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# Development of Disaster Mitigation Interactive E-Modules Based on Socio-Scientific Issues (SSI) to Facilitate Junior High School Students' Science Literacy

**Nofenka Permata Islami, *Agung Mulyo Setiawan**
Department of Science Education, Universitas Negeri Malang. Jl. Semarang No. 5, Malang, East Java, Indonesia. Postal code: 65145
*Corresponding Author e-mail: agung.mulyo.fmipa@um.ac.id

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**Abstract**

In the 21st century, scientific literacy is crucial for students as it connects science to real-life issues. The Socio-Scientific Issues (SSI) approach can be used through contextual learning to enhance students' scientific literacy. This approach involves developing teaching materials based on SSI and for this research, the focus is on disasters and mitigation to increase preparedness in disaster-prone areas. The research aims to develop and test the feasibility and practicality of SSI-based teaching products using the Research and Development (R&D) method, specifically the ADDIE model. The novelty of the SSI e-module is in the issues discussed, the interactive and varied material, and the quiz features. These can improve students' scientific reasoning by involving them in real-life problem-based discussions relevant to everyday life, thus encouraging critical analysis, decision-making, and collaborative problem-solving. Data was collected through interviews with teachers to analyze their needs and through questionnaires distributed to students, feasibility tests, and product practicality tests. The results showed 90% material feasibility, 100% concept correctness, 95% media feasibility, and 96% question feasibility, all falling within the "very feasible" category. Additionally, an empirical test of the questions through validity testing resulted in 10 valid and 5 invalid questions, with a reliability test yielding a score of 0.717. The score is included in the high category, it needs to be increased to the very high category ($0.80 \leq r \leq 1.00$) by evaluating the material, design, and structure of the module. The product's practicality was tested on 2 science teachers and 32 class VIII students, and achieved percentages of 94% and 89% respectively, categorizing it as "very practical". In conclusion, the e-modules developed in this research are deemed very feasible and practical for facilitating scientific literacy in students.

**Keywords:** Interactive E-Module, SSI, Science Literacy, Disaster Mitigation.

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## INTRODUCTION

In education, science plays an important role in the development of science in the 21st century, requiring students to have literacy skills that are useful in improving the quality of human resources (Anggraeni et al., 2022). Science literacy is included in basic literacy, which is important for students to learn science (Amala et al., 2023). Science literacy is defined as students' ability to engage with science-related issues, along with scientific ideas (OECD, 2023a). Assessment of students' abilities in science includes four aspects, namely context, knowledge, competence, and attitude (OECD 2023a).

Through science literacy, students are not only required to memorize information but also to have the ability to understand and analyze scientific concepts and their contextual processes (Amala et al., 2023). Additionally, it helps in developing critical thinking skills,

problem-solving abilities, and making decisions based on scientific knowledge (Kurniawati et al., 2021). According to the PISA data, the average results for Indonesia in 2022 have decreased. In science literacy, Indonesia scored 383 (OECD, 2023b). This decline in results is partly due to learning loss during the COVID-19 pandemic (Fuadi et al., 2020). Indonesia's low PISA scores reflect students' lack of ability especially in science which is caused by various factors, including the limitations of the existing curriculum. The current curriculum does not fully support teaching methods based on real-world problem solving (such as Socio-Scientific Issues/SSI), which can help students develop critical reasoning and scientific thinking skills. The inadequacy of teaching materials and teaching methods that focus on theoretical concepts without connection to everyday life creates a gap in the mastery of 21st-century competencies.

SSI-based e-modules have the potential to address this problem by providing contextual and interactive teaching materials, facilitating students' exploration of socially relevant scientific issues. Using this approach, e-modules can help students not only understand science concepts in depth but also apply them to solve real-world problems, which can ultimately improve student performance in international assessments such as PISA.

Scientific literacy abilities are closely linked to socio-scientific issues (SSI) as they involve applying scientific reasoning and thinking processes to address community challenges. This implies that everyone holds a responsibility to use science and technology to address social problems (General et al. 2012; Rahmawati et al., 2022). Marks et al. (2014) outline five recommended learning steps for SSI-based teaching, including (1) textual approach and problem analysis, (2) clarifying the science background, (3) resuming the socio-scientific dimension, (4) discussing and evaluating different points of view, dan (5) meta-reflection. Implementing SSI in education is crucial for enhancing critical thinking skills, the ability to solve problems through argumentation, and understanding scientific concepts within real-life social controversies (Febriani et al., 2023). Several studies testify to the effectiveness of SSI in improving students' scientific literacy skills (Saija et al., 2022). However, research conducted by Nida et al. (2020) suggests that obstacles such as limited student skills, insufficient teacher knowledge and expertise, curriculum constraints, and inadequate resources and time hinder the widespread adoption of SSI-based learning (Nida et al., 2020).

