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EFFECTIVENESS OF SOCIO-SCIENTIFIC ISSUE-BASED E-MODULES IN FORMING ECOSYSTEM LITERACY AND SOCIAL AWARENESS OF ELEMENTARY SCHOOL STUDENTS

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Abstract. This study aims to develop and analyze the effectiveness of an e-module based on Socio-Scientific Issues for the Integrated Science and Social Studies (IPAS) subject, specifically on the ecosystem topic for fifth-grade elementary school students. The main objectives include: (1) analyzing the development procedure, (2) evaluating the validity level, (3) measuring practicality, and (4) testing the effectiveness of the e-module in improving students' learning outcomes and critical thinking skills. The research methodology employed a Research and Development (R&D) approach using the Plomp model, consisting of five phases: preliminary investigation, design, realization, evaluation-revision, and implementation. The trial subjects comprised 25 fifth-grade students from SD Negeri 2 Dewantara. Data were collected through expert validation (7 multidisciplinary validators), practitioner observation, student response questionnaires, as well as pre-test and post-test assessments analyzed using Shapiro-Wilk normality tests and N-Gain calculations. The results indicate that the e-module is highly valid (average score 4.62–4.81), highly practical (observation average 4.63; practicality percentage 83.64%), and highly effective, student learning mastery significantly increased from 28% to 88%, with 36% of students achieving "high" improvement category based on N-Gain. Students' responses were overwhelmingly positive, with 100% expressing enjoyment and 88% finding the material easy to understand. In conclusion, the SSI-based e-module proves to be an innovative pedagogical solution that bridges scientific theory with real-world social issues, enhances learning motivation, strengthens science literacy and critical thinking, and is therefore suitable for adoption and replication in other elementary schools.

Keywords : E-Module; Socio-Scientific Issues; Ecosystem; Learning Effectiveness.

Introduction

In the 21st-century educational era, which emphasizes character building, critical, creative, collaborative, and communicative thinking, learning Natural and Social Sciences (IPAS) in elementary schools plays a central role. IPAS is not simply a transfer of knowledge, but vehicle For form participant educate Which capable logical thinking, innovation, and global competitiveness (Irsan, 2021; Sumanti et al., 2022). However, the reality on the ground, particularly at SD Negeri 2 Dewantara, presents challenges. significant. Results Study student on material ecosystem Still classified as sufficient, with average test scores ranging from 70-75. The main problem lies in the limited availability of innovative learning resources; available conventional textbooks tend to be static, fail to relate the material to current social phenomena, and are less able to arouse students' interest and sensitivity to environmental issues around them. Furthermore, based on initial observations and a more in-depth needs analysis, it was found that the learning process is still teacher-centered and does not utilize interactive digital learning media. This condition results in students being less actively involved in the learning process, resulting in low critical thinking skills and scientific literacy in understanding ecosystem concepts contextually. In response to this challenge, the development of technology-based teaching materials, particularly e-modules, is a relevant solution. E-modules offer flexibility, accessibility, And potential interactivity Which tall, answer trend style

Students in the Society 5.0 era are more familiar with digital devices (Mukaromah, 2020; Widiastuti, 2021). Recent research further strengthens the potential of e-modules. Istiqoma et al. (2023)

emphasized that e-modules can be a learning medium. independent Which effective, temporary Inanna (2021) highlight his role in facilitating distance learning. Furthermore, the integration of the Socio-Scientific Issues (SSI) approach into e-modules has been shown to improve students' critical thinking skills (Azizah et al., 2022; Febrina et al., 2023). The SSI approach encourages students to analyze scientific issues with social dimensions, such as ecosystem balance, through information evaluation, impact assessment, and decision-making. Nevertheless, there is a gap (research significant gap in the existing literature. Many studies on e-modules focus on technical aspects and their feasibility, but few have comprehensively integrated the SSI approach holistically into e-module design for elementary school students, particularly on complex topics such as ecosystems. Furthermore, there is inconsistency in implementation. A number of study state While there is widespread praise for the success of SSI e-modules, they are often not accompanied by an in-depth analysis of the validity of their pedagogical constructs, their practicality in real classroom contexts, and their effectiveness in comprehensively improving learning outcomes, including affective and cognitive aspects. Controversy also arises regarding whether SSI e-modules are truly accessible and well understood by elementary school students, given the level of complexity of thinking required by this approach.

