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An Analysis of the Needs for Developing a CPS–EIS (Collaborative Problem Solving for Environmental Issue-Based Socio-Scientific Issues) Based Environmental Change E-Module as an Effort to Improve Students' Critical Thinking Skills

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Abstract: This study aims to analyze the need for developing an e-module based on Collaborative Problem Solving for Environmental Issue-Based Socio-Scientific Issues (CPS–EIS) on environmental change as an effort to improve students' critical thinking skills. This research employed a descriptive design with a needs analysis approach, conducted in December 2025 at a public high school in Karanganyar, involving 10th-grade students and biology teachers. Data were collected through Likert-scale questionnaires and interviews, then analyzed using percentage techniques and qualitative interpretation. The results indicate that although the level of difficulty of environmental change material was relatively low (42.57%), the current learning process remains less engaging and lacks structured problem-solving activities. Students showed a high need for multimedia integration (76.00%), strong readiness for collaboration (84.28%), and high interest in critical thinking-oriented learning (84.00%). From the teachers' perspective, there was an absolute need (100%) for e-modules that present real-life environmental cases, facilitate collaboration, provide clear problem-solving steps, and integrate multimedia elements. These findings highlight a gap between existing learning conditions and the expectations of interactive, student-centered, and contextual learning. In conclusion, the development of a CPS–EIS-based e-module is strongly needed as an innovative solution to support meaningful learning, bridge theory and real-world environmental issues, and enhance students' critical thinking skills in the digital era.

Keywords: Collaborative problem solving; CPS–EIS model; Critical thinking skills; Environmental change e-module; Needs analysis; Socio-scientific issues (SSI)

Introduction

Environmental change is a crucial topic in science education because it is closely linked to increasingly complex global issues, such as environmental pollution, climate change, ecosystem degradation, and unsustainable exploitation of natural resources. This phenomenon demonstrates that the relationship between human behavior and nature can significantly impact ecosystem stability (Fitriandhini & Putra, 2022). Therefore, learning about environmental change aims not only to provide students with conceptual understanding but also to foster awareness and responsibility for environmental sustainability.

In today's science education, the learning process focuses not only on mastering theory but also on developing higher-order thinking skills (Syahputra, 2024). One crucial skill in addressing various environmental issues is critical thinking (Ariadila et al., 2023). Critical thinking skills provide students with the opportunity to identify problems, analyze data logically, evaluate various opinions, and make decisions based on

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scientific facts (Manurung et al., 2023). With these skills, it is hoped that students will be able to understand various environmental issues.

The development of critical thinking skills is important because, according to Facione (2015), critical thinking encompasses the abilities of interpretation, analysis, evaluation, inference, explanation, and self-regulation. These skills are necessary for students to objectively assess evidence, evaluate various information related to environmental issues, and make decisions based on scientific facts. Furthermore, constructivist theory explains that knowledge is actively built thru individuals' interactions with their experiences and social environments (Darwati & Purana, 2021). Therefore, learning needs to be designed so that students are actively involved in the process of discovering, analyzing, and constructing knowledge, allowing critical thinking skills to develop optimally. That learning environments that actively engage students in discussion, inquiry, and problem-solving processes can significantly enhance critical thinking skills (Ho et al., 2023). The study shows that when students are encouraged to analyse information, evaluate evidence, and construct their own understanding through interaction and reflection, their abilities in clarity, logic, and depth of thinking improve.

However, science learning in schools often focuses on theoretical concepts and provides few opportunities for students to analyze and evaluate real-world problems (Rahmadhani, 2025). Learning is teacher-centered and contains teaching materials limited to textbooks or traditional modules. This results in students not being actively involved in the educational process and not gaining experiences that can hone their critical thinking skills. Consequently, students struggle to connect the scientific concepts they learn to everyday environmental phenomena. Critical thinking skills are essential to develop so that students become accustomed to responding to various problems using logical and reflective reasoning (Wanda et al., 2026). One method that can be applied to improve critical thinking skills in science learning is by integrating Socio-Scientific Issues (SSI) (Amelia et al., 2025). This method prioritizes scientific problems related to social and environmental issues as a context for learning, which encourages students to analyze various points of view, investigate controversial issues based on science, evaluate existing information, and consider various solution options (Faizah, 2025). Learning about environmental change, issues such as pollution, waste management, deforestation, and climate change can be used as an important context for training students' analytical and argumentative skills (Setiawan & Fadilah, 2023).

