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Designing Pirposal-learning based Module integrated with Socio-Scientific Issue to Enhance Students' Scientific Reasoning Skill

Kiki Septaria[1*], Atika Fatharani[1], Binar Ayu Dewanti[1], Wilda Choiryn Najawa[1]
[1] Science Education Department, Faculty of Teacher Training ang Education, Lamongan Islamic University, Indonesia

[*]E-mail: kikiseptaria@unisla.ac.id

Abstract

The purpose of this study is to explain the development of a Pirposal-learning based module that integrates with Socio-Scientific Issue (SSI) to enhance students' scientific reasoning skill. This study is included in a mix method research, using Borg and Gall development and one group pretest and posttest design. Experts validate the development process, and its efficacy is measured using pre-test and post-test question sheets. Findings of the development of the learning module reached a validation score that was classified as very feasible; the results of the implementation of the learning module were seen through the realization of learning that was carried out very well, an increase in the average N-Gain of student scores, which the N-Gain was obtained by 0.701 with a high category. Furthermore, the results of calculations using the paired sample t-test show that the designed learning module considerably improves students' scientific reasoning skill. Based on the findings, it is possible to infer that the Pirposal-learning based module that integrates with Socio-Scientific Issue (SSI) is an excellent learning media for training junior high school students in scientific reasoning skill.

Keywords: module, pirposal learning scientific reasoning, socio scientific issue,

INTRODUCTION

Scientists analyze unexpected occurrences. The results of these investigations are subsequently applied to a wide range of human circumstances (Edi Supartawan et al., 2021; Safirah et al., 2022). Natural catastrophes that have happened and are examined in scientific education include disasters caused by both nature and human, such as earthquakes, volcanic eruptions, floods, and Covid-19, which have affected the whole planet (Johan et al., 2021; Miftahul Jannah et al., 2022; Yari, 2021). The entire territory of Indonesia has the potential to experience various disasters with numerous differences, so this disaster phenomenon has become a scientific issue in society (Socio-scientific Issue), which is concerning because no one knows when or where it will occur, so mitigation education must begin as soon as possible in society (Nida et al., 2020; Putriana, 2020; Schenk et al., 2021; Sutopo, 2022).

Due to the necessity of disaster education as early as possible in the community, the Indonesian government legislated disaster education in the independent curriculum, one of which is at the junior high school level, particularly in the science subject for seventh grade (Johan et al., 2021; Prastyo et al., 2021;

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Sari & Apriyantika, 2020). Schools, being areas where teaching and learning take place, have the potential to be affected by disasters on a small to large scale, posing a risk to children who may suffer injuries or even die.

The school must reduce the possibility of catastrophes in the school environment as much as possible, not only by employing disaster education materials but also by enhancing understanding and disaster readiness for all elements in the school, including students (Genika et al., 2023; Puspaningrum, 2022; Zahara, 2019). According to the findings of interviews with teachers at Junior High School 2 Lamongan, disaster mitigation learning was taught using presentation techniques, such as the display of disaster images, rather than directly engaging in disaster mitigation experiments, practices, or simulations. Furthermore, the teaching process of disaster-related topics has traditionally focused exclusively on the biological aspects, overlooking the critical integration of other scientific disciplines. Teachers concentrate on the biological impacts of disasters, such as the effects on ecosystems, human health, and biodiversity. However, this approach neglects the comprehensive science learning process that should interconnect biology with physics, chemistry, and other relevant fields. For instance, understanding the physics of earthquakes, the chemistry of atmospheric changes during volcanic eruptions, and the technological and environmental aspects of disaster mitigation are all crucial for a well-rounded education on disaster topics. This narrow focus limits students' holistic understanding of disasters and their ability to apply interdisciplinary scientific reasoning to real-world problems. This has been confirmed by observations made on teaching modules prepared by instructors, which did not include learning models that improve understanding of information and disaster practices or simulations in disaster mitigation learning objectives.