Furthermore, previous research findings indicate that most e-module development still focuses on technical aspects and presentation, without systematically integrating Socio-Scientific Issues (SSI) into the learning structure. However, SSI integration is crucial for connecting scientific concepts to students' real-life situations, making learning more meaningful and contextual. Based on the background and identification of the gaps, this study was formulated to answer the question: How to develop a valid, practical, and effective Socio-Scientific Issue (SSI)-based e-module on the subject of natural sciences (IPAS) on ecosystem material for fifth-grade elementary school students? The purpose of this study is to analyze the development procedure, as well as to evaluate the level of validity, practicality, and effectiveness of the resulting e-module. The context of this study is learning at SD Negeri 2 Dewantara, North Aceh Regency, with the main unit of analysis being the e-module product itself, the learning process, and the responses and learning outcomes of 25 fifth-grade students.

Methodology Study

This research uses a Research and Development (R&D) approach by adopting the Plomp development model, which was chosen because of its systematic, procedural structure and suitability for developing technology-based learning products such as e-modules. The Plomp model consists of five main phases: (1) Preliminary Investigation, (2) Design, (3) Realization/Construction, (4) Test, Evaluation, and Revision, And (5) Implementation. Approach This considered valid And reliable because every phase each other related And done in a way iterative with process evaluation And continuous revision, ensuring the final product meets valid, practical, and effective criteria before implementation. Subject trials limited on 25 students class V Elementary School Country 2 Dewantara, Regency North Aceh was selected using purposive sampling because it was the initial location for problem identification and product development. This sample selection was relevant for assessing the practicality and effectiveness of the e-module in the real-life learning contexts faced by students.

Data was collected through mixed methods, both qualitative and quantitative, using various instruments:

1. Sheet Validation by 7 expert multidisciplinary (material, Language, strategy learning, technology, and design) to assess content and construct validity.
2. Observation Sheet and Questionnaire Practicality by 3 practitioners/observers to assess the implementation and ease of use of the e-module during learning.
3. Questionnaire Response Student For measure perception And interest student to e- module.
4. The Learning Outcome Test consists of a pre-test and post-test to measure the effectiveness of the e-module in improving understanding of ecosystem concepts.
5. Focus Group Discussion (FGD) with teachers, experts, and students to obtain holistic input on the product.
6. Interview with Teacher And student For delve into experience use e- module.

Furthermore, to strengthen data validity, this study also employed method triangulation techniques, comparing the results of questionnaires, observations, tests, and interviews. This aimed to ensure that the data obtained was consistent and could comprehensively describe the learning conditions.

Reliability And accuracy data guaranteed through analysis Which measurable:

1. Validity
   Measured by the average expert assessment score using a Likert scale (1-5), categorized based on the value range (mean >3.20 = very valid). The intraclass correlation test (ICC) with SPSS was used to ensure consistency between assessors.
2. Practicality
   Assessed based on the average observer score and the percentage of student responses (e.g., >80% = "easy" category). Practicality criteria also refer to ease of use, understanding, and implementation in the learning process.
3. Effectiveness
   Measured through improvement results Study with test N-Gain (Normalized Gain) to see the increase in students' understanding, as well as the Shapiro-Wilk normality test to ensure data pre-test And post-test distributed normal before analyzed further . The N-Gain interpretation criteria refer to the categories: high ($g > 0.7$), medium ($0.3 \leq g \leq 0.7$), and low ($g < 0.3$), so that it can provide a more measurable picture of the level of improvement in student learning outcomes.

