Jurnal Inovasi dan Teknologi Pembelajaran
Vol 10, No 2, (2023), page 129-140
https://doi.org/10.17977/um031v10i22023p129
P-ISSN: 2406-8780 E-ISSN: 2654-7953
Open access: http://journal2.um.ac.id/index.php/jinotep/index

Development of e-modules based on socio-scientific issues on Chemistry content

Fransiska Putri Sonia Ndruru*, Susilawati Amdayani

Department of Chemistry, Medan State University
Jl. Pancing, Kenangan Baru, Kec. Percut Sei Tuan, Kab. Deli Serdang, Sumatera Utara 20221
**Corresponding author, e-mail: fransiskapsndr13@gmail.com*

ARTICLE INFO

Article history:
Received: 04-04-2023
Revised: 13-05-2023
Accepted: 05-06-2023

Kata kunci:
E-modul;
Socio scientific issues;
momen kappa;
validitas;
kepraktisan.

Keywords:
E-module;
Socio scientific issues;
kappa moment;
validity;
practicality.

ABSTRAK

Penelitian ini dilatarbelakangi oleh motivasi siswa yang rendah. Hasil belajar siswa pada materi sifat koligatif larutan juga rata-rata masih di bawah Kriteria Ketuntasan Minimal. Sumber belajar yang digunakan berupa buku ajar dan masih belum terintegrasi socio scientific issues. Penelitian ini bertujuan untuk mengetahui tingkat validitas, kepraktisan, dan efektivitas dari e-modul yang dikembangkan. Jenis penelitian ini adalah penelitian dan pengembangan (R&D) dan menggunakan model Four D. Produk yang dikembangkan berupa e-modul berbasis socio scientific issues pada materi sifat koligatif larutan. Instrumen yang digunakan pada penelitian ini adalah lembar penilaian berupa angket dan soal pilihan ganda. Analisis data yang digunakan adalah rumus momen kappa. Hasilnya menunjukkan bahwa e-modul yang dikembangkan memiliki tingkat validitas dan kepraktisan yang sangat tinggi dengan nilai k = 0,90 dan 0,92. Di samping itu, efektivitas e-modul berada pada kategori medium dengan nilai n gain sebesar 0,32. Kesimpulan dari penelitian ini adalah e-modul berbasis socio scientific issues pada materi sifat koligatif larutan telah layak dan efektif pada proses pembelajaran.

ABSTRACT

This research is in the latter due to low student learning motivation. Student's learning results on the material of the colligative properties of the solution also the mean values were still under the Minimum Completeness Criteria. The learning resources used were in the form of textbooks and were still not integrated with socio-scientific issues. This research aims to know the scale of validity, practicality, and effectiveness of the e-modules developed. This form of study qualifies as research and development (R&D) and employs the Four D model. The product development is an e-module based on socio-scientific issues on colligative materials in solution. The instrument used in this study is an assessment sheet of the type of anxiety and the multiple-choice question. Data analysis employed the kappa moment formula. The results show that the developed and practical e-module had a very high level of validity with a value of k=0.91 and 0.92. Alongside this, the effectiveness of the e-module is in the medium category, with an N-gain value of 0.32. This study concludes that the e-modules based on socio-scientific issues in the colligative properties of solutions are feasible and effective in the learning process.

INTRODUCTION

To succeed in the development of Indonesia in the 21st century, it was necessary for Indonesian society to master six basic literature based on the fields of (1) language, (2) numeration, (3) science, (4) digital, (5) financial literature, and (6) culture and citizenship. Literacy skills must be balanced with critical thinking/problem solving, collaboration, communication, and creativity. The Programme for International Student Assessment (PISA) results in 2006 claims that scientific literacy became main topic of great concern in Indonesia. Scientific literacy is scientific knowledge and skills to identify questions, explain scientific phenomena, awareness of how science is, develop judgments based on facts, acquire new knowledge, grasp the features of science and technology that shape the natural, cultural, and intellectual environment, as well as the willingness to be involved and concerned on science-related issues. The material in scientific literacy aim to function as a benchmark for the development of contextual and diverse scientific literacy activities (Kementerian Pendidikan and Kebudayaan, 2017).