Furthermore, the results of observations show that learning about disaster mitigation at Junior High School 2 Lamongan during three learning meetings failed to provide students with the opportunity to practice scientific reasoning. This finding can be witnessed by the absence of opportunities for questions and answers in learning; no students ask questions, and no students answer questions from fellow students or teachers. In fact, reasoning abilities are one of the most important skills in the twenty-first century. Reasoning skills are capable of helping someone explain knowledge clearly and scientifically to others, which may be done both orally and nonverbally (Akili et al., 2022; Devy et al., 2020; Sánchez et al., 2021).

The lack of disaster learning at State Junior High School 2 Lamongan is based on the fact that there has never been a development of learning planning or teaching modules that integrate scientific understanding of disaster content and disaster practice or simulation, supported by the absence of analysis of potential disasters that may occur in schools, so that the development of teaching modules that

integrate cognitive content and practice oe simulation that can be facilitate.

The Pirposal learning model is a learning model developed from STEAM-based learning (science, technology, engineering, art, and mathematics), which focuses on cognitive understanding and practice or simulation so that students not only understand the concepts taught but also provide skills in mitigation practices according to the topics taught (Anggereini et al., 2023; Harris & de Bruin, 2018; Teo et al., 2021; Wells, 2016). The Pirposal learning model contains eight forms of syntax: (1) issue identification; (2) formulating ideas; (3) doing research; and (4) formulating viable solutions. (5) Experimental optimization; (6) Evaluation of solutions; (7) Change; and (8) Learning outcomes (Wells, 2016). It is envisaged that by using this Pirposal learning model syntax, students would actively learn to understand catastrophe concepts, do disaster practices/simulations, and give alternative disaster mitigation methods in an appropriate and right manner using scientifically constructed arguments.

This study aims to describe the development and implementation of a Learning Module based on the Pirposal Learning Model, which integrates Socio-Scientific Issue (SSI) disasters to enhance the scientific reasoning students of junior high school students. By leveraging real-world disaster scenarios, the module fosters critical thinking and problem-solving skills, encouraging students to engage deeply with scientific concepts and their applications. The innovative approach combines theoretical knowledge with practical, issue-based learning, aiming to create a dynamic educational experience that not only bolsters students' scientific reasoning but also raises their awareness and understanding of socio-scientific issues. This module seeks to bridge the gap between face-to-face science education and contemporary societal challenges, preparing students to apply their scientific knowledge in meaningful and impactful ways.

As a result, this study provides a solution to schools through the development of teaching materials based on the integrated Socio-Scientific Issue (SSI) disaster conceptual learning model to train students' scientific reasoning skill so that students have good and correct cognitive abilities and disaster mitigation skills and are able to educate the larger community through good scientific arguments.

METHOD

The research and development method used in this study follows the Borg & Gall model, known for its systematic approach to educational research (Jamaluddin et al., 2020). This method incorporates ten distinct steps: research and information gathering, planning, preliminary product development, preliminary field testing, main product revision, main field testing, operational product revision, operational field testing, final product revision, and dissemination and implementation (Alfiah et al., 2018; Amaliyah et al., 2021).

To enhance the accuracy of the study,

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a mix method approach is employed, combining qualitative insights with quantitative rigor. Specifically, a one-group pretest and posttest design is used to quantitatively measure the effectiveness of the developed teaching materials. This mixed-method approach allows for a comprehensive evaluation of the learning module, ensuring its efficacy in training junior high school students' scientific reasoning abilities (Utami et al., 2020). The flow of Borg and Gall method follows Figure 1.

technique used a purposive random sampling technique by looking at the normality and homogeneity of students and recommendations from the school.