The study by Nuryanti et al. (2023) revealed that students exhibit low scientific literacy, especially in topics such as climate change. This can be attributed to factors like inadequate learning resources and evaluation questions that do not align with scientific literacy indicators. As a result, students struggle with questions that require reading and discussion, limiting their analytical abilities (Anggraini, 2014). Teachers often focus on assessing students' knowledge of the material and the teaching methods, which hampers students' active involvement in developing scientific knowledge and applying it to real-life scenarios (Rizkita, 2016). The study suggests that there is a lack of teaching materials that effectively promote scientific literacy and the use of Socio-Scientific Issues (SSI) learning. Consequently, there is a need to understand the current use of SSI in education and the requirement for appropriate teaching materials. Interviews with science teachers revealed that conventional teaching materials, which seldom cover social phenomena comprehensively, are still predominantly used. Additionally, the interviews indicated that science teachers are not well-versed in SSI-based learning and have a limited understanding of scientific literacy. As a result, there is a disconnect between theoretical knowledge and practical application, impeding students' ability to relate academic concepts to real life (Spackman et al., 2016). Barriers experienced by teachers based on interviews include the lack of specific training linking scientific issues to social contexts, especially disaster literacy topics. Professional training often focuses more on conceptual aspects, rather than real-issue-based applications. In addition, teachers often have to develop relevant teaching materials themselves, which requires additional time and effort coupled with a dense curriculum. In addition, there is a teacher perception that it is difficult to evaluate SSI-based learning outcomes because this approach focuses on critical reasoning and decision-

making. Besides that, teachers need to play a role in teaching science literacy, including becoming facilitators of contextual learning which will certainly develop critical and analytical thinking skills as students' curiosity and exploration grow. Supporting this also requires the provision of diverse media and learning resources (Yasa et al., 2021).

The fast pace of scientific and technological advancement must be accompanied by thoughtful consideration of how students engage with and adapt to science, the environment, society, and technology (Situmorang, 2016). Electronic modules are educational materials that have leveraged the progress in science and technology. Based on the results of the needs analysis, it is evident that time constraints during learning remain a challenge, so teachers require media that integrate technology to assist students in independent learning. Diverse learning resources can cultivate interest in learning, thereby encouraging students to actively seek and comprehend information in a comprehensive manner (Yasa et al., 2021).

Junior high school students in the Merdeka Curriculum study various environmental issues such as environmental health in schools, global warming, energy crisis, and food availability. One important topic is disaster mitigation, which is linked to global warming as a cause of climate change. This is particularly relevant for students in Indonesia, a country prone to natural disasters. Research shows that disaster literacy education is crucial for students to be prepared and reduce activities that harm the environment (Purwanto et al., 2023). The existence of disaster literacy education plays an important role in increasing students' knowledge, attitudes, and behavior in disaster preparedness to reduce activities that cause environmental damage due to humans (Cahya et al., 2023). This is also supported by the results of interviews with science teachers who often mention that on the topic of disaster mitigation, students are immediately given assignments and rarely get complex knowledge, especially about phenomena that occur around them. The results of the student needs analysis of 90.9% stated that the topic needs to be linked to current phenomena and issues. Environmental Issues Topics are also included in the knowledge content in the PISA framework (OECD, 2019). Based on research by Nida et al. (2020), suggests that over 40% of teachers recommend focusing on topics related to the environment or technology.

Based on previous research, there has been no utilization of disaster and mitigation content in the development of SSI-based e-modules. Platini et al. (2022) conducted a study that created an interactive e-module using Microsoft Sway, which yielded valid and effective results in enhancing students' disaster literacy skills. Other research, such as that by Auwaliyah et al. (2023), focused on developing e-modules for disaster mitigation material for grade $9^{th}$ high school but did not implement SSI. Ika et al. (2019) conducted a study on SSI-based science teaching materials and achieved an N-Gain score of 0.60, showing significant effectiveness in enhancing students' science literacy. Similarly, Rostikawati & Permanasari (2016) developed SSI teaching materials for additive materials, demonstrating a substantial impact on meeting students' learning expectations and improving scientific literacy in terms of both competence and attitude.

Based on various literature studies and previous research findings, the researcher developed a research project titled "Development of Disaster Mitigation Interactive E-Modules Based on Socio-Scientific Issues (SSI) to Facilitate Junior High School Students' Science Literacy". The novelty of the product lies in its comprehensive curriculum, covering various mitigation efforts and technologies, and addressing important issues. The e-module includes features such as highlighted text, different quiz formats like crosswords and word searches, as well as buttons, QR codes, and access links to learning videos, websites, and quizzes. The module contains descriptions of relevant real issues, with supporting data or cases along with content that includes introductions to scientific concepts, social impacts, and practical solutions, so that students see the problem from multiple perspectives. This supports the presentation of interactive debates where students play certain roles and then develop their understanding through spontaneous arguments and interactions. The material often focuses on

debate skills or group work rather than systematic scientific in-depth. Furthermore, at the end of the learning process, meta-reflection for students to share thoughts or experiences based on the activities carried out. The purpose of this research is to create a feasible and practical e-module based on SSI for junior high school students, focusing on the subtopic of disaster mitigation to enhance their science literacy. And then promoting the application of socio-scientific reasoning through learning and addressing curriculum gaps, especially in understanding disasters for students.

## METHOD

### Research Design

The research method used is Research and Development (R&D), which involves producing an interactive e-module for SSI-based disaster mitigation to enhance junior high school students' scientific literacy. According to Borg and Gall (1998) as cited in Sugiyono (2022), research and development is a method used to validate or develop a product. The research model employed is ADDIE, adapted from Branch (2009), which consists of five key components: 1) analyze, 2) design, 3) develop, 4) implement, and 5) evaluate. ADDIE is an effective learning design model for developing learning products (Sudatha, 2017). This model focuses on solving research problems by creating multimedia products, with a revision stage at each step to support product development in line with the research objectives (Safitri & Aziz, 2022).