Based on an interview with the chemistry teacher at State High School 2 Percut Sei Tuan (October 27, 2022), it was found that chemistry learning used Problem-Based Learning and Project Based Learning models. Students had low motivation, so they did not focus on learning. The learning resources used were textbooks and were not yet integrated with socio-scientific issues. The student's cognitive learning outcomes in the matter of colligative properties of the average solution were still below the minimum completeness criteria. In line with the case study questionnaire data given to 18 out of 36 students (November 10, 2022), it was found that 66.6% of students had problems learning the material colligative properties of solutions. As many as 60% of students still could not associate colligative properties with everyday life and agreed that there are more interesting learning resources. Almost all students agreed that the learning resources used were adequate, but these learning resources have not been integrated with socio-scientific issues. On the other hand, students also strongly agreed that there are more compelling learning resources.

At State High School 2 Percut Sei Tuan, a Science Literacy Movement has applied. Teachers have used the reading-to-learn method, but the implementation and results haven't been maximum. The primary tactic of the Science Literacy Movement School is a literacy science curriculum, an approach to literature consistently and thoroughly in the school to support the development of scientific literature for each student (Kementerian Pendidikan and Kebudayaan, 2017). Research by Armas, et al. (2019) revealed that scientific literacy has a positive correlation with the chemistry learning achievement of Class XI Sciences at State High Schools in Makassar City. The scientific literacy skills possessed by high school students affect their motivation and learning style. Socio-scientific issues are conceptual representations of issues in social life related to science. The increasingly dynamic conditions of society make changes occur as a result of social dynamics and changes in the characteristics of the community and the surrounding environment (Mudawamah, 2020). In Indonesia, socio-scientific issues content has started to be applied in the classroom and integrated into the development of materials that support its application, but it is still in limited quantities (Genisa et al., 2020).

The importance of socio-scientific issues has increased in the world of education, having their benefits as a tool to make science instruction more relevant to students' lives; as a medium for addressing learning goals such as awareness of the nature of science; increase dialogic argumentation; capacity to analyze scientific facts and information; and become a crucial component of scientific literacy (Sadler & Zeidler, 2004). Learning using socio-scientific issues encourages students to pay attention to social problems that occur in society and relate them to science. Students learn about impacts and solutions discussed together. Through various references and discussions, students can make decisions related to a social problem. These decisions are not thought of from a scientific point of view but also consider the social impacts that remain in society. So learning will be more meaningful if the learning takes place in the reality of everyday life. Thus, a learning process like this can increase students' scientific literacy (Afrilya et al., 2022).

One method for raising students' scientific literacy was the socio-scientific issues approach. Based on the study results of Nurmilawati et al. (2021), students' scientific literacy abilities in colloidal system material in terms of knowledge and scientific competence were in a decent category. According to research by Afrilya et al. (2022), the experimental study in Class XI Sciences 2 and Class XI Sciences 3 at Public High School 5 in the City of Pekanbaru improved student scientific literacy skills in oil materials.

Modules are teaching materials that can help implement socio-scientific issues. As a result of technology, the modules may be delivered electronically, called e-modules. This is supported by the research of Novitasari et al. (2022), claiming that the chemistry e-module based on social scientific issues was beneficial in boosting students' chemical literacy in the matter of material reaction rates. Meanwhile, research by Amdayani et al. (2022) obtained an average kappa moment (k) value of 0.93, which falls in the very high category, and an N-Gain value of 0.82 with high criteria, and the validity of modules based on socio-scientific issues and scientific literacy is said to be very valid in the reaction rate material.

Flip PDF Professional is a program that might help create e-modules. Flip PDF Professional makes it simple to include many kinds of animated material in flipbooks (Fatmianeri et al., 2021). A study by Seruni et al. (2019) implied that e-modules created using Flip PDF Professional are well-designed and appropriate for usage in the learning process. Based on research by *Dalaila et al.* (2022), e-modules based on socio-scientific issues were created on the immune system material were successfully improved the students' scientific literacy.

