Chemined 14 (1) (2025)

Chemistry in Education

https://journal.unnes.ac.id/journals/chemined

Development of E-Module Teaching Materials Based on Socio-Scientific Issues to Improve Students' Science Literacy on The Global Warming Topic

Amalia Cahya Anggraheni[1*)], Ulfa Lutfianasari[1]

[1]Department of Chemistry, Faculty of Science and Technology, Universitas Islam Negeri Walisongo, Indonesia

ARTICLE INFO

Article history:
Received: April 2025
Approved: June 2025
Published: July 2025

Kata Kunci:
E-modul, Literasi Sains, Socio Scientific Issue, Pemanasan Global

Keywords:
E-module, Science Literacy, Socio Scientific Issue, Global Warming

DOI:
10.15294/chemined.v14i1.23530

ABSTRAK

Pendidikan di Indonesia mengalami perubahan kurikulum melalui penerapan Kurikulum Merdeka. Salah satu tantangan yang dihadapi adalah keterbatasan ketersediaan bahan ajar yang berdampak pada proses pembelajaran siswa. Selain itu, rendahnya literasi sains siswa menjadi persoalan yang memerlukan perhatian khusus. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan e-modul berbasis isu sosio-saintifik (SSI) guna meningkatkan literasi sains siswa. Tujuan khusus dari penelitian ini meliputi: (1) mengetahui kelayakan e-modul yang dikembangkan, (2) mengetahui respons siswa terhadap e-modul, serta (3) mengevaluasi efektivitas e-modul dalam meningkatkan literasi sains siswa. Penelitian ini merupakan jenis Research and Development (R&D) dengan menggunakan model pengembangan 4D yang terdiri atas tahap define, design, develop, dan disseminate. E-modul yang dikembangkan telah divalidasi oleh lima ahli dengan tingkat validitas yang sangat tinggi, yaitu 90,3% untuk aspek isi dan 90% untuk aspek media. Respons siswa terhadap e-modul menunjukkan hasil yang sangat baik, dengan rata-rata skor sebesar 60,85 untuk kelas X-3 dan 61,59 untuk kelas X-4. Uji efektivitas menggunakan N-gain menunjukkan hasil yang signifikan, yakni sebesar 0,735 (kategori tinggi) untuk kelas X-3 dan 0,677 (kategori sedang) untuk kelas X-4. Hasil penelitian ini menunjukkan bahwa e-modul berbasis isu sosio-saintifik efektif dalam meningkatkan literasi sains siswa pada topik pemanasan global.

ABSTRACT

Indonesian education has undergone a curriculum change in the form of the "Merdeka Curriculum," where one of the challenges faced is the limited availability of teaching materials, which affects the learning process of students. Another challenge Indonesia faces is the low level of scientific literacy among students. Therefore, it is necessary to develop teaching materials in the form of an e-module based on socio-scientific issues to improve students' scientific literacy. The purpose of this study is to determine the feasibility, student responses, and effectiveness of the e-module, as well as to analyze the improvement in students' scientific literacy. This type of research is Research and Development (R&D) using the 4D development model, namely define, design, develop, and disseminate, to produce a product that is suitable for use. The developed e-module was validated by five experts and achieved a high validity level (90.3% for content and 90% for media). Student responses to the e-module showed very good results, with an average score of 60.85 for class X-3 and 61.59 for class X-4. The N-gain test showed significant effectiveness, with a score of 0.735 (high category) for class X-3 and 0.677 (medium category) for class X-4. The results of this study indicate that the socio-scientific issue-based e-module is effective in improving students' scientific literacy on the topic of global warming.

*) **Correspondence address:**
Jln. Prof. Hamka (kampus III), Kec. Ngaliyan, Semarang 50185
E-mail: amaliacahyaanggraheni@gmail.com

p-ISSN 2252-6609
e-ISSN 2502-6852

INTRODUCTION

Indonesia's education has recently shown its ability to achieve improvements in the quality and standard of education through the renewal of the curriculum, namely the *Merdeka Curriculum* (Pratikno, 2022). Students in the *Merdeka Curriculum* are granted the freedom to develop and explore their own abilities (Jojor & Sihotang, 2022). The implementation of this curriculum learning expects students to learn independently, be active, and not rely on the teacher (Hasmiati et al., 2024). The *Merdeka Curriculum* emphasizes literacy in various aspects, more specifically on literacy in classroom learning (Muliaman et al., 2023).