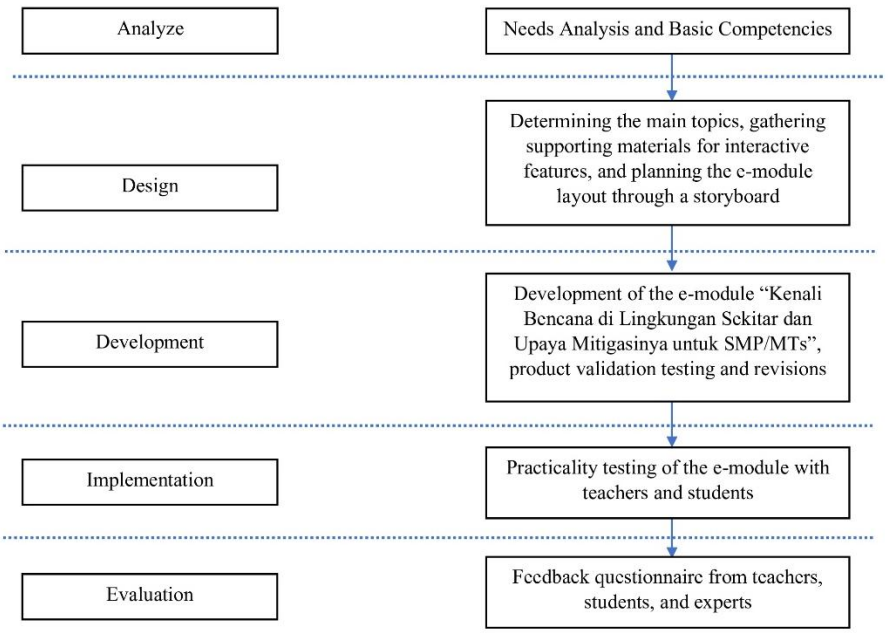



**Figure 1.** The development stages of the ADDIE model are adapted from Branch (2009)

### Research Objectives

The research was conducted from February to May 2024. The study included expert validators from the Department of Science Education, grade 9$^{th}$ students to test the questions, and grade 8$^{th}$ students who were in the even semester of the 2023/2024 academic year. Additionally, 2 science teachers from SMPN 1 Tutur in Pasuruan Regency conducted a practicality test of the product.

The condition of the residential area that has the potential for disasters such as earthquakes, floods, or landslides requires a deep understanding of the types of disasters that may occur and the mitigation steps that can be taken to reduce the negative impacts of the disaster. This e-module is designed to provide information that is relevant to local conditions

and help students develop skills in dealing with disasters more effectively, thereby increasing their preparedness and ability to act when facing emergencies. Furthermore, teachers have experience in facilitating critical discussions and guiding students in analyzing social scientific issues. However, it is necessary to develop support for the development of decision-making skills based on evidence and social values according to a deeper SSI context.

**Data Collection**

Different types of data can be collected through qualitative and quantitative methods. Qualitative data is obtained through interviews with science teachers and feedback on the questionnaire sheet. On the other hand, quantitative data is gathered from student needs analysis, product validation tests (such as media feasibility tests, material feasibility tests, concept truth tests, and question feasibility tests), and product practicality tests. The specific research techniques used are detailed in Table 1 and Table 2.

**Table 1.** Qualitative Data Research Techniques

| Test | Data Collection | Subject | Data Analysis |
|---|---|---|---|
| Teacher Need Analysis | Interview | 2 science teachers | Descriptive analysis |

**Table 2.** Quantitative Data Research Techniques

| Test | Data Collection | Subject | Data Analysis |
|---|---|---|---|
| Conceptual Truth Test | Questionnaire | Expert Validator | *Guttman* scale statistical analysis |
| Student Need Analysis | Questionnaire | 32 students in $8^{th}$ grade | |
| Media Feasibility Test | Questionnaire | Expert Validator | *Likert* scale statistical analysis |
| Material Feasibility Test | Questionnaire | Expert Validator | |
| Question Item Feasibility Test | Questionnaire | Expert Validator | *Likert* scale statistical analysis |
| | Written Test | 30 students in $9^{th}$ grade | Statistical analysis of validity and reliability |
| Practicality Test | Questionnaire | 32 students in $8^{th}$ grade and 2 science teachers | *Likert* scale statistical analysis |

The Guttman scale scoring criteria consist of True and False options to ensure firm and consistent scoring (Sugiyono, 2022).

**Table 3.** Guttman Scale (Riduwan, 2013)

| Score | Criteria |
|---|---|
| 1 | True |
| 0 | False |

And then, the Likert scale uses four scoring criteria, which are as follows:

**Table 4.** Likert Scale (Riduwan, 2013)

| Score | Criteria |
|---|---|
| 4 | Very valid/very practical |
| 3 | Valid/practical |
| 2 | Invalid/impractical |
| 1 | Very invalid/very impractical |

Then the formula used in processing the results of the feasibility and practicality test data is as follows:

$$P = \frac{\sum X}{\sum X_i} \times 100\%$$

$P =$ percentage of the total score (%)
$X =$ number of test subject
$X_i =$ maximum number of answers

The Guttman scale is used to measure data that requires definite information, especially in identifying patterns of consistency or inconsistency in responses. Meanwhile, the Likert scale is used to measure attitudes, opinions, and perceptions of respondents in a graduated manner. The calculation results are then adjusted according to the following scoring criteria:

**Table 5.** Percentage Criteria for Assessment Results (Arikunto & Jabar, 2014)

| Percentage (%) | Criteria |
|---|---|
| 81 – 100 | Very valid/very practical |
| 61 – 80 | Valid/practical |
| 41 – 60 | Quite valid/quite practical |
| 21 – 40 | Invalid/impractical |
| 0 – 20 | Very invalid/very impractical |

After conducting the question validation test with an expert validator, the next step is to perform an empirical test using validity and reliability tests with the assistance of SPSS. A question is considered valid if the $r_{count} > rt_{able}$, and considered invalid if the $r_{count} \leq t_{table}$ (Sundayana, 2018). Next, a Cronbach's Alpha (α) reliability test is conducted on the questions identified as valid (Sundayana, 2018). The results of the reliability coefficient are then interpreted based on specific criteria.