Based on the problems described, it is required to construct instructional resources to strengthen students' analytical skills and scientific literacy in the form of online modules focused on socio-science concerns. Through the context of social problems, students are challenged to consider scientific principles based on specific problems and to analyze scientific data that can generate debates about such issues. In the context of social science problems used in learning, it is anticipated that instruction will assist students in creating arguments about scientific ideas and societal issues involving science (Setyaningsih et al., 2019). Therefore, to improve student science literacy, learning materials in the form of e-modules are required.

METHOD

This form of research is research and development (R&D). This study attempts to determine the degree of validity, applicability, and efficacy of e-modules. In this research, an e-module was the final result of teaching material based on Socio Scientific Issues on colligative properties of solutions. Students of the XII Sciences 4 class at State High School 2 Percut Sei Tuan served as the study's subjects. The study adopted the 4-D model of Thiagarajan with four steps, namely define, design, develop, and disseminate.

Figure 1 below provides further information on the research design.

1. Define was to find out the problem and determine the requirements needed in the learning through front-end analysis, student analysis, idea analysis, task analysis, and design learning objectives based on basic skills.

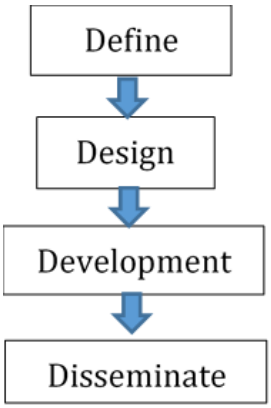

Figure 1. Development stage

2. Design aimed to design an initial description of the teaching materials or products made and began after the learning objectives for teaching materials were determined. The phases of the design stage include medium selection, format selection, and basic design.
3. At this stage of development, the developed module experienced an instrument validation test as an effective test and a practicality test for the instructor using the e-module: a) three media experts and material experts tested the product's legitimacy; b) two Chemistry teachers of State High School 2 Percut Sei Tuan tested the practicality; and c) 30 students tested the effectiveness in a small-scale.

The instruments utilized were validity questionnaires, practicality questionnaires, and the multiple-choice test. The media validity questionnaire includes aspects of cover, layout, images, illustrations, and colors, as in Table 1. The material validity questionnaire includes aspects of curriculum suitability, material accuracy, evaluation clarity, language accuracy, and material presentation accuracy, as in Table 2. In the practicality of the content design questionnaire are the benefits and efficiency of learning time, as in Table 3.

Table 1. Instrument Media Validation Guide

No.	Aspect	Indicator
1.	Cover	1. The use of letters used on the cover
		2. Display module cover design
		3. The image/icon display corresponds to the hydrocarbon material on the cover
2.	Layouts	4. Use of typing layouts
		5. Clarity of writing and typing on e-module
		6. The use of varied fonts and, font sizes in the headings and sub-chapters
		7. Paragraph arrangement in each writing
		8. Consistency in the use of spaces in typing
		9. Use of the numbering system
3.	Pictures and illustrations	10. The presentation of the module is accompanied by pictures/illustrations accompanied by sources
		11. There are messages/benefits found in pictures or illustrations
		12. Background selection accuracy
4.	Color	13. Accuracy of color selection in the e-module

Table 2. Instrument Material Validation Guide

No.	Aspect	Indicator
1.	Curriculum suitability	1. Appropriateness of the presentation of KI, KD, indicators and learning objectives in the colligative properties of solutions in the e-module
		2. KD achievement and learning objectives
2.	Material accuracy	3. The suitability of the material with the curriculum
		4. Appropriate presentation of facts and symptoms in the e-module
		5. The suitability of writing chemical compounds in e-modules
		6. The suitability of the material with the problems contained in the e-module
3.	Clarity of evaluation in the e-module	7. Example questions and solutions
		8. The stimulus is in the form of practice questions
		9. Literature sources that support e-module evaluation
4.	The accuracy of the presentation of the material	10. Presentation of material and concepts according to simple to complex flow
		11. Conformity of content with basic competence
		12. The suitability of the image with the subject matter
		13. The suitability of the problems in the material presented
5.	Conformity with the rules of writing	14. Use of good and correct language
		15. Grammatical accuracy
		16. EID accuracy
		17. Terminology
		18. Use of punctuation