In the fifth phase, data was collected via a survey. The study team was aided by three validators (expert validators, media, and language) in validating the viability of the produced teaching module, as well as test methodologies (pretest at stage 10 and post-test at stage 12). Furthermore, the collected data was examined utilizing validation feasibility criteria, precondition

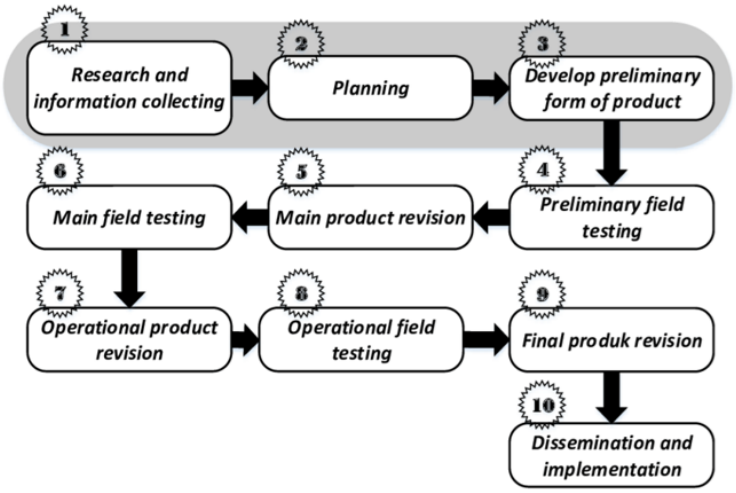

Figure 1. Research Flow adapted from the Borg & Gall method.

This study was conducted at State Junior High School 2 Lamongan. This school was chosen because of its potential for disasters that occur not only from earthquakes but also other disasters such as floods and fires because it is located in a densely populated area. The subjects of this study were 50 students in grade VII, but at the trial stage (Trial 1 and 2 at stages 6 and 8), only 20% of the student population was used, and then at the pre-test, implementation, and post-test stages, 100% of the student population was used. The trial sample determination

tests (normality, homogeneity), and T-tests. The efficacy of this training module is determined by the outcomes of the pre-test and post-test, which will then be examined for improvement using N-Gain with the following criteria in table 1.

Table 1. N-Gain Score Criteria

Score	Criteria
$0.0 < g \leq 0.3$	Low
$0.3 < g \leq 0.4$	Medium
$0.7 < g \leq 1.0$	High

The instruction module based on the pirposal learning model for training students' scientific reasoning is considered

effective if students reach a gain score of $0.0 < (\langle g \rangle) \leq 1.0$.

RESULT AND DISCUSSION

This teaching module development intends to address the demands of the teaching and learning process that has not yet been implemented at junior high school 2 Lamongan, by integrating comprehension of catastrophe material and disaster simulation procedures. This study and development resulted in a Teaching Module based on the Pirposal Learning Model, which was combined with Socio Scientific Issues (SSI).

The first step in this study was to perform a curriculum and student needs analysis in order to acquire data on student difficulties and the teaching module to be built. The outcomes of the needs analysis exercise conducted on January 15, 2024, included a discussion with the science teaching team to better understand the curriculum being implemented. The Merdeka Curriculum was examined, which focuses on contextual learning, critical thinking abilities, and scientific arguments. According to the findings, this curriculum is flexible in terms of integrating numerous learning models that may be tailored to local needs, including socio-scientific issue (SSI) connected to natural disasters that are relevant to Lamongan geographic environment.

From January 29 to February 12, 2024, the research was extended with interviews and surveys of grade VIII learners. Interviews were done to determine students' comprehension and interest in natural disaster-related scientific content. According to the interview results, many students were interested in the issue of natural catastrophes because of personal experiences or stories from their community. However, their scientific grasp of the causes and consequences of catastrophes is still limited. According to the poll, most students struggled to relate science ideas to real-world occurrences and construct logical arguments based on scientific facts. On February 13, 2024, a classroom observation was undertaken to directly examine science instructors' teaching techniques at Junior High School 2 Lamongan. This observation lasted until February 26, 2024, and included several learning sessions. It was discovered that teaching techniques were generally conventional, with a lecture style and textbooks serving as the primary sources. Student-teacher participation in scientific conversations remained restricted, and pupils were rarely given the opportunity to dispute scientifically while learning. This highlights the urgent need to implement a more participatory learning paradigm and actively engage students in scientific discourse.