**Table 6.** Interpretation of Reliability Coefficients (Guilford, 1956; Sundayana 2018)

| Reliability Coefficients (r) | Interpretation |
|---|---|
| $0.00 \leq r < 0.20$ | Very Low |
| $0.20 \leq r < 0.40$ | Low |
| $0.40 \leq r < 0.60$ | Medium |
| $0.60 \leq r < 0.80$ | High |
| $0.80 \leq r \leq 1.00$ | Very High |

## RESULTS AND DISCUSSION

### Analysis Stage

The first step in developing the e-module is to conduct a needs analysis. This involves interviewing two 8$^{th}$ grade junior high school science teachers and distributing questionnaires to 32 students. The analysis aims to determine the teaching materials typically used and the criteria for teaching materials required in science learning. Based on the interviews with science teachers, the following information was obtained:

1. Students' science literacy is relatively low.
2. The teachers predominantly use printed teaching materials provided by the government.
3. There is a lack of teaching materials that facilitate science literacy for students.
4. There is also a lack of teaching materials that address current social issues.

The student needs analysis in Table 7. indicated that there is a need for teaching materials that discuss relevant phenomena or social issues to enhance students' science literacy. Additionally, a review of previous research literature was conducted during the analysis stage.

**Table 7.** Student Need Analysis Results

| Indicator | Frequency | | Percentage | |
|---|---|---|---|---|
| | True | False | True | False |
| Teachers' teaching methods help science understanding | 20 | 12 | 62.5 | 37.5 |
| Availability of teaching materials can help science understanding | 19 | 13 | 59.4 | 40.6 |
| Availability of teaching materials can support science literacy | 15 | 17 | 46.9 | 53.1 |
| The urgency of linking science material to situations in everyday life | 25 | 7 | 78.1 | 21.9 |
| Understanding disaster material and mitigation efforts | 15 | 17 | 46.9 | 53.1 |
| Disaster and mitigation material needs to be linked to phenomena in the surrounding environment and current issues | 27 | 5 | 84.4 | 15.6 |
| Interactive features such as images, videos, graphs, and case examples in everyday life can help in understanding disaster material and mitigation | 26 | 6 | 81.2 | 18.8 |
| Interactive quizzes can help in understanding disaster material and mitigation | 25 | 7 | 78.1 | 21.9 |
| Need an interactive electronic module for disasters and mitigation based on SSI to facilitate science literacy | 29 | 3 | 90.6 | 9.4 |

In Table 7, the results of a needs analysis conducted on 32 students are presented. The response categories consist of Yes and No answers. The analysis revealed that only 46.9% of students indicated that they understood the disaster and mitigation material. The science teacher mentioned in the interview that due to time constraints and it being the last chapter studied, learning is often only done independently even though it is carried out face-to-face, with the material being covered briefly in one meeting. The teaching materials used also do not fully support students' science literacy. This may occur due to a lack of effective lesson planning, which results in some material not being fully delivered. Regarding the development of the e-module, 81.2% of students responded positively to the interactive features, and 78.1% responded positively to the evaluations presented in the e-module. Additionally, it is suggested by Asshiddiqi et al. (2021) and Rahmatsyah & Dwiningsih (2021) that disaster literacy should be integrated into the Indonesian curriculum through teaching materials, as the knowledge of the community, especially students, about disasters is still low. Furthermore, 90.6% of students stated that they needed an interactive electronic module on disasters and mitigation based on SSI to facilitate scientific literacy.

**Design Stage**

The design stage involves creating learning materials based on the results of the previous analysis. In this stage, tasks include planning the material, designing learning activities according to SSI stages and science literacy competencies, determining interactive features, gathering supporting media such as images, animations, videos, and audio, and creating a storyboard or content framework for the e-module layout. Including interactive features aims to stimulate students' interest in learning and encourage them to be more engaged to achieve

learning objectives (Yasa et al., 2021). This is followed by developing validation test instruments and conducting practical tests for expert lecturers, science teachers, and students.

## Development Stage

### *Product Description*

This product was developed based on the characteristics of a good e-module, as outlined by Daryanto in 2013 and further discussed in Wulansari et al. (2018). These characteristics include: self-instruction, self-contained, stand-alone, adaptive, and user friendly. Self-instruction refers to the need for clear instructions or directions in the e-module, as well as content that supports the achievement of learning objectives, allowing students to use it independently (Wulansari et al., 2018). The developed e-module aligns with these characteristics by presenting learning achievements, objectives, materials equipped with supporting features, practice questions, and feedback. Self-contained means that the material in the e-module is in one unit (Wulansari et al., 2018). Therefore, the e-module presents materials and learning activities coherently and consistently, completely according to the context of disaster learning and its mitigation for junior high school students. The stand-alone characteristic indicates that the e-module should not require other supporting materials or tools during use (Wulansari et al., 2018). In addition to the completeness of the material presentation, this e-module is supported by buttons, barcodes, and links that directly connect to learning videos or practice questions. Adaptive e-modules align with the development of science and technology (Wulansari et al., 2018) through the use of case examples and current issues related to everyday phenomena, offering flexibility in usage. User-friendly e-modules aim to make it easy for users to operate (Wulansari et al., 2018) as demonstrated by the ease of access to various features, the use of operational buttons with accompanying instructions, and language tailored to the students' age, facilitating their understanding (Rostikawati & Permanasari, 2016).