Table 3. Instrument Practicality Guide

No.	Aspect	Indicator
1.	Design and content	1. Instructions for utilizing the e-module
		2. Affordable e-module access
		3. Compatibility of colligative properties of the material with core competencies and fundamental competencies
		4. Understanding of the questions contained in the e-module
		5. The questions used are by the learning objectives
		6. Writing interest and writing size of the e-module
		7. Practicality in the use of e-modules
		8. The benefits of e-modules for teachers in learning
2.	Benefit	9. The SSI approach is easy to understand and helpful to teachers
		10. The effectiveness of the teacher's time in managing time
		11. Providing updated information helps teachers in SSI-based learning
		12. The practice questions on the e-module become the teacher's reference in making concepts
		13. References to SSI-based information/learning resources that are implemented in everyday life
3.	Efficiency of learning time	14. E-modules as independent learning media
		15. Efficiency of learning time with structured learning resources
		16. Preparation of material by the teacher becomes easier

The results of the validity and practicality questionnaire assessments were analyzed using Kappa Moment (Boslaugh & Watters, 2008). For the evaluation, category may be noted in Table 4.

$$kappa\ moment\ = \frac{P_o - P_e}{1 - P_e} \quad (1)$$

Information:

P_0 = Realized proportions, the number of values of the validator divided by the number of highest values

P_e = Unrealized proportions, the total highest value is removed from the entire value of the validator then divided by the total maximum value

Table 4. Category of value K

Value	Category
0.81 – 1.00	Very high
0.61 – 0.80	High
0.41 – 0.60	Medium
0.21 – 0.40	Low
0.00 – 0.20	Very low
≤ 0.00	No

In this study, to find out the efficiency of the e-module, the data obtained from the test was then analyzed with the N-gain test. The category score of the followingformula G by Meltzer is shown in Table 5 based on Ramdhani *et al*. (2020).

$$g = \frac{skor\ posttest - skor\ pretest}{skor\ ideal - skor\ pretest} \quad (2)$$

Table 5. Category of Score

Interval	Category
(g) > 0.7	High
0.3 ≤ (g) ≤ 0.7	Medium
(g) < 0.3	Low

4. Disseminate, the product was distributed to samples and teachers in schools.

RESULT

This research intends to assess the validity of the module by experts and the usability of the e-module by the instructor. The study adopted the 4-D model of Thiagarajan with four steps, namely (1) define, (2) design, (3) develop, and (4) disseminate. The following discusses each stage in detail.

Define

A front-end analysis was conducted by interviewing a Chemistry teacher at State High School 2 Percut Sei Tuan. Based on the interview, students' cognitive learning results in the matter of colligative properties of the average solution were still below the minimum completeness criteria. The teacher's used textbooks as the learning resources, and there were no integrated learning resources for socio scientific issues. The student analysis was by distributing a preliminary study questionnaire to students. Based on these data, it was found that 60% of students still could not relate colligative material to everyday life and agreed that learning resources would be even more interesting. Task analysis is a result of analyzing fundamental competencies according to the revised 2013 curriculum. Concept analysis was carried out to assist researchers in planning learning procedures and sequences. The themes in this colligative property material include pt diagrams, lowering saturated reducing saturated pressure of vapor, the boiling point elevation, lowering of the freezing point, and osmotic pressure decrease establish learning goals that must be completed by students in keeping with the expectations of the curriculum.