Constructivist learning methods, which place an emphasis on relating scientific ideas to real-world scenarios, are consistent with the application of Socio-Scientific Issues (SSI). Students actively create knowledge through SSI-based learning by investigating environmental concerns, assessing evidence from various sources, taking into account a variety of viewpoints, and formulating arguments supported by evidence. As a result, SSI offers worthwhile educational opportunities that foster the growth of critical thinking and scientific reasoning abilities.

In addition, the application of Collaborative Problem Solving (CPS) can also support the development of critical thinking skills because it emphasizes the collaborative problem-solving process through discussion, exchange of ideas, and joint decision-making (Sun et al., 2026). Through CPS, students not only learn to understand concepts but are also trained to identify problems, analyze relevant information, develop alternative solutions, and systematically evaluate decisions. The integration of CPS with the Environmental Issue-Based Socio-Scientific Issues (EIS) approach enables more contextual learning because students are directly involved in the analysis of real-life environmental problems (Prayitno et al., 2025). Vygotsky's social constructivist theory, which emphasizes the significance of social interaction in knowledge production, also supports the application of Collaborative Problem Solving (CPS). Students can learn in their Zone of Proximal Development (ZPD) by working together, where they can solve issues that might be challenging to handle on their own (Damanik et al., 2025). Students are encouraged to critically analyze information, defend their conclusions, consider other options, and reach decisions as a group through this cooperative process.

To support the implementation of this learning approach, teaching materials are needed that can facilitate interactive, contextual, and student-centered learning. This need is supported by previous studies indicating that interactive teaching materials promote active student engagement, encourage independent knowledge construction, and improve critical thinking skills by providing meaningful learning experiences and opportunities for exploration. Furthermore, contextual learning materials help students connect scientific concepts with real-world situations, making learning more relevant and fostering deeper understanding (Mardiyanti, 2026). One form of teaching material that can be used is an e-module. An e-module is a systematically compiled electronic teaching material designed to support independent learning through the use of digital technology (Erdi & Padwa, 2021). The advantage of e-modules lies in their ability to integrate various learning media, such as images, videos, animations, and problem-solving activities that can increase student involvement in the learning process

(Amalia et al., 2023). Thus, the use of e-modules can provide a more interactive and meaningful learning experience compared to conventional teaching materials.

Developing technology-based teaching materials requires a comprehensive needs analysis to ensure that the resulting product is appropriate to the learning context and needs (Saraswati et al., 2025). Needs analysis is an important initial stage in research and development because it aims to identify gaps between current learning conditions and desired conditions (Daniati et al., 2025). This analysis provides an understanding of student characteristics, the availability of teaching materials, and the needs of teachers and students for learning media that support the development of critical thinking skills.

Although constructivist learning theory suggests that students learn more effectively through active engagement, collaboration, and authentic problem-solving, classroom practices and existing teaching materials still tend to emphasize content delivery rather than knowledge construction. Consequently, students have limited opportunities to develop critical thinking skills through meaningful learning experiences. This gap provides a strong rationale for developing a CPS-EIS e-module that aligns with constructivist learning principles and supports the development of critical thinking skills in environmental change learning. The CPS-EIS e-module is designed around authentic environmental issues that are closely related to students' daily lives, including forest land conversion, pollution of the Bengawan Solo River caused by waste from ciu (traditional alcohol) production, and waste management challenges. These socio-scientific issues require students to collaboratively identify environmental problems, analyze their causes and impacts, evaluate scientific evidence, discuss alternative solutions, and make evidence-based decisions. Through engagement with these real-world environmental cases, students are expected not only to develop critical thinking skills but also to strengthen their environmental awareness, environmental responsibility, and commitment to sustainable environmental practices (Demssie et al., 2023). Such learning experiences are consistent with constructivist learning principles, which emphasize the active construction of knowledge through interaction with authentic contexts and collaborative learning experiences (Defianty & Wilson, 2024).

Based on this description, this study aims to analyze the need to develop an e-module based on Collaborative Problem Solving for Environmental Issue-Based Socio-Scientific Issues (CPS-EIS) as an effort to improve students' critical thinking skills in environmental change. This needs analysis is expected to form the basis for the next stage, namely the design and development of an e-module that is appropriate to student characteristics and aligned with the demands of 21st-century learning.