**Figure 2.** E-module before revision

The study results are presented as an e-module focused on Science, Society, and the Environment (SSI). The e-module aims to enhance the science literacy of junior high school students through the topic of " Kenali Bencana di Lingkungan Sekitar dan Upaya Mitigasinya untuk SMP/MTs". It covers environmental issues related to global warming, emphasizing the impact of climate change and its role in causing disasters. The learning outcomes include students being able to explain natural phenomena and climate change by understanding the relative position of the earth-moon-sun in the solar system. The e-module was developed using Canva as the design platform and Heyzine Flipbook for interactive features. The final e-module output can be accessed through an HTML link. Currently, a feasibility test is being conducted to assess whether the e-module meets the predefined indicators or requires further improvement.

Figure 2 (a,b,c,d,e) below illustrates the appearance of the e-module before the revision, based on the results of the feasibility test. The selection of topics and learning activities in the initial e-module did not align with the SSI criteria and lacked indicators of scientific literacy. The chosen topics were less controversial and didn't encourage open discussions that could lead to diverse student perspectives. After the revision, the e-module was modified to adhere to the SSI learning steps and focus on scientific literacy activities. The revised e-module included the following topics: (1) Climate Change Brings Floods, (2) Solutions to Flood Problems, and (3) Disaster Mitigation Efforts and Technology. Marks and Eilks (2009) in Marks et al. (2014) recommended five SSI criteria: (1) authenticity, (2) relevance, (3) open-endedness concerning societal questioning, (4) being openly discussable in a public forum, and (5) having a clear-cut relationship to science and technology. The phenomenon of flooding due to climate change was chosen as the main topic based on these criteria.

In the e-module below, figure 3a shows learning activities that refer to the SSI Approach and Problem Analysis stages that discuss the phenomenon of climate change that has an impact on flooding in the capital city of DKI Jakarta and major cities in Indonesia. Then figure 3b shows learning activities to clarify problems through practical activities by raising the problem of clean water shortages as one of the impacts of flooding. Furthermore, figure 3c is an activity to continue the issue of social problems by discussing the controversy surrounding the relocation of the nation's capital which is claimed to be able to overcome flooding problems. Figure 3d shows discussion and evaluation activities related to the pros and cons of relocating the capital city reviewed from social aspects, economic aspects, and environmental aspects through debate activities. Then figure 3e shows meta-reflection as a form of learning reflection in the form of material, benefits, solutions, and follow-up to the material obtained. Based on the results of the practicality test (Table 13), students stated that the material was quite complete and helped their understanding. In addition, students were also interested in the issues discussed in the e-module and actively participated in expressing their opinions to draw final solutions based on the various points of view provided.

Table 8 shows the aspects of scientific literacy competency as a reference. In addition, the learning activities at each stage of SSI are also geared towards developing scientific literacy competencies based on PISA 2022. This can be observed in Table 8, where the focus is on the ability to: (1) explain phenomena scientifically, in this section students watch video presentations or read articles and then explain the phenomena in the provided column; (2) evaluate and design scientific enquiry, here students carry out experiments related to the impact of flooding, evaluate the variables used, and record the results; and (3) interpret data and evidence scientifically, in this section, students interpret presented data along with scientific evidence (OECD 2023a).