From February 27 to March 12, 2024, an examination of current instructional materials was done. The study team examined the modules used by science instructors at Junior High School 2 Lamongan to determine how well the materials trained scientific reasoning abilities. The investigation revealed that the existing instructional materials were not adequately linked with the SSI method,

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and they lacked real-world settings relevant to students' everyday lives. The instructional materials emphasized factual information above critical thinking and persuasive abilities. As a result, the development of SSI disaster-based training modules is critical to addressing this gap.

On March 13, 2024, a focus group discussion was held with students, teachers, and education professionals to review the findings of the needs analysis and solicit additional feedback. This activity ran until March 27, 2024, revealing that including socio-scientific concerns connected to natural catastrophes in science education modules will help students improve their scientific reasoning abilities. Teachers also voiced support for the creation of interactive modules that are more relevant to students' lives. The findings of this FGD give crucial guidance for the creation of the proposed teaching module, with an emphasis on local context and an interdisciplinary approach addressing real-world problems.

Next, the learning outcomes is identified based on phase D of the autonomous curriculum, which will lead to obtain integrated science content that is appropriate for the student's condition, learning outcomes, and learning styles. If the learning outcomes have been defined, the next step is to identify particular learning objectives related to disaster mitigation. The researcher will next assemble and create a teaching module based on the Pirposal learning model that is combined with a socio-scientific issue (SSI) on disaster mitigation in order to teach students scientific reasoning.

Table 2. Validation of Module

Validation Aspects	Validator			Average	Category
	Content	Language	Media		
Content quality	5	4	4	4.33	Very Appropriate
Curriculum suitability	5	4	4	4.33	Very Appropriate
Concept accuracy	4	4	4	4.00	Appropriate
Understanding ease	4	5	4	4.33	Very Appropriate
Readability	4	5	4	4.33	Very Appropriate
Media display	4	4	5	4.33	Very Appropriate
Interactivity	4	4	5	4.33	Very Appropriate
Student involvement	5	4	4	4.33	Very Appropriate
Novelty	5	4	4	4.33	Very Appropriate
Total Average	**4.44**	**4.22**	**4.22**	**4.30**	**Very Appropriate**

After the draft of the teaching module is completed, a validation test of the material and media is performed, as well as a formative evaluation with individual trials, group trials, and field trials to test 1) the quality of the material; 2) the suitability of the curriculum; 3) concept accuracy; 4) ease of understanding; 5) readability; 6) media display; 7) interactivity; 8) student involvement; and 9) the novelty of the developed teaching module approach. The validation findings for the three validators are as follows table 2.

The validation results show that the lesson module has achieved a very high level of quality, with an average rating from validators of 4.3 out of 5. After conducting the validation test, the module draft is revised based on the suggestions given by the validator, shown in Table 3.

The validation process for the disaster mitigation teaching module involved thorough reviews by three expert validators, who provided critical feedback and suggestions for improvement. Their evaluations focused on the content accuracy, pedagogical effectiveness, and the integration of interdisciplinary scientific concepts. Based on their input, several revisions were made to enhance the clarity, relevance, and instructional design of the module. These improvements have resulted in a refined and effective teaching resource. The final draft of the disaster mitigation teaching module, incorporating all the recommended changes, is shown in Figure 2.

The final teaching module, designed for three comprehensive learning meetings, was implemented successfully, demonstrating its effectiveness in engaging students and enhancing their understanding of disaster mitigation. This module integrates constructivist learning theories, which emphasize active learning through real-world problem-

Table 3. Revision of Module

Validator Suggestion	Improvement status
Content Validator: "The information offered is highly relevant to the curriculum and goes into great detail to clarify natural catastrophe topics. However, certain sections should be streamlined to make them easier for pupils to grasp."	The researcher applied improvements.
Language Validator: "The language chosen is excellent and easy for kids to comprehend. The usage of phrases and technical terminology has been explained clearly. My advice is to include some real-world examples to help understand the topic.	The researcher has included instances of catastrophic events and scientific explanations.
Media Validator: "The media representation is very fascinating and interactive; it can pique students' interest in learning." The media interaction is nice, but it may be enhanced by include more animations or disaster simulations to better depict real-world circumstances."	The researcher has made enhancements by including disaster animation and representations.