Method

This study was conducted in December 2025 during the even semester of the 2024/2025 academic year at a public senior high school in Karanganyar. The research employed a descriptive design with a needs analysis approach aimed at identifying the necessity for developing a CPS–EIS (Collaborative Problem Solving for Environmental Issue-Based Socio-Scientific Issues) e-module to enhance students' critical thinking skills. The needs analysis was conducted to understand the current learning situation, the availability of teaching materials, and students' and teachers' expectations for innovative learning media to support the improvement of critical thinking skills (Pratama et al., 2022). The population of this study consisted of all 10th-grade students and biology teachers involved in environmental change learning, while the sample included selected students and teachers who met specific criteria. A purposive sampling technique was applied, considering curriculum relevance, the suitability of environmental change materials, and the availability of respondents capable of providing comprehensive information about the ongoing learning process. The research variables focused on the need for CPS–EIS-based e-module development, including aspects of learning conditions, teaching materials availability, and support for critical thinking skills. Data were collected using questionnaires and interviews. The instruments used included a structured needs analysis questionnaire based on a Likert scale and an interview guideline. The student needs analysis questionnaire grid is presented in Table 1, while the teacher needs analysis grid is shown in Table 2.

Table 1. Student Needs Analysis Questionnaire Grid

Aspects	Indicator	I Item Number
Knowledge	Students' level of understanding of the concept of environmental change	1
Skills	Students' ability to solve environmental problems	3
Skills	Students' ability to work together or collaborate in learning	4
Skills	Students' critical thinking skills in analyzing environmental problems	5
Attitudes	Students' cooperative attitudes in solving problems in groups	6

Aspects	Indicator	I Item Number
Attitudes	Students' interest in learning that fosters critical thinking	7
Learning	Students' interest in the learning media used	8
Learning	Need for e-module-based teaching materials in learning	9
Learning	Need for e-module based on real-life cases related to environmental change	
Learning	Need for multimedia-based e-module (videos, images, graphs, and environmental data)	
Facilities and Infrastructure	Availability and utilization of technology (cell phones/laptops) in learning	10

Table 2. Teacher Needs Analysis Grid

Aspects	Indicators	I Item Number
Knowledge	Students' difficulties in understanding environmental change material	1
Knowledge	Limited learning resources on environmental issues	2
Knowledge	Teachers' understanding of the concept of Collaborative Problem Solving (CPS)	3
Skills	Lack of collaborative activities in learning	4
Skills	Lack of problem-solving activities in learning	5
Skills	Students' low critical thinking skills	6
Learning	Need for e-module based on real-life cases related to environmental change	7
Learning	Need for e-module that facilitates collaboration (CPS)	8
Learning	Need for e-module with clear problem-solving steps	9
Learning	Need for multimedia-based e-modules	10
Learning	Need for evaluations that train critical thinking	11
Attitude	Teachers' readiness to implement CPS-EIS e-module in learning	12

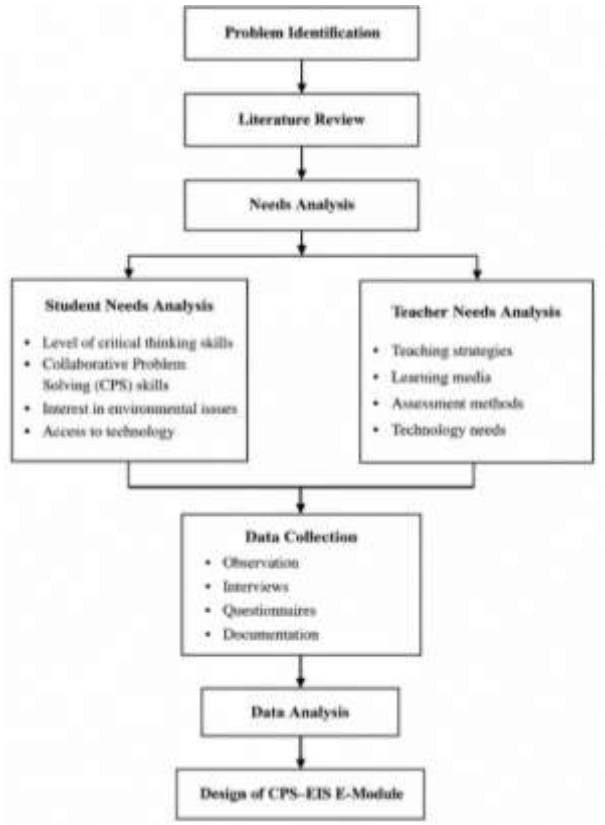

Figure 1. Flowchart of needs analysis for CPS–EIS e-module development

The research procedure was carried out in several stages, including (1) preliminary study through literature review and field observation, (2) development of research instruments based on identified indicators, (3) validation of instruments, (4) data collection through questionnaire distribution and interviews, (5) data tabulation and organization, and (6) interpretation of findings to determine the level of need for CPS–EIS e-module development. The flowchart of the research procedure is presented in Figure 1.