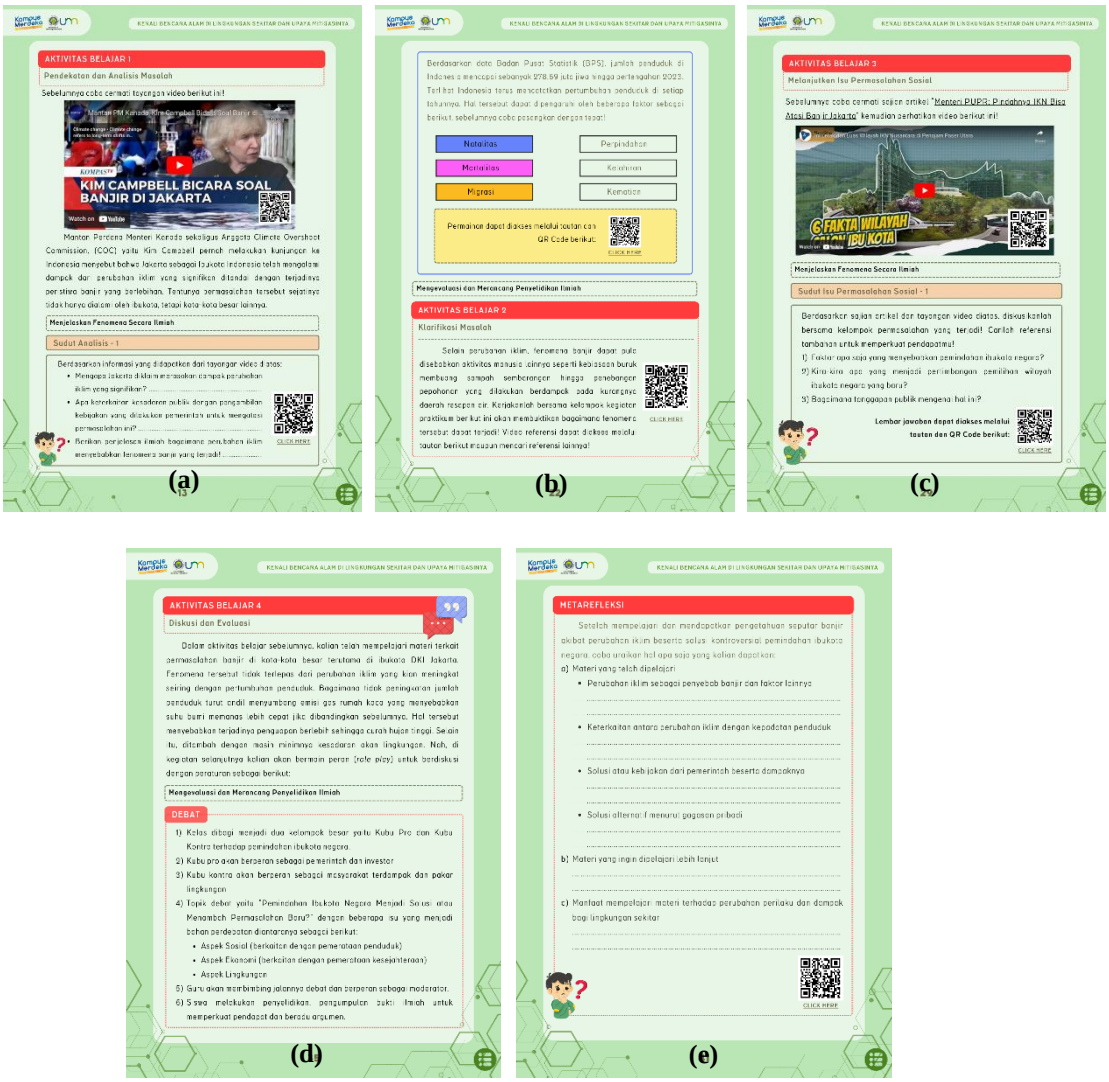
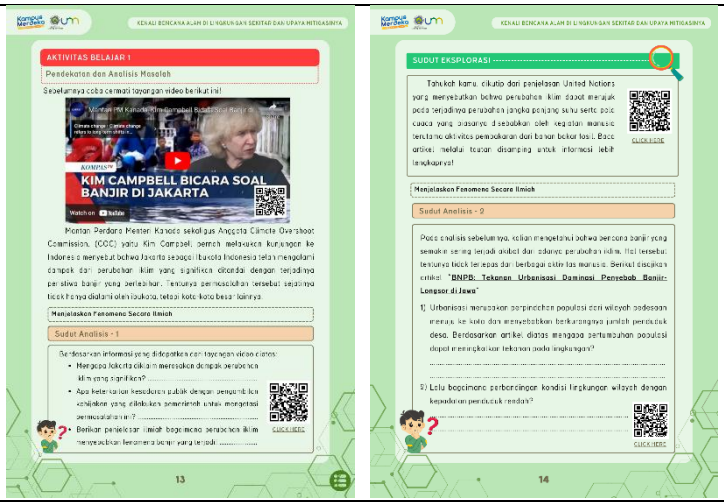
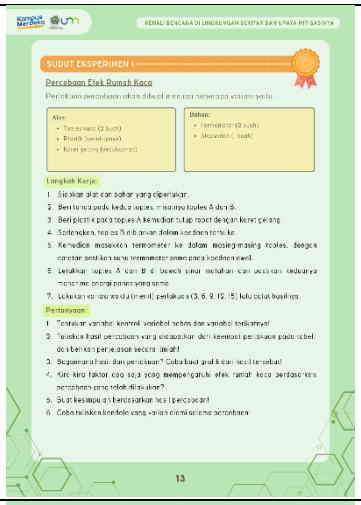
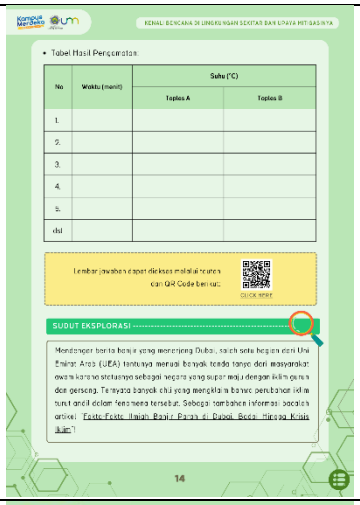
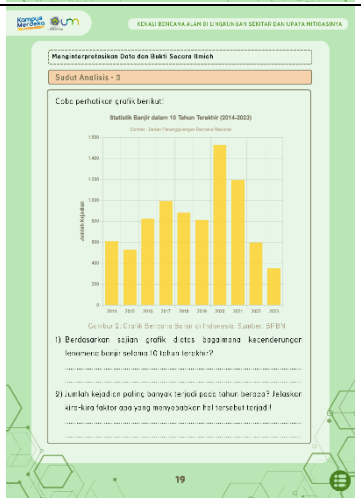
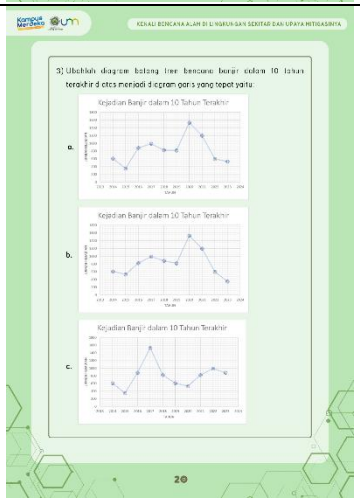