Literacy skills are very important because they affect students' success in learning and daily life (Mifidah, 2023). Scientific literacy is the ability to apply existing facts with existing knowledge and to identify and draw conclusions (Nasution et al., 2019). During classroom learning, it is important for students to have the ability to understand scientific literacy because the chemistry learning process is inseparable from phenomena in everyday life (Astuti, 2023).

The scientific literacy skills possessed by Indonesian students are currently categorized as low. The results of the PISA 2022 report show that the scientific literacy of Indonesian students has not increased significantly, with the scientific literacy score decreasing by 13 points to 383 (OCDE, 2024). Based on these data, it indicates that the scientific literacy implemented in Indonesia falls into the low category; thus, it can be considered that Indonesian students have a limited awareness of the existence of science (Yusmar dan Fadilah, 2023).

Several aspects affect the low scientific literacy capability of Indonesian students, one of which is the use of inadequate teaching materials (Kartika, 2019). Teaching materials are tools or media used by educators to achieve the intended learning competencies (Agustina dan Okmarisa, 2023). Students can develop their potential through appropriate teaching materials (Yuliana, 2023). Based on an interview with a teacher from SMA N 1 Purbalingga, the *Merdeka Curriculum* is currently a revision of *Curriculum 13*. During the learning process, students use teaching materials in the form of textbooks and student worksheets (LKPD), which are occasionally used to support practicum activities. The available textbooks have limitations due to their simplicity and the need for access to external links, as well as suboptimal quality that requires improvement.

The limitations of printed teaching materials open opportunities for innovation in teaching materials through information technology to support the achievement of 21st-century skills. The teaching materials developed must be feasible, independently usable, and easily accessible by students following current developments (Trisnawati, 2024). The *Merdeka Curriculum* also requires teachers to be creative and innovative in developing teaching materials, as teachers play an important role in supporting the success of the learning process (Noorhapizah et al., 2023).

Based on the student needs questionnaire, it was shown that the media most frequently used by students in their learning activities was textbooks provided by the school, with a percentage of 93.75%. Furthermore, students stated that classroom learning related to socio-scientific issues in the global warming topic reached 31.25%. In addition, the results of the student needs questionnaire also indicated that 84.375% of students found chemistry questions related to scientific literacy to be difficult. An alternative that can be undertaken to address this issue is to develop teaching materials that support a high-quality learning process for students (Tampubolon, 2022). E-modules can serve as a solution to the limitations of textbooks that have not been optimally used in the learning process.

E-modules are classified as a type of interactive teaching material. Interactive teaching materials have the potential to create interaction between the media and students. E-modules are a learning resource that focuses on a specific topic and is presented in the form of an electronic book, which serves as a self-learning source aimed at improving students' competence and understanding of the material (Safitri dan Sari, 2022). E-modules are designed more interactively and have flexible characteristics, making them easier to carry and access anytime and anywhere compared to printed teaching materials (Mufida et al., 2022). The advantages of e-modules include content that reflects real-world contexts; the development of science-based reading materials; and the presentation of information such as facts, concepts, and procedures. Another advantage of e-modules is the inclusion of instructional videos to broaden students' insights (Asrizal, 2020).

Based on the problems that have been presented, it is necessary to implement a learning method that can positively affect scientific literacy (Vonna, 2022). The learning method applied in this study is Socio-Scientific Issue (SSI)-based learning. The socio-scientific issue approach is an appropriate method to support the chemistry learning process because the current learning process has not yet integrated scientific issues with social issues. The socio-scientific issue approach is based on the principle that students are confronted with conditions and problems present in their environment and connected to knowledge related to social activities (Purwanto, 2022). Teaching materials in the form of e-modules through a socio-scientific issue-based approach broaden insights in the chemistry learning process by developing students' understanding of chemistry and their awareness of the actions needed to solve problems (Fitriani, 2023). The use of the Socio-Scientific Issue approach in chemistry learning can be implemented because this approach involves contextual issues occurring in Indonesia that are important to be raised during the learning process so that students can stimulate their scientific literacy skills (Marneli dan Susanti, 2023).