Design

Media selection

At this stage, the appropriate media for content and presentation of learning content was selected according to the teacher's needs and student's characteristics. Teaching materials made by the teacher can come from the basic concept combining several topics adapted to the students' cognitive development and environment so students can understand the material systematically (Ginting et al., 2022). The product developed in this research is a module in electronic form. The flipbook-based e-module product that has been generated is suitable to be utilized as instructional material (Firdaus & Pahlevi, 2022). The material employed in this e-module development is Microsoft office word, Canva, and Flip PDF Professional.

Format selection

The module display format selected in this study is the A4-sized paper. The typefaces used in cover titles are Alice, Calistoga, and Alegreya, bold, with font sizes 20, 43, and 27, while the typefaces for the chapters are mixed, bold, with a font size of 20. In the sub-chapters, the contents of the chapter (manuscript text) include links, reading sources, and descriptions in Times New Roman, bold, with sub-chapter font sizes and contents of chapter 12 and that of links and descriptions 10. The main color used in this e-module is orange.

Initial draft

Innovative e-modules are e-modules that can refer to 21st-century educational skills. One of them is the presentation of problems in observing or recognizing problems that can be linked to social science issues that are developing in society (Azizah et al., 2022). The module prepared by the researcher consists of cover, a prologue, a list of contents, core competencies and fundamental competencies, competency learning indicators, and learning objectives, with the socio-scientific issues (approach and problem analysis; problem clarification; experimentary; learning materials; continuing issues social issues; discussion and evaluation; meta-reflection), concept maps, instructions for use, integrated learning with the stage of socio-scientific issues, competency tests along with answer keys, glossary, bibliography and biography of the author. In this module is also a website link as a reading resource that can increase student literacy and a stimulus in pictures.

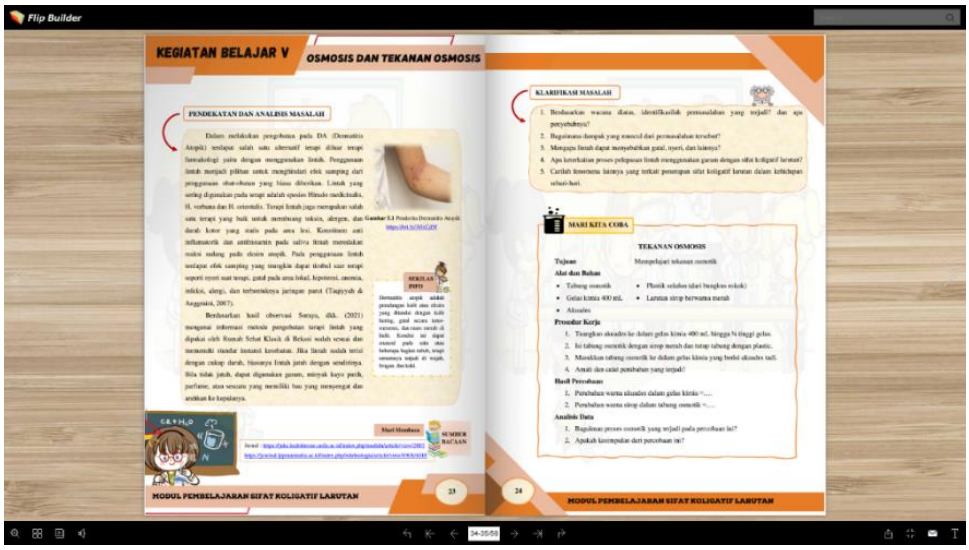

Figure 2. Problem analysis stage (left) and clarification of science and practice (right)