The data collection techniques in this study included observation, interviews, questionnaires, documentation. The questionnaires were used to obtain information about students' learning experiences, perceptions of the current teaching materials, and the need for digital learning media, such as e-modules. The interviews were conducted with biology teachers to gain a deeper understanding of the implementation of the learning process, the challenges faced in teaching environmental change, and the need for learning media that could support the development of students' critical thinking skills (Kalinovskaya, 2021).

The instruments used in this study included a needs analysis questionnaire for students and educators. Indicators for teacher needs analysis included students' difficulty understanding the material, limited learning resources, lack of collaborative activities, minimal problem-solving activities, students' critical thinking skills, the need for real-world cases in learning, the need for Collaborative Problem Solving (CPS) learning, the need for problem-solving steps, the need for multimedia in e-modules, the need for critical thinking evaluation, teachers' understanding of CPS, and readiness to implement the CPS–EIS e-module. Then, indicators for student needs analysis included understanding the material, interest in learning media, problem-solving experience, the need for real-world cases, the need for collaborative learning, the need for multimedia in e-

modules, the need for critical thinking exercises, technological readiness, readiness to work in groups, and interest in critical thinking learning. The questionnaire used a Likert scale to assess respondents' level of agreement with the statements presented. In addition, an interview guide was also developed to obtain more comprehensive data regarding learning strategies, the use of learning media, and the integration of socio-scientific issues in biology learning. The collected data were then analyzed by using descriptive statistical analysis and qualitative analysis. The completed questionnaires were then analyzed using a percentage technique with the following formula:

$$P = (f/N) \times 100\% \quad (1)$$

Description:
P = percentage
f = total score obtained
N = maximum score

The criteria for categorizing the level of needs are presented in Table 3. The percentage results were then categorized based on the level of need (very low, low, moderate, and high).

Table 3. Needs Category (Arikunto, 2019)

Percentage (%)	Needs Category
0–25	Very Low
26–50	Low
51–75	Moderate
76–100	High

The percentage results were then interpreted based on these categories to describe the level of need for developing CPS–EIS-based e-modules. Qualitative data from interviews were analyzed through data reduction, data display, and conclusion drawing to support and strengthen the quantitative findings.

Result and Discussion

Results

Based on the needs analysis questionnaire distributed to 70 respondents, the data processing was conducted by using a percentage formula to determine the tendency of student needs for the development of a Collaborative Problem Solving-based e-module. The detailed results of this data processing are presented in Tables 4 and 5.

Table 4. Results of Needs Analysis Data Processing

Statement Items	Total Score (f)	Percentage (P)	Needs Category
Environmental change material is difficult to understand	149	42.57%	Low
Current learning media are less engaging	176	50.28%	Moderate
Rarely encouraged to solve environmental problems	180	51.43%	Moderate
E-module contains real-life cases (SSI)	247	70.57%	Moderate
Desire for group work activities	260	74.28%	Moderate
E-module with multimedia (video/graphics)	266	76.00%	High
Need critical thinking practice	259	74.00%	Moderate
Accustomed to using a cell phone/laptop for learning	286	81.71%	High
Enjoy working in groups	295	84.28%	High
Interested in learning through critical thinking	294	84.00%	High

Based on Table 4, regarding the results of the needs analysis data processing, the main findings can be outlined as follows. First, regarding the identification of learning problems, the difficulty level of the environmental change material according to students was in the low category, with a percentage of 42.57%. Although the material was considered not too difficult, the quality of the learning media currently used, and student engagement in environmental problem-solving activities were still in the moderate category, with percentages of 50.28% and 51.43%, respectively. This indicates the need for innovation in learning media to increase student appeal and active participation in the classroom (No et al., 2024). The high demand for multimedia elements such as videos, illustrations, and graphics is supported by previous research indicating that multimodal learning materials help bridge abstract concepts with real-life experiences and significantly enhance student engagement and understanding (Zia et al., 2026)