Results Study

Procedure Development E- module

Procedure development follow model Plomp Which consists of from five Phases: Preliminary Investigation, Design, Realization, Test-Evaluation-Revision, and Implementation. The initial investigation phase identified real needs in the field: limited digital teaching materials, low learning motivation, and a lack of relevance of the material to social issues. The design phase produced an initial prototype based on the SSI approach in collaboration with the Canva and Flip PDF Professional applications. The realization phase produced an interactive digital product equipped with videos, quizzes, pre-tests, and post-tests. The evaluation phase involved iterative revisions based on input from experts, practitioners, and focus group discussions until a final product was created that was ready for implementation.

Level Validity E- Module

Validity was assessed by 7 multidisciplinary experts (materials, language, learning strategies, technology, design). The result show average score 4.62–4.81 on all aspect (organization, format, materials, language, and supporting videos), which are categorized as “Very Valid” (>3.20). The intraclass correlation (ICC) test showed a low value (0.073–0.318), meaning that the assessments between experts were consistent individually although not highly correlated. This is normal because each expert assessed different aspects. Thus, the e-module has met academic and pedagogical standards in terms of substance and construction and is suitable for use as teaching materials. Specifically, the highest-scoring aspects were material and curriculum alignment, while language and visual presentation also ranked highly valid. This demonstrates that the e-module is not only academically accurate but also communicative and visually appealing to students.

Level Practicality E- Module

Practicality was measured through observations by three practitioners during the learning process and questionnaire responses from 25 students. The average observation score was 4.63 (categorized as "Very Practical"). The percentage of practicality based on practitioners' assessments reached 83.64%, falling into the "Easy to Use" category (range 80–89%). Student responses were also positive: 100% stated like And interested, 88% state e-modul easy understood, And 75% felt confident in solving the problems. Therefore, the e-module was easy for teachers to implement and easy for students to understand, creating a fun and motivating learning environment. Interviews with students showed that using the e-module made learning more engaging due to the videos, images, and interactive quizzes. Students also stated that the material was easier to understand because of its contextual presentation and its connection to everyday life.

Level Effectiveness E- Module

Effectiveness was measured through improvements in student learning outcomes using pre-tests and post-tests, analyzed using N-Gain. The results showed that learning outcomes increased. significant from 28% (pre-test) become 88% (post-test). This improvement shows that SSI-based e-modules are able to facilitate a more meaningful learning process, where students not only memorize concepts, but also understand the

relationship between ecosystem concepts and real environmental issues they face. Results analysis N-Gain (Figure 1) shows that 36% of students achieved the "High" category (N-Gain >0.7), 56% the "Medium" category, and only 8% the "Low" category. Meanwhile, the Shapiro-Wilk normality test ensures that the data is normally distributed (p>0.05), so that the statistical analysis is valid. This can be confirmed by the e-module being proven effective in improving students' understanding of ecosystem concepts and critical thinking skills through a contextual SSI approach.

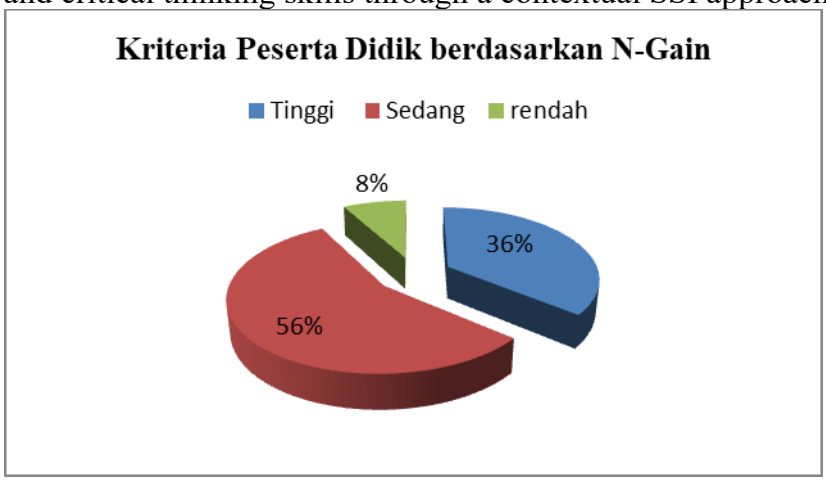

Figure 1Distribution of Learning Outcome Improvement Categories Based on N-Gain

This research successfully answered the four problem formulations through the development of an SSI-based e-module on ecosystem material for fifth-grade students of SD Negeri 2 Dewantara, as seen in Table 1. The final product was declared valid, practical, and effective based on a series of trials and systematic analysis.