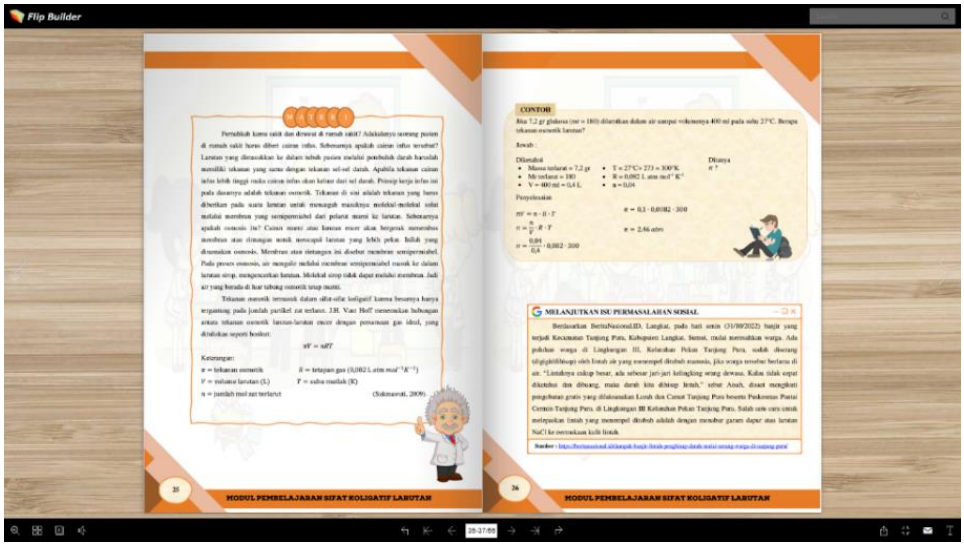

Figure 3. Material (left), sample questions and stages of refocus on the socio scientific dilemma (right)

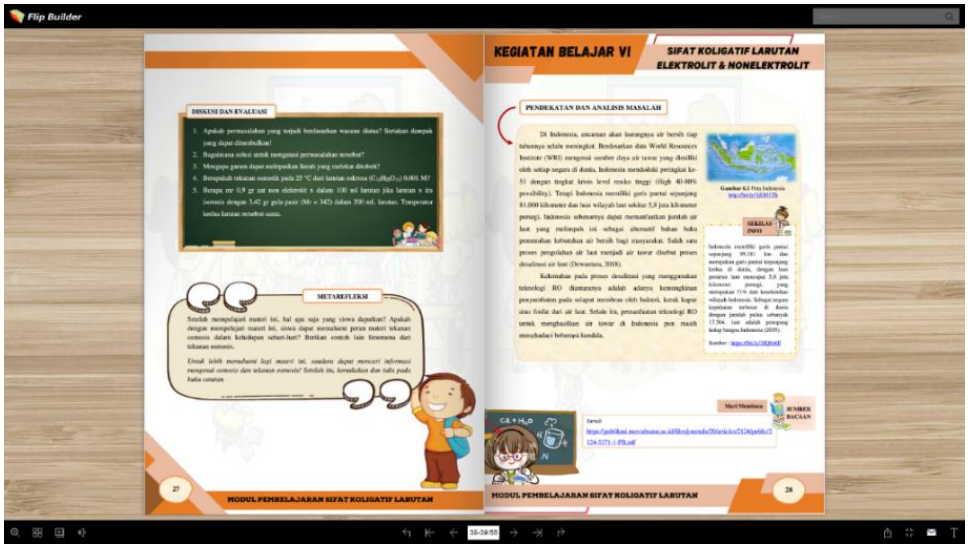

Figure 4. Discussion and evaluation stage, meta-reflection stage (left)

Figure 2 shows the approach and problem analysis stages in the osmosis pressure sub-material. At this stage, students are presented with issues of problems that occur in society through articles, media, news, and their own experiences. Furthermore, it links to the material to be studied so that students are required to realize the importance of understanding the material. Meanwhile, at the stage of clarification of science, instructor pushes students to make direct observations and helps them comprehend the principles behind the problem.

Figure 3 shows the presentation of the material, sample questions, and the stages of refocusing on socio-scientific issues. At this stage, students refocus their attention on related social problems. Then, students are given questions to stimulate them to express existing issues or problems. Figure 4 shows the discussion and evaluation stage, which presented some questions expected to provide solutions or overcome the problems discussed earlier. In meta-reflection stage, students are asked to offer feedback on their entire experience with the problems and material being studied and conclude the entire learning.