Second, the results of the e-module need analysis indicate that the students have a high need for multimedia aspects, such as videos and graphics, with a percentage reaching 76.00%. The finding that students highly needed multimedia features such as videos and graphics is supported by recent research showing that multimedia-assisted modules can effectively enhance students' critical thinking and learning engagement (Hidayatullah et al., 2024). The content development aspects that included the use of real-life cases (Socio-Scientific Issues), group work in the CPS-EIS model, and critical thinking exercises were in the moderate category with a percentage range of 70.57% to 74.28%. These data validated that the structure of the e-module to be developed must be able to comprehensively accommodate these various needs. Thus, the e-module

functions not only as a digital learning resource but also as a learning tool capable of facilitating the development of critical thinking skills, problem-solving, and student collaboration in examining environmental change issues contextually (Neyarasmi & Mardatillah, 2025). The use of e-modules based on Education for Sustainable Development (ESD) can improve students' critical thinking abilities, especially in analyzing, synthesizing, problem-solving, and drawing conclusions, through case-based learning activities, discussions, and the use of pertinent and contextual materials related to environmental issues (Wulandari et al., 2025).

Third, the student characteristics and readiness to implement technology-based and collaboration-based e-module were recorded as high. This was evidenced by the high frequency of the students using mobile phones or laptops for learning (81.71%), a strong preference for group collaboration (84.28%), and a strong interest in practicing critical thinking skills (84.00%). The high percentage of students who preferred group work activities is consistent with the findings of Xu et al. (2023), who reported that collaborative problem solving significantly improves students' critical thinking skills and promotes active engagement in the learning process.

Table 5. Results of Teacher Needs Analysis Data Processing

Statement Items	Total Score (f)	Percentage (P)	Needs Category
Difficulty understanding the concept of environmental change	14	70%	Moderate
Learning resources on environmental issues are still limited in schools	13	65%	Moderate
Learning about environmental change rarely involves group discussions	14	70%	Moderate
Students are rarely encouraged to solve environmental problems in a structured manner	14	70%	Moderate
Students are less able to provide critical analysis when examining environmental issues	12	60%	Moderate
The need for e-modules that provide real-life cases related to environmental change	20	100%	High
The need for e-modules that facilitate collaboration in problem-solving	20	100%	High
The need for e-modules with clear problem-solving steps	19	95%	High
E-module should include videos, images, graphs, and data related to environmental issues	20	100%	High
E-module should provide questions that train critical thinking skills	20	100%	High
Understanding the concept of collaborative learning and problem-solving	16	80%	High
Readiness to implement the CPS-EIS e-module in learning	20	100%	High

A teacher needs assessment was conducted to identify issues in teaching and learning activities related to environmental change and the need to develop e-modules oriented towards Collaborative Problem Solving for Environmental Issue-Based Socio-Scientific Issues (CPS-EIS). The Collaborative Problem Solving for Environmental Issue-Based Socio-Scientific Issues (CPS-EIS) model shows potential in improving critical thinking skills and environmental responsibility (Prayitno et al., 2025). The results of the teachers' need analysis data processing can be seen in Table 5. The study revealed that the majority of indicators indicated a high demand for the development of new teaching materials. Regarding learning constraints, several indicators showed a moderate level of need, including students' difficulty understanding the idea of environmental change (70%), a lack of teaching materials related to environmental issues in schools (65%), and a lack of group discussions in environmental change studies (70%). Furthermore, the students were assessed as rarely being involved in structured environmental problem-solving (70%) and having difficulty providing in-depth analysis when assessing environmental issues (60%). Students' critical thinking skills can significantly improve thru interactive learning that involves analysis, evaluation, and problem-solving activities. Therefore, the low engagement of students in structured problem-solving becomes one of the reasons for the difficulty in producing in-depth analyzes of environmental issues (Dermawan, 2025). This indicates that current learning methods do not fully support the development of students' critical thinking skills and problem-solving capabilities (Saputro & Budiarto, 2026). In another section, regarding the need for teaching media design, all indicators showed the highest level of need. The teachers expressed a very strong need for e-modules that include real-life case studies related to environmental change (100%), facilitate collaboration in solving problems (100%), and provide clear problem-solving steps (95%). Furthermore, the e-module is expected to contain various multimedia elements, such as recordings, illustrations, charts, and information related to environmental issues (100%), and present questions that can hone the students' critical thinking skills (100%). This finding is in line with the research by Amanda et al. (2025), which shows that context-based environmental e-modules equipped with higher-order thinking

activities are effective in enhancing critical thinking skills.