The chemistry subject that is directly related to socio-scientific issues is global warming. Global warming is included as one of the topics in the chemistry learning outcomes for phase E at the senior high school (SMA/MA) level. The Indonesian government considers it important to study this topic due to various natural phenomena that have emerged as a result of global warming (Tamara dkk., 2019). In

addition, as the real impacts of global warming become more apparent, there is a need for educational efforts to expand students' knowledge and understanding of this topic (Camelia, 2022).

METHODS

Development model used in this study was the 4D model, which consisted of four stages: Define, Design, Develop, and Disseminate. Efforts to address problems in the learning process had to align with the needs and conditions of the students, as well as to facilitate the research in developing e-module teaching materials. The 4D development model was chosen because it offered a systematic and flexible approach that was highly feasible for product development and supported the enhancement of effectiveness, interactivity, and depth of material understanding by students (Yuliana, 2023).

The first stage in this development was the defining stage. The purpose of the define stage was to determine and describe the requirements for developing the e-module. The following actions needed to be carried out during the define stage: Front-End Analysis, Learner Analysis, Task Analysis, Concept Analysis, and Specifying Instructional Objectives.

After the analysis results were obtained in the define stage, the next step was to develop the e-module with content based on SSI (socio-scientific issues) about global warming. In the design stage, several steps were carried out, namely: Media Selection, Format Selection, and Initial Design.

Process of producing the final e-module is known as the development stage. In the development stage, the first step carried out was expert validation, which included product validation and item validation. Then, the validated product and items were tested on students. The dissemination was conducted by distributing the e-module based on socio-scientific issues containing global warming material to senior high schools (SMA/MA) in Purbalingga.

RESULT AND DISCUSSION

Result

Determining and describing the requirements for developing the e-module was the objective of the defining stage. The following actions were carried out during the define stage: Front-End Analysis using a combination of literature review and field study methods. The literature review involved searching for several relevant references in the research. The field study was conducted through observation and interviews with senior high school chemistry teachers. Subsequently, learner analysis was conducted with the aim of identifying problems experienced by students during the learning process. The researcher conducted this stage by distributing a needs questionnaire to grade X students of SMAN 1 Purbalingga. Then, task analysis was carried out to identify various competencies required by grade X students at SMAN 1 Purbalingga. This task analysis identified the learning outcomes (CP). The final

stage, concept analysis, aimed to analyze the teaching module, particularly on the topic of global warming.

After the analysis results were obtained in the define stage, the next step was to develop the e-module with content based on SSI (socio-scientific issue) about global warming. In the design stage, several steps were carried out as follows: Media Selection aimed to choose the type of media that suited the needs and interests of grade X students at SMAN 1 Purbalingga. Based on the selected media, the format selection for the writing structure in the e-module development referred to the Ministry of National Education (Depdiknas) in 2008. The SSI (Socio-Scientific Issue)-based e-module served as the foundation for the creation of this product. After the necessary components were determined, the e-module draft was refined.