Table 1. Interpretation findings in development e- module

No	Assessment Aspects	Interpretation Category	Results	Short
1	Mean Validity 4.62–4.81	Very Valid	Meets standard content And construction academic	
2	Average Practicality 4.63; 83.64%	Very Practical	Easy for teachers to use and loved by students	
3	N-Gain Effectiveness 56% Tall; 88% complete	Effectively	Improve understanding and learning outcomes	

Discussion

Results study prove that e-modul Which developed through model Plomp meets all of these criteria: valid, practical, and effective. These findings not only empirically answer the problem formulation but also make a significant contribution. to development media learning digital Which contextual,

relevant, and oriented towards strengthening character and scientific literacy at the elementary education level. The main contribution of this research lies in the holistic integration between learning technologies (e-module) And approach pedagogical SSI in One learning products Which measurable. In middle transformation education century 21st which requires students to have 4C abilities (critical thinking, creativity, collaboration, communication), as well as post-pandemic learning challenges that demand flexibility and digital adaptation, SSI-based e-modules are present as an innovative solution. Product This No only fulfil function technical as material teach digital, but also functions as a vehicle for forming critical attitudes, social concern, and awareness ecological through approach issues real Which near with student life (Purwaningsih et al., 2023; Vincent-Lancrin et al., 2019).

Theoretically, these findings reinforce constructivism theory, which states that knowledge is constructed through meaningful learning experiences. The SSI approach in e-modules allows students to construct knowledge through analysis of real-world issues, resulting in an integration of cognitive, affective, and social aspects of learning. Findings study show that procedure development e-modul through Plomp's five-phase model: Preliminary Investigation, Design, Realization, Test-Evaluation-Revision, and Implementation, has proven to be systematic and effective in producing products. end Which quality. Phase investigation beginning Which deep, including Analysis of student needs, characteristics, and resource availability provides a strong foundation for contextual and relevant product design. The collaboration between Canva and Flip PDF Professional enables visual, interactive, and accessible presentation of materials. through device digital, answer style Study generation Z Which familiar with technology (Rahayu et al., 2021; Sugiarni et al., 2024; Wulandari et al., 2024). E-modules can be an effective independent learning medium, especially when designed with user characteristics and learning context in mind (Safitri & Dafit, 2025; Setiyawan et al., 2024).

From aspect validity, e-modul stated very valid with average score 4.62–4.81 from the assessment of seven multidisciplinary experts. Content validity is met through the suitability of the material to curriculum And achievements learning, temporary validity construction This is achieved through consistency between e-module components, from structure, navigation, to multimedia integration. Although the intraclass correlation (ICC) test shows a low value (0.073–0.318), this does not reduce the validity of the product, because each expert assesses different aspects (material, language, design, technology, learning strategies), so that variation evaluation nature reasonable And precisely strengthen validity comprehensive product, that the validity of the product development must include content and construct validity as a whole (Setiawan et al., 2024).

In terms of practicality, the e-module was also found to be highly practical, with an average observation score of 4.63 and a practicality percentage of 83.64%. Teachers were able to implement the e-module smoothly, and students responded positively: 100% said they were happy, 88% said it was easy to understand, and 75% felt more confident in solving problems. The implementation of the learning process, which reached the "very good" category, indicates that the e-module is not only visually appealing but also functional in supporting learning activities. This confirms Sholihah's (2023) findings that e-modules can facilitate distance and independent learning, as well as Nurhafizah et al.'s (2024) research, which found that e-modules can increase students' interest in learning ecosystems . Findings most significant lies in the aspect of effectiveness. Analysis N-Gain show improvement results Study Which very significant: completeness Study increase from

28% (pre-test) to 88% (post-test). Fifty-six percent of students achieved the "high" improvement category (N-Gain >0.7), and 36% the "moderate" category. Shapiro-Wilk normality test ensure data distributed normal (p>0.05), so that analysis statistics This valid and reliable. This improvement not only measures conceptual mastery but also critical thinking skills through SSI-based questions that require analysis, evaluation, and decision-making on environmental issues. These findings reinforce Nur et al.'s (2023) argument that the SSI approach is effective in developing students' critical thinking and scientific literacy skills because it connects scientific concepts to social realities.