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Figure 2. Display of the module

solving and critical thinking. It also draws on Vygotsky's social constructivism, encouraging collaborative learning and peer interactions to build scientific reasoning skills. Additionally, the module incorporates principles of experiential learning, allowing students to directly engage with socio-scientific issues and apply their knowledge in meaningful contexts.

The positive outcomes observed during the implementation phase indicate that the module effectively supports students' cognitive development and practical skills in disaster mitigation. The efficiency of the teaching module based on the integrated Socio-Scientific Issue (SSI) Pirposal learning model in training students' scientific reasoning is measured by pre-test and post-test scores, which are then assessed using the N-Gain formula. The pre-test and post-test are designed to examine if students' academic and practical grasp of disaster mitigation has improved, as well as their ability to argue scientifically. The following are

Table 4. Observation Data of Implementation of Learning Process

Pirposal Learning Syntax	Average Score	Criteria
Problem Identification	4.8	Very good
Ideation	4.7	Very good
Research	4.6	Very good
Potensial Solution	4.8	Very good
Optimization	4.7	Very good
Solution Evaluation	4.6	Very good
Alteration	4.7	Very good
Learned Outcome	4.8	Very good
Average	**4,7**	**Very good**

the outcomes of the implementation of learning using the pirposal learning model, as witnessed by three observers during three learning meetings.

Based on the findings of the pirposal learning model syntax realization, it is clear that all phases of learning were completed successfully. The average rating from three observers ranged from 4.6 to 4.8, placing it in the "Very Good" category. This demonstrates that students can effectively follow each stage of the problem-solving process. According to Pedersen and Liu (2023), the successful implementation of a well-structured learning model has a significant impact on student learning results. The Pirposal paradigm used in this study enables students to think critically and create scientific arguments successfully.

The problem identification and potential solution stages had the highest average score (4.8). This demonstrates that pupils are highly competent at detecting issues and suggesting viable solutions. This is consistent with Zohar and Nemet's

(2022) results, which claim that problem-based learning enhances students' abilities to understand and solve complicated issues. Furthermore, a high score at the learned result stage (4.8) indicates that students not only grasp the subject well but can also apply their knowledge in real-world circumstances, which is the primary aim of socio-scientific issue (SSI)-based learning.

However, while the average score is excellent, there is still room for improvement in the research and solution evaluation stage, which received an average score of 4.6. This suggests that students confront a variety of challenges when conducting research and evaluating solutions. This might be due to a lack of resources or restricted time. According to Bybee (2021), in order to improve the efficacy of this stage, further assistance in the form of suitable resources and more time is required. By increasing this element, it is intended that the overall learning process would operate more smoothly and generate better results. The following analysis involved 50 students' pre-test and post-test results. The investigation's data gathered yielded the following table 5.

According to Table 5, the average pre-test score of students was 61.36, and the average post-test score was 88.56, for a total of 50 students. The paired sample t-test findings on 50 students' pre-test and post-test scores revealed a substantial increase in student learning outcomes after utilizing the Socio-Scientific Issue (SSI) disaster integrated viewpoint learning model-based learning module. The average pre-test score of 61.36 climbed to 88.56 in the post-test, with a t-value of 25.29 and a p-value of 0.000, indicating that the rise was highly statistically significant. This suggests that the created teaching module is successful in increasing students' comprehension and scientific reasoning abilities regarding disaster-related science concerns.

This considerable rise demonstrates that the SSI-based learning strategy may engage students and help them better comprehend the topic. SSI-based learning has been shown to boost student engagement by connecting scientific concepts to real-world situations, making learning more relevant and meaningful for students (Zeidler et al., 2022). In this environment, students not only study scientific topics in theory but also apply them to real-world catastrophic scenarios. This encourages and challenges students to think critically and build scientific reasoning abilities.