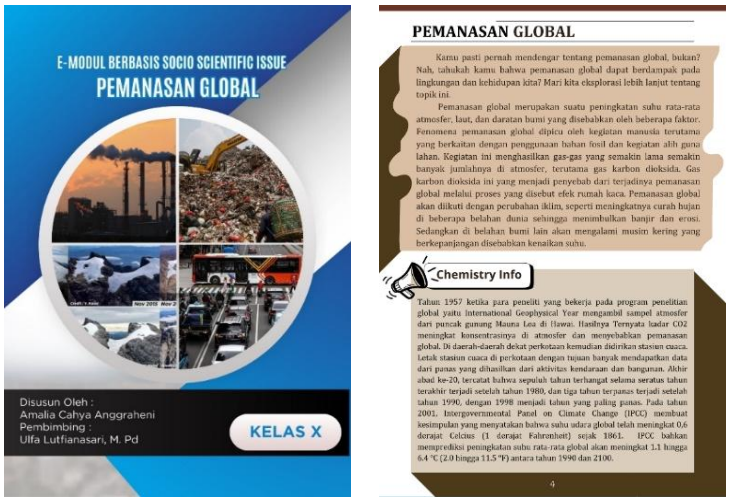

Figure 1. Content Design of the E-Module

The process of producing the final e-module is known as the development stage. In the development stage, several steps were carried out as follows: e-module testing and item testing. E-module testing consisted of expert validation and product testing. The purpose of the expert validation phase was to determine whether the developed SSI-based e-module on the topic of global warming was feasible for trial use. The validation process consisted of five material expert validations and media expert validations. The product testing aimed to obtain feedback in the form of students' responses to the developed e-module. Meanwhile, the scientific literacy item testing consisted of item validation and item trial. The following are the results of the e-module validation and item validation.

Table 1. Results of Material Expert Evaluation

No	Aspect	Number of Indicators	$\bar{X}$	%	Category
1	Material Delivery	3	14	93,3	Very Feasible
2	Content	5	22,6	90,4	Very Feasible
3	Language	4	17,6	88	Very Feasible
	Overall	12	54,2	90,3	Very Feasible

Table 2. Results of Media Expert Validation

No	Aspect	Number of Indicators	$\bar{X}$	%	Category
1	Graphic Feasibility	7	31,4	89,71	Very Feasible
2	Display Quality	1	4,4	88	Very Feasible
Overall		8	36	90	Very Feasible

Tabel 3. Results of Item Expert Validation

No	Aspect	Number of Indicators	$\bar{X}$	%	Category
1	Fill	5	23,2	92,8	Very Feasible
2	Science Literacy	3	13,4	89,3	Very Feasible
3	Contruction	6	26,4	88	Very Feasible
4	Language	2	9,2	92	Very Feasible
Overall		16	72,2	90,24	Very Feasible

After the developed e-module was declared feasible by the validators, the next step was to proceed to the product trial stage with students and the product effectiveness testing stage. Grade X-3 and Grade X-4 students were the respondents used for the trial of the developed product.

Table 4. Results of the Questionnaire on Student Responses from Class X-3

No	Aspect	Number of Indicators	$\bar{X}$	Category
1	Presentation	7	30,15	Very Good
2	Material	3	13,15	Very Good
3	Language	3	13,12	Very Good
4	Easy of Use	1	4,42	Very Good

Table 5. Results of the Questionnaire on Student Responses from Class X-3

No	Aspect	Number of Indicators	$\bar{X}$	Category
1	Presentation	7	30,34	Very Good
2	Material	3	13,28	Very Good
3	Language	3	13,47	Very Good
4	Easy of Use	1	4,5	Very Good

The results obtained from the product trial showed a total average score of 60.85 for class X-3 and 61.59 for class X-4, with the category obtained being "Very Good." Based on this category, the e-module based on socio-scientific issues can be used as a learning resource for students, particularly for the topic of global warming.

The dissemination stage of the e-module based on socio-scientific issues on the topic of global warming that had been developed was the final stage of the R&D process. The dissemination was carried out by distributing the e-module based on socio-scientific issues containing global warming material to MA Tahfidzul Qur'an Darussalam Purbalingga, MA Tahfidzul Qur'an Sambas, MA Minhajut Tholabah Kembangan, SMAN 1 Kemangkon, and MAN Purbalingga. The e-module was sent to the principals of these schools via the WhatsApp platform to be used as a learning medium by chemistry teachers.

Discussion

Final product produced was an e-module that had been tested for its effectiveness. The developed e-module was based on socio-scientific issues, and the selected material was the topic of global warming. This study aimed to provide teaching materials to support students in independent learning. The 4D development approach, which consists of the following steps: define, design, develop, and disseminate, was used to create this e-module. The developed e-module had undergone validation testing by five validators who were experts in content and media.