Discussion

The results of the needs analysis indicate a significant gap between actual learning conditions and the expectations of both students and teachers. Although environmental change material was considered to have a low level of difficulty by students (42.57%), the low quality of learning media (50.28%), and the lack of involvement in problem-solving activities (51.43%), it indicated that the current learning process tends to be theoretical and less applicable. This is in line with the view that learning biology on environmental material requires a contextual approach so that students can connect scientific concepts with real phenomena around them (Fajeriadi, 2024).

The high demand for multimedia aspects (76.00%) confirms that today's students are digital natives who more easily absorb information through dynamic visualizations such as videos and data graphics (Kusmardiningsih, 2024). The integration of multimedia in e-modules not only serves to increase attractiveness but also acts as a cognitive aid to simplify complex environmental phenomena (Razilu et al., 2026). Furthermore, support for the use of real-world cases or Socio-Scientific Issues (70.57%) reinforces the urgency of implementing the Collaborative Problem Solving (CPS) model. Through socio-scientific issues, students are encouraged to develop argumentation and decision-making skills based on scientific evidence (Dianti et al., 2023). The most crucial finding was students' strategic readiness, which was high in terms of collaboration (84.28%) and interest in critical thinking skills (84.00%). This demonstrates that the study subjects possess sufficient social and cognitive maturity to implement the CPS-EIS model. High technological readiness (81.71%) also minimized technical barriers to future digital media implementation.

From a teacher's perspective, the analysis results indicated a very high demand (100%) for teaching materials that can facilitate collaboration in solving problems through clear steps. The teachers confirmed that the current learning methods did not fully support the growth of the students' critical thinking skills (60%). This indicates that the learning process still needs to be developed to further encourage students to analyze, evaluate, and solve problems actively (Pangesti et al., 2025). Therefore, the development of CPS-EIS-based e-modules is the right pedagogical solution to bridge the needs of teachers and students for interactive, collaborative, and real-world problem-based learning in the digital era. The full support of teachers (100%) for the need for real case studies, collaboration features, and multimedia integration demonstrates the importance of contextual and student-centered learning (Khadijah et al., 2025). Interactive digital learning media integrated with socio-scientific issues and equipped with multimedia features such as videos, quizzes, and simulations can actively engage learners in identifying problems, analyzing information, and building arguments (Febliza et al., 2023). Moreover, issue-based learning encourages students to evaluate evidence and make decisions based on scientific reasoning, thereby enhancing critical thinking and problem-solving skills.

The students' high technological infrastructure readiness (81.71%) was a key factor in implementing the digital-based e-module. Therefore, the results of this needs analysis provide a strong foundation for continuing to the development stage of the CPS-EIS e-module, an effort to improve students' critical thinking skills in line with the demands of 21st-century learning. The need for critical thinking-oriented questions is consistent with Rahman et al. (2024), who reported that problem-based e-modules effectively promote students' critical thinking skills.

Conclusion

This study concludes that there is a strong and urgent need to develop a CPS–EIS (Collaborative Problem Solving for Environmental Issue-Based Socio-Scientific Issues) based e-module on environmental change as an innovative learning solution to enhance students' critical thinking skills. Although students perceived the material as relatively easy, the current learning process remains less engaging, minimally interactive, and limited in facilitating problem-solving activities. Both student and teacher analyses reveal a high demand for teaching materials that integrate multimedia, real-life environmental cases, collaborative learning, and structured problem-solving steps. Students also demonstrate high readiness in terms of technology use, collaboration, and interest in critical thinking-oriented learning, while teachers express full support for the development of contextual, interactive, and student-centered e-modules. These findings indicate a clear gap between existing learning conditions and the expectations of 21st-century education, emphasizing the importance of developing a CPS–EIS-based e-module that aligns with constructivist principles, promotes active knowledge construction, and bridges theory with real-world environmental problem-solving. Therefore, this needs analysis provides a strong foundation for the design and development of an e-module that is capable of fostering critical thinking skills and meaningful learning experiences in the digital era.

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Author Contributions
Endah Pratiwi contributed to the research conceptualization, methodology development, software provision, validation process, formal analysis, investigation implementation, resource provision, data curation, writing the original draft, writing and reviewing and editing the manuscript, data visualization, supervision, and project administration. Then, Baskoro Adi Prayitno contributed to the research conceptualization, methodology development, validation process, formal analysis, investigation, resource provision, data curation, writing the original draft, reviewing and editing the manuscript, supervision, project administration, and funding acquisition. Meanwhile, Umi Fatmawati contributed to the research conceptualization, software development, validation process, resource provision, writing the original draft, reviewing and editing the manuscript, supervision, and project administration.

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Conflicts of Interest
The authors declare no conflict of interest.

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