Development

Media Validation

At this stage, three UNIMED lectures became media experts. Based on the validators assessment results, the average kappa moment value for media validation was 0.92 (very high). It can be seen more clearly in Table 6.

Table 6. The average value K of media validation

No.	Aspect	Average grades (k)
1.	Cover	0.95
2.	Layouts	0.93
3.	Pictures and illustrations	0.90
4.	Color	0.91
	Average:	0.92

Material Validation

At this stage, three UNIMED lectures became material experts. Based on the validator's assessment results, the average kappa moment value for material validation was 0.89 (very high). It can be seen more clearly in Table 7.

Table 7. The average value K of material validation

No.	Aspect	Average grades (k)
1.	Curriculum suitability	0.94
2.	Material	0.87
3.	Clarity of evaluation in the e-module	0.98
4.	The accuracy of the presentation of the material	0.84
5.	Conformity with the rules of language	0.83
	Average:	0.89

Practicality by teacher

Practicality test was by the teacher, awarded to two Chemistry teachers at State High School 2 Percut Sei Tuan. Assessment questionnaire for chemistry professors to find out the usefulness of e-modules in terms of design and content, benefits, and efficiency of learning time. Based on the teacher's assessment results, the average kappa moment value for material validation was 0.92 (very high). It can be seen more clearly in Table 8.

Table 8. The average value K of practicality

No.	Aspect	Average grades (k)
1.	Design and content	0.91
2.	Benefit	0.90
3.	Time efficiency	0.96
	Average:	0.92

Small scale testing

Once the product has been deemed legitimate and practical by experts and Chemistry teachers, additionally researchers performed pretests and posttests to students to figure out the efficiency of the e-modules based on socio-scientific issues. This written examination was taken by 30 students in Class 12 Science 4 State High School 2 Percut Sei Tuan. Based on the effectiveness test, N-Gain value of 0.32 was obtained. The findings of the exam are in Table 9.

Table 9. Effectiveness testing

No.	Treatment	Average score	Value of *N-gain*	Category
1.	Pretest	29	0.32	Medium
2.	Posttest	52.16		

Disseminate

The generated e-module is provided in the form of a link that may be accessed through a data network. Grade 12 Science 4 students and Chemistry teachers were the targets of the distribution.

DISCUSSION

Based on the above results, the media validation rate is very high, with an average kappa moment value of 0.92. According to Sukmanasa et al. (2017), media validation aims to obtain criticism, information, and advice for the learning media developed to be a quality product in terms of program and appearance. The evaluation results from the validator of the cover were 0.95 (very high), and the layout was 0.93 (very high). The images, illustrations, and colours obtained a value of 0.90 and 0.91 (very high). Several revisions from experts include reproducing the image on the cover and increasing the background transparency level. The colors used are nice and attractive. According to color expert Molly E. Holzschlag, the orange color symbolizes warmth, enthusiasm, cheerfulness, freshness, balance, and energy (Desriani & Franzia, 2017).

Moreover, the material validation level is also very high and the average kappa moment value was 0.89. The objective of validating the material is to acquire data in the form of assessments, views, and suggestions regarding the correctness and applicability of learning materials in the media (Warastuti et al., 2017). Based on the findings of the examination of the three validators, curriculum appropriateness has a value of 0.94 (very high). To the teacher's interests, teaching materials contain material that is programmed to the demands of the curriculum. Curriculum 2013 is a curriculum that guides students to have three competitions (affective, cognitive, and psychomotor) (Dalimunthe & Ginting, 2022). The material accuracy has a value of 0.87 (very high). Material accuracy has something to do with the alignment and truth of the material concepts presented in teaching materials (Ulfah & Jumaiyah, 2018). The evaluation clarity has a value of 0.98 (very high). The accuracy in presenting the material has a value of 0.84 (very high). The conformity with language rules has a value of 0.83 (very high). User-friendliness is one of the module's qualities, which indicates that each instruction and information exposure occurring in the module is beneficial and welcoming to the user. The simple, understandable language that incorporates regularly-used phrases is part of what makes anything user-pleasant (Purwati et al., 2019).