Validation results presented in **Tables 1, 2, and 3** were declared feasible by both content experts and media experts. The total percentage from the content expert validation was 90.3%, the media expert validation was 90%, and the item expert validation showed a result of 90.25%. The category "Very Valid" was obtained from the validation results. The electronic module was refined based on suggestions and feedback from the validators to ensure its feasibility for the trial phase. After the developed e-module was declared feasible by the validators, the next step was to proceed to the product trial stage with students and the product effectiveness testing stage.

Grade X-3 and Grade X-4 students were the respondents used for the trial of the developed product. The results obtained from the product trial showed a total average score of 60.85 for Class X-3 and 61.59 for Class X-4, with the category obtained being "Very Good." Based on this category, the e-module based on a socio-scientific approach can be used as a learning resource for students, particularly for the topic of global warming.

The N-gain test was used to determine the improvement in students' scientific literacy after receiving the treatment. The N-gain test could be measured after the pre-test and post-test had been administered.

Table 6. Results of the N-Gain Test

Test	Class X-3	Class X-4
N-Gain Value	0,735	0,58
% N-Gain	73,5	58,01
Categori	High	Moderate

The treatment in Class X-3, which involved learning using the e-module, resulted in an N-gain score of 0.735, categorized as high. Meanwhile, Class X-4, which received conventional instruction using a textbook, obtained an N-gain score of 0.58, categorized as moderate. After different treatments were applied to each class, the results showed an improvement. The difference observed was that Class X-3 experienced a higher increase compared to Class X-4. The conclusion obtained from this study is that the development of an e-module based on socio-scientific issues can improve students' scientific literacy on the topic of global warming.

CONCLUSION

Development of the e-module teaching material on the topic of global warming is feasible for use in learning. This is supported by the validation results of the e-module conducted by five validators, with the score from the content expert validation being 90.3% in the "Very Feasible" category and the media expert validation yielding 90% in the "Very Feasible" category. Therefore, the developed e-module is considered feasible for use in learning the topic of global warming. Students' scientific literacy improved after learning using the e-module based on socio-scientific issues. This was observed from the results of the pre-test and post-test on scientific literacy questions obtained by students after the treatment, which showed an increase. Based on the results of the N-gain test, the N-gain score for Class X-3, which received treatment using the e-module, was 0.735 and categorized as high, while Class X-4, which served as the comparison group and received instruction through a textbook, obtained a score of 0.677 and was categorized as moderate.

In order for the developed e-module to be of better quality, there are various suggestions that can be made, namely: The material in the e-module based on socio-scientific issues needs to be disseminated to other chemistry materials. Then the use of this e-module should be expanded to various schools with different student characteristics. This is important to test the effectiveness of the e-module in various conditions and obtain more diverse feedback for further development.

REFERENCE

Agustina, D., dan Okmarisa, H. (2023). Pengembangan E-Lkpd Berbasis LSlC Untuk Mendukung Literasi Sains Siswa Pada Materi Kesetimbangan Kimia. *Konfigurasi : Jurnal Pendidikan Kimia dan Terapan*, *7*(1), 43.

Camelia, S. (2022). Pengembangan Bahan Ajar untuk Menunjang Pembelajaran Kurikulum Merdeka pada Materi Konsep dan Dampak Pemanasan Global Fase E SMA/MA. *Jurnal Pendidikan MIPA*, *12*(September), 682–689.

Fitriani, R. (2023). Development of Environmental Pollution E-Module Containing Socio Scientific Issue to Train Students' Scientific Literacy. *Journal of Environmental and Science Education*, *3*(1), 14–20.

Hasmiati, H., Fawzani, N., & Muhlis, W. (2024). Implementasi Kurikulum Merdeka Untuk Mengembangkan Kreativitas Peserta Didik Di Sekolah Dasar. *Jurnal Pendidikan Dasar*, *14*(2), 158–170.

Kartika, I. (2019). Pengembangan Bahan Ajar Berbasis Socio scientific Issue pada Materi Bioteknologi Untuk Meningkatkan Literasi Sains Siswa. *Journal of Science Education And Practice*, *x*, 1–12.