**Figure 3.** SSI Based Learning Activities (after revision)

**Table 8.** Scientific Literacy Aspects in the E-Module (after revision)

| E-Module Section | Science Literacy Aspect |
|---|---|
|  | Explaining phenomena scientifically |

| E-Module Section | Science Literacy Aspect |
|---|---|
|   | Evaluating and designing scientific enquiry |
|   | Interpreting data and evidence scientifically |

### *Feasibility of E-Module*

*Logical Validation Test*

After developing the e-module, expert lecturers conducted a feasibility test on the material, concept, media, and questions. Here's a summary of the results obtained:

**Table 9.** Results of Material Feasibility Test and Conceptual

| Test | Aspect | Average Score (%) | Categories |
|---|---|---|---|
| Material Feasibility Test | Content Feasibility | 100 | Very Valid |
| | Presentation Feasibility | 100 | Very Valid |
| | Language Feasibility | 100 | Very Valid |
| | Feasibility of SSI indicators | 75 | Valid |
| | Feasibility of scientific literacy competencies | 75 | Valid |
| **Total Average Score (%)** | | **90** | **Very Valid** |
| **Test** | **Aspect** | **Average Score (%)** | **Categories** |
| Conceptual Test | Concept | 100 | Very Valid |
| **Total Average Score (%)** | | **100** | **Very Valid** |

Table 9 presents the results of the material feasibility validation test, indicating a 90% feasibility, which suggests the material is highly feasible. The SSI indicators and science literacy competencies had the lowest average scores but still fell within the feasible category. The validator provided qualitative comments and suggestions to emphasize these aspects by reconsidering their characteristics and improving the questions in each learning activity to enhance interactivity. Based on this feedback, the e-module was improved before undergoing testing. Additionally, the concept truth test yielded a 100% validity rating, indicating the concept presented in the e-module has been thoroughly tested for accuracy.

**Table 10.** Results of Media and Question Item Feasibility Test

| Test | Aspect | Average Score (%) | Categories |
|---|---|---|---|
| Media Feasibility Test | Presentation Feasibility | 96 | Very Valid |
| | Technical Feasibility | 94 | Very Valid |
| **Total Average Score (%)** | | **95** | **Very Valid** |
| **Test** | **Aspect** | **Average Score (%)** | **Categories** |
| Question Item Feasibility | Question Item | 96 | Very Valid |
| **Total Average Score (%)** | | **96** | **Very Valid** |

Table 10 displays the results of the media feasibility assessment, showing an average percentage of 95%, which falls into the "very feasible" category. The validator's feedback suggests that the presentation of questions should be made more interactive. An interactive module's characteristics are evaluated in terms of technical feasibility, including the availability of usage instructions, ease of operation, accessibility to various supporting media, the module's ability to promote student interactivity, and its flexibility for use. An e-module is considered interactive when it incorporates features such as images, videos/animations, quizzes, and interactive elements to effectively engage students (Rahmatsyah & Dwiningsih, 2021). The e-module contains 15 evaluation questions, which need to undergo both logical validation tests by expert validators and empirical validation tests, which involve validity and reliability testing (Riyani et al., 2017). The results of the question feasibility test show a percentage of 96%, positioning it in the "very feasible" category. The feedback includes suggestions for revising the module's learning activities and specific question numbers to better align with the SSI context criteria.

*Empirical Test*

After making improvements to the e-module and revising the questions based on assessments and suggestions, we conducted an empirical test. The trial involved 30 grade 9$^{th}$ students who had studied disaster mitigation material. This test aimed to determine the validity and reliability of the questions.

**Tabel 11.** Question Validity Test Results

| Number Question | $r_{hitung}$ | Kategori |
|---|---|---|
| 1 | -0.113 | Invalid |
| 2 | 0.461 | Valid |
| 3 | 0.482 | Valid |
| 4 | 0.146 | Invalid |
| 5 | 0.589 | Valid |
| 6 | 0.538 | Valid |
| 7 | 0.427 | Valid |

| Number Question | $r_{hitung}$ | Kategori |
|---|---|---|
| 8 | 0.405 | Valid |
| 9 | 0.072 | Invalid |
| 10 | 0.373 | Valid |
| 11 | 0.664 | Valid |
| 12 | 0.326 | Invalid |
| 13 | 0.479 | Valid |
| 14 | 0.528 | Valid |
| 15 | 0.152 | Invalid |

According to Sugiyono (2022), an instrument is considered valid if it can effectively measure the intended attribute. The table displays the summary of the validity test results conducted using SPSS. Since there were 30 respondents, the obtained rtable value was 0.361. As a result, 10 questions were categorized as valid, while 5 questions were categorized as invalid. All invalid questions will be removed or excluded from further testing. This is to maintain data quality, improve reliability and validity, as well as consistency in measurements.

