formal learning contexts. Disaster risk reduction by directly involving vulnerable groups (elementary school students) provides benefits such as learning about disasters, understanding pre-disaster measures, understanding the process of self-rescue during a disaster, and direct involvement in emergency response (Suarmika et al., 2025). This is crucial for improving student preparedness. This level of readiness includes knowledge of disaster threats, direct experience with disasters, and safety measures for responding to them (Ronggowulan et al., 2025).

The research findings indicate that students' scientific reasoning skills improve when using e-Student Worksheets. Scientific reasoning is a valuable and desirable skill for gaining a deeper understanding of science at all grade levels (Orhan & Demirhan, 2025). Scientific reasoning consists of the ability to identify conclusive experiments, interpret simple data patterns, and articulate emerging epistemic understandings about the nature of science (Koerber & Osterhaus, 2019; Osterhaus & Koerber, 2023).

Environmental sensitivity of the present study's variable also increased. The normalised gain calculation results were in the moderate category. This implies that numerous students have not yet fully grasped environmental sensitivity. This is due to the lack of specific ecological learning (Budiono et al., 2024) and innovation in environmental teaching (Maharani & Swandayani, 2025). Ecological issues are crucial for sustainable development. The use of digital media in learning can improve students' knowledge and attitudes toward the environment, as well as their decision-making skills regarding the consequences of environmental change (Chuang et al., 2025). Environmental education is crucial for understanding changes in students' attitudes and perceptions regarding the ecological impacts of climate change (Baek, 2023).

## 5 Conclusion and implications

The e-Student Worksheet product, with the theme of natural disasters as a science learning tool, significantly improves fifth-grade students' scientific reasoning skills and their attitudes toward environmental sensitivity. The results of the feasibility and effectiveness test of the product are very suitable for application in elementary school learning. The use of electronic media in education can foster students' curiosity, especially about disasters they have not experienced or environmental damage. Digital platforms are a practical solution in 21st-century learning, focusing on higher-order thinking and utilising digital learning technologies.

These findings imply that the use of virtual learning tools improves students' science learning outcomes. In the future, integrating virtual learning with reality (contextual) is essential in designing learning tools. The advantages of using electronic tools are that they are more efficient than physical or authentic media, easy to use, and require much space (a computer or smartphone is sufficient).

## 6 Limitation

The research limitations focused on a single electronic learning device (Student Worksheet) for science learning. The variables measured were related to skills and attitudes that correlated with science learning outcomes. In the future, it is necessary to develop electronic learning devices such as teaching modules and formative assessments for other subjects in elementary schools. Dissemination of the developed product is still on a small scale, so it needs to be expanded.


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**Credit authorship contribution statement**
**Putu Eka Suarmika**: Methodology, Formal analysis, Data curation, Conceptualisation. **Nuris Hidayat**: Resources, Project Administration, Methodology. **Mufarrahatus Syarifah**: Resources, Project Administration, Methodology. **Afira**: Funding acquisition, Formal analysis, Data curation. **Nurul Arifa**: Funding acquisition, Formal analysis, Data curation

**Declaration of competing interest**
The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

**Ethical Declaration**
All participants provided informed consent before their involvement in the study. They were informed about the study's purpose, procedures, and their right to withdraw at any time without consequence.

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