An unexpected finding that needs to be explained is that although the majority of students showed significant improvement, two students (8%) did not experience any improvement. (N-Gain = 0). Matter This can explained through analysis qualitative interviews, which show that both students have low learning motivation and lack of active involvement during the learning process, even though e-modules are available. This indicates that the effectiveness of e-modules depends not only on product quality, but also on external factors such as students' intrinsic motivation, teacher support, and the learning environment. Therefore, the implementation of e-modules needs to be accompanied by strategy mentoring And motivation by Teacher For ensure all over students are optimally involved.

The implications of this research are twofold: theoretical and practical. Theoretically, this study strengthens the theoretical framework of contextual learning and scientific literacy by demonstrating that the integration of SSI in digital media can improve conceptual understanding and higher-order thinking skills. Practically, this e-module provides a concrete solution for elementary school teachers who often lack innovative teaching materials. And contextual. Product This Ready adopted, replicated, or developed further for other materials or levels, especially in the context of the Independent Curriculum which emphasizes project-based learning and problem solving. However, this study also has several limitations. First, the trial subjects were limited to 25 students at one school (SD Negeri 2 Dewantara), so generalization of the findings should be done with caution. Second, this study only measured short-term effectiveness (improvement in learning outcomes after one learning cycle), and did not measure long-term retention or impact on students' social attitudes and behavior. Third, although the e-module was designed for independent access, this study was conducted in a classroom setting with teacher guidance, so it is not yet fully test ability e-modul as media Study independent pure.

Findings study this is also in line and strengthen previous research results in context education Indonesia. Nurhafizah's research et al (2024) in Civil: The Multidisciplinary Scientific Journal, which developed the ecosystem e-module, also found an increase in student learning interest, although it did not measure effectiveness through N-Gain in depth. Febrina et al.'s (2023) research in the Mathematics and Natural Sciences Education Journal, which developed the SSI e-module on the theme of Food Loss and Waste, also found an increase in critical thinking skills, but focused on junior high school students. Meanwhile, research by Yunus et al. (2023) in the journal Mathematics Education, which used the Plomp model, also confirmed the model's reliability in producing valid and practical digital learning products. These three studies, although different context material, each other strengthen findings that

The SSI approach and the Plomp development model are an effective combination in developing 21st century learning media.

CONCLUSION

This research successfully developed a valid, practical, and effective Socio-Scientific Issue (SSI)-based e-module for fifth-grade elementary school ecosystems. Using the Plomp development model, the e-module was validated by seven experts with an average score of 4.62–4.81 (very valid), was rated as very practical by teachers and students (average 4.63; practicality 83.64%), and was proven effective in increasing learning outcomes, increasing from 28% to 30%. 88%, with 56% student reach improvement category "tall" (N-Gain >0.7). This e-module is not just a digital tool, but a pedagogical solution that is capable of arousing interest, critical thinking, and concern environment student through Real-world issues are ready to be adopted to strengthen science learning in the digital age. Socio-Scientific Issues-based e-modules are not only effective as digital learning media but also as a means to improve students' scientific literacy, social awareness, and critical thinking skills, making them relevant for 21st-century learning.

SUGGESTION

1. Teachers are advised to integrate SSI-based e-modules in science learning to increase student engagement and understanding.
2. Further researchers can develop e-modules on other materials or different levels to test the consistency of their effectiveness.
3. Further research is needed to examine the long-term impact on students' scientific literacy and environmental attitudes.

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