**Tabel 12.** Question Reliability Test Results

| Reliability | Category |
|---|---|
| 0.717 | High |

The next step after categorizing questions as valid is to conduct a reliability test. Reliability is a tool to determine whether an instrument is consistent and stable (Sundayana, 2018). After performing the calculations, a reliability value of 0.717 was obtained, which falls into the high category. A construct or variable can be considered reliable if the Cronbach's alpha value is > 0.60 (Gunawan, 2016).

***Implementation Stage***

After conducting a feasibility test on the e-module, we proceeded with a practicality test involving 32 students and 2 science teachers. The purpose of the practicality test is to determine if the e-module is practical and easy to use (Fitriyah & Abdur, 2013; Annisa et al., 2020). The practicality test began with distributing the e-module link, followed by teachers and students accessing the content and receiving a brief explanation. Students were encouraged to share their thoughts on climate change and the government's proposal to move the nation's capital. Finally, students provided their proposed solutions considering the various impacts and completed a practicality test questionnaire.

**Tabel 13.** Practicality Test Results

| Respondent | Average Score (%) | Categories |
|---|---|---|
| Teacher | 94 | Very Practical |
| Student | 89 | Very Practical |

Table 13 presents the results of the practicality test of the e-module by teachers, which received a 94% rating, and by students, who rated it at 89%, placing it in the "very practical" category. The teacher's practicality test included assessment aspects such as appearance, content presentation, and technical aspects. Some of the aspects evaluated were the size, layout, and illustrations used, the suitability of the material with learning competencies, and the ease of use of the e-module. The comments and suggestions provided indicated that the e-module is very practical in terms of access and use, despite facing constraints due to internet connection problems. There is still a process of content adaptation when using e-modules, especially when considering the location of schools in rural areas. Limited access to technology and internet

infrastructure in these areas can affect the effectiveness of using e-modules. Therefore, adjustments in the presentation of material are necessary to match the conditions and needs of students in rural areas, including the possibility of simplifying the content or providing alternative access to ensure that learning remains effective. According to Utama & Zulyusri (2022), a module's practicality and suitability for use are often evaluated based on factors such as the clarity of content, the attractiveness of design, ease of understanding, and interactivity. The results showing a high level of practicality demonstrate that the use of the e-module addresses the previous issue of the lack of teacher-friendly SSI resources. This e-module is designed to provide materials that are more accessible, understandable, and applicable for teachers, making it easier for them to integrate SSI into the learning process in a more effective and efficient manner.

**Tabel 14.** Student Practicality Test Indicators

| Indicator | Average Score (%) |
|---|---|
| Appearance | 91 |
| Content Presentation | 88 |
| Technical | 89 |

Table 14 shows some of the indicators of practicality test assessment for students, including in terms of appearance and presentation of content, obtaining a positive response of 91% and 88%, which shows that the e-module design has an attractive appearance and helps students to learn more easily. Then for the technical aspect, it obtained a percentage of 89%, which shows that the e-module is easily accessible to students and helps learning activities based on scientific literacy competencies. There are some improvements in student competency in the aspect of explaining phenomena scientifically before using the e-module, students have difficulty explaining phenomena such as climate change and its impact on the environment. After using the e-module that presents animations and illustrations, students can connect this theory with signs of climate change that occur around them. Then in the aspect of designing scientific investigations, students can design experiments involving independent and dependent variables, as well as control other variables that can affect the results. They also demonstrate the ability to write clear experimental reports, including analysis and conclusions based on the data obtained. And in the aspect of interpreting data, students are better able to read graphs or data displayed.

Compared to previous research indicates that the SSI approach in science education, while effective in helping students understand basic concepts and design experiments, has not sufficiently emphasized the application of scientific concepts in a broader social context. Therefore, the development of this e-module presents scientific concepts in a more visual and interactive manner and provides opportunities for students to actively design experiments or interpret data in more practical contexts.

***Evaluation Stage (Evaluate)***

At the evaluation stage, improvements or refinements are made to the e-module by suggestions and comments from students, teachers, and expert validators on the questionnaire to make the product more targeted.

## CONCLUSION

The study concludes that an SSI-based interactive e-module on disaster and mitigation was developed to strengthen students' scientific literacy, with each topic structured through SSI learning stages aligned to literacy competencies and supported by interactive features. Feasibility evaluations reported 90% for material (rated "very feasible"), 100% for concept accuracy (rated "very valid"), 95% for media (rated "very feasible"), and 96% for test items (rated "very feasible"). A limited item trial yielded 10 valid and 5 invalid questions, and the reliability of the valid items was 0.717, indicating high reliability. Practicality assessments

returned scores of 94% from teachers and 89% from students, supporting the e-module's feasibility and classroom practicality for eighth-grade science on disaster and mitigation. Pedagogically, the e-module frames disasters not only as natural phenomena but as socio-scientific problems that require science-informed solutions and concrete action.

## RECOMMENDATION

Based on the study, several directions for further work are recommended: expand the e-modules beyond disaster and mitigation for junior high school to other subjects; refine learning activities and interactive features to align more closely with SSI stages and science literacy competencies; examine teachers' perceptions of science literacy within SSI-based instruction; evaluate the module's impact on students' science literacy through a formal effectiveness test; consider integrating SSI-based modules into the curriculum to prepare students for complex global issues; investigate the long-term effects of the module on students' understanding and application of science in real contexts; and develop teacher training initiatives to support effective SSI integration and classroom practice.

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