Marneli, D., dan Susanti, F. Y. (2023). Development of Socioscientific Issues-Based E-module on Environmental Change Topic. *Jurnal Biolokus: Jurnal Penelitian …*, *5*(2), 160–165.

Mifidah, L. (2023). Pengaruh Learning Cycle 5E Berbasis Masalah Lokal Terhadap Environmental

Literacy Siswa pada Kurikulum Merdeka Materi Perubahan dan Pelestarian Lingkungan Hidup Kelas X SMA NU Al Ma ' ruf Kudus. *JEID Journal of Educational Integration and Development*, *3*(1), 54–70.

Mufida, L., Subandowo, M. S., & Gunawan, W. (2022). Pengembangan E-Modul Kimia Pada Materi Struktur Atom Untuk Meningkatkan Hasil Belajar. In *JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)* (Vol. 7, Nomor 1).

Muliaman, A., Sakdiah, H., Wahdi Ginting, F., & Sabrin, N. (2023). Analisis Employability Skill dan Literasi Sains Siswa melalui Authentic Self-Assessment pada Kurikulum Merdeka di Sma Aceh Utara. *JPF (Jurnal Pendidikan Fisika) Universitas Islam Negeri Alauddin Makassar*, *11*(1), 24–32.

Nasution, I. B., Liliawati, W., & Hasanah, L. (2019). Development of scientific literacy instruments based on pisa framework for high school students on global warming topic. *Journal of Physics: Conference Series*, *1157*(3).

Noorhapizah, N., Pratiwi, D. A., & Putri, T. A. S. (2023). Pelatihan Pengembangan Bahan Ajar Berbasis Muatan Lokal dalam Implementasi Kurikulum Merdeka. *Bubungan Tinggi: Jurnal Pengabdian Masyarakat*, *5*(1), 63.

OCDE. (2024). PISA 2022. Notas por país: México. In *Perfiles Educativos* (Vol. 46, Nomor 183).

Pratikno, Y. (2022). Human Resource "Kurikulum Merdeka" from Design to Implementation in the School: What Worked and What not in Indonesian Education. *Jurnal Iqra' : Kajian Ilmu Pendidikan*, *7*(1), 326–343.

Purwanto, A. (2022). Socio-Critical and Problem-oriented Approach in Environmental Issues for Students ' Critical Thinking. *Journal of Technology and Science Education*, *12*(1), 50–67.

Safitri, R., dan Sari, M. (2022). Pengembangan E-Modul Kimia Berbasis Sets (Science, Environment, Technology, and Society) Untuk Siswa Sman 1 Kecamatan Payakumbuh. *Journal of Chemistry Education and Integration*, *1*(1), 9.

Tamara, N. C., Supriyati, Y., & Fahdiran, R. (2019). *Pengembangan Bahan Ajar Dampak Pemanasan Global Berbasis Problem Based Learning Management System (Lms) Schoology*. *VIII*, SNF2019-PE-281–290.

Tampubolon, I. W. (2022). E-Module Development Based on Problem Based Learning (PBL) on Material Class X High School Chemistry Association. *Jurnal Mekintek : Jurnal Mekanikal, Energi, Industri, Dan Teknologi*, *13*(1), 69–74.

Trisnawati, F. P. (2024). Studi Literatur : Pengaruh E-Modul terhadap Hasil Belajar Siswa. *Jurnal Pendidikan Tambusai*, *8*(1), 7149–7156.

Vonna, A. M. (2022). *Pengembangan Media Pembelajaran Berbasis Kontekstual Lembar Kerja Peserta Didik Elektronik (E-LKPD) Berbantuan Liveworksheet*.

Yuliana, V. (2023). Pengembangan E-Modul Kimia Interaktif Berbasis Pendekatan Saintifik Menggunakan Liveworksheets pada Materi Laju Reaksi. In *JIPK* (Vol. 17, Nomor 1).

Yusmar, F., dan Fadilah, R. E. (2023). Analisis Rendahnya Literasi Sains Peserta Didik Indonesia: Hasil Pisa Dan Faktor Penyebab. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, *13*(1), 11–19.