Furthermore, the substantial positive connection between pre-test and post-test scores (r = 0.721) indicates that students who have a solid starting comprehension are likely to gain more significantly after participating in learning using this module. This demonstrates that the SSI-

Table 5. Students' Pre-Test and Post-Test

	Mean	N	Std. Deviation	Std. Error Mean
Pre-Test	61.36	50	7.67	2.148
Post-Test	**88.56**	**50**	**6.18**	**1.326**

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based catastrophe learning module is not only successful in boosting students' overall comprehension but also in assisting students with varying degrees of baseline ability to progress. Because students are urged to examine and discuss complex topics requiring in-depth comprehension and different viewpoints, SSI-based learning has been found to be helpful in boosting their critical thinking and scientific reasoning abilities (Sadler, 2024).

Finally, the results of the paired sample t-test support the notion that using a teaching module based on the Socio-Scientific Issue (SSI) disaster integrated conceptual learning model can significantly improve students' learning outcomes in terms of understanding science concepts and scientific reasoning skills. A considerable improvement in post-test scores suggests that this strategy is beneficial and should be considered one of the suggested ways to promote scientific learning in junior high. This study supports previous research demonstrating that the SSI-based learning strategy increases not just conceptual knowledge but also students' critical thinking and debate abilities (Zeidler & Nichols, 2023).

From the pre-test and post-test correlation results, indicates if there is a significant difference in outcomes between the Pre-Test and Post-Test. A significance value of <0.05 indicates a significant difference between the pre-test and post-test. The table findings indicate a substantial difference between the Pre-Test and Post-Test, with a value of 0.003, which is less than 0.05.

This considerable positive association lends credence to the claim that the SSI-based learning strategy improves students' comprehension and scientific reasoning skills. In the framework of this study, the teaching module that incorporates disaster-related socio-scientific topics was successful in increasing student engagement in the learning process. These relevant and contextual topics might drive students to think critically and analytically while also connecting scientific information to real-life circumstances (Zeidler et al., 2020). This is consistent with earlier studies demonstrating that the SSI strategy can increase overall student learning results.

Furthermore, the substantial correlation results revealed that students with superior initial knowledge (higher pre-test scores) performed better on post-test. This suggests that SSI-based learning modules can help students with varying degrees of ability improve their learning outcomes, in addition to benefiting students with strong starting skills. These findings confirm the use of SSI-based learning modules as an effective technique for improving students' scientific reasoning abilities and conceptual comprehension, which is consistent with the study's aims (Sadler, 2020). Thus, implementing this module may be regarded as one of the unique methods to improve the quality of scientific instruction in secondary schools.

Based on the pre-test and post-test scores acquired by students, there is a significant improvement in student scores, reaching 0.701, indicating a category of higher learning outcomes. Based on these

findings, it can be concluded that the construction of this teaching module was successful in developing students' scientific reasoning skills through a content-based learning process and simulations of disaster mitigation material. This is consistent with Riwayani's (2019) assertion, which argues that simulation-based learning improves students' scientific reasoning skills.

This Teaching Module, based on the Pirposal Learning Model and connected with Socio Scientific Issues (SSI), was created with cognitive material and practice/simulation to provide students with active learning and direct experience, making learning more relevant. Meaningful learning will improve students' mastery of the concepts. This meaningful learning is also impacted by students' learning motivation; if students are highly motivated, the learning they get will be more meaningful since they will follow the content and simulations with passion.

CONCLUSION

The establishment of a Teaching Module based on the Pirposal Learning Model and connected with the disaster Socio Scientific Issue (SSI) has been deemed beneficial and has a major impact on enhancing students' scientific reasoning skill. This teaching module may be used to develop new learning plans for State Junior High School 2 Lamongan, allowing disaster mitigation learning to be carried out while combining scientific and practical understanding of catastrophe topics.

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