For practicality, the e-module has a value of 0.92 (very high). The design and content have a value of 0.91 (very high). The benefits have a value of 0.90 (very high). The e-module can improve confidence for both experienced students and beginners. This e-module is an effective tool for all learners who wish to prepare themselves during the learning process (Cloonan et al., 2020). Aspects efficacy in learning has a value of 0.96 (very high). In line with this, Sumarmi et al. (2021) claimed that one of the benefits of e-modules is that it may be studied anytime and any places.

Once the product has been deemed legitimate and practical by experts and Chemistry teachers, additionally researchers performed pretests and posttests on students to figure out the efficiency of the e-modules based on socio-scientific issues. This written examination was taken by 30 students in Class 12 IPA 4 State High School 2 Percut Sei Tuan. Pre-test in Class XII Science 4 took place on March 2, 2023. Four days after the pre-test, the researchers gave the e-module

link to the students through a WhatsApp group. On March 9, 2023, before carrying out the post-test, the researchers gave 20 minutes to the students to re-learn the content of the e-module. Based on the effectiveness test, the N-Gain value of grade 12 Science 4 was 0.32, which belongs to the medium category. The mean pre-test score was 29 and the post-test was 52.16. Effectiveness tests are as a measure of the success of the learning process. E-modules can be said to be effective when it gives a good impact on the learning outcomes of students (Laili et al., 2019). From the test questions asked, the average student was able to answer questions related to everyday life. This is in line with Khalid et al. (2021) who stated that scientific literacy is the capacity for students to recognize ideas, comprehend, explain, and communicate science, as well as to use science to solve issues in their daily lives and make connections to the subject they have learned.

Zeidler et al. (2005) suggested that socio-scientific issues are an approach to foster individual intellectual growth in morals and ethics as a knowledge of the relationship between science and society. In Indonesia, socio-scientific issues content has started to be applied in the classroom and integrated into the development of materials that support its application, but it is still in limited quantities (Genisa et al., 2020). Modules are teaching materials that can help implement Socio Scientific Issues. By utilizing technology, modules can be presented in electronic form, or called e-modules. E-modules are learning media in which videos, motion animations, and navigation can be added to make learning more interactive. One application that can help in making e-modules is Flip pdf professional.

This e-module based on socio-scientific issues can increase student learning motivation. According to the viewpoint of Suastrawan et al. (2021), socio-scientific issues are controversial that have a close relationship with science, and modules integrated with socio-science issues in each material can increase student motivation and scientific literacy. According to Sadler & Zeidler (2004), the relevance of socio-scientific concerns in the area of science education has grown: (1) a strategy to increase the relevance of science instruction to student's lives; (2) a means of responding to educational objectives, such as an understanding of the nature of science; (3) enhancing dialogic argumentation; (4) the capacity to assess scientific knowledge and data; and (5) a crucial facet of scientific literacy.

In this final stage, the generated e-module is in a link that may be accessed through a data network. The dissemination was done on a small scale to teachers and students at State High School 2 Percut Sei Tuan. Based on the findings of the aforementioned analysis, it may be inferred that the developed e-module is feasible, practical, and effective for use in learning as a reference for teaching materials for both teachers and students.

CONCLUSION

E-modules based on social scientific problems that have been developed are declared valid with a material validation value of 0.89 and media validation of 0.92. Meanwhile, the level of practicality of the e-module is in a very high category with a rating of 0.92. The effectiveness of the e-module is in the middle category, with a score of 0.32. The conclusion is that the social science-based e-module is a viable, practical, and effective collaborative solution in the learning process. The disadvantage of the developed product is that the e-module can only be accessed using the Internet or a data network. A suggestion for future researchers is to further develop this e-module in the Android application format, so it works in conditions without a data network connection and can apply e-modules in the teaching process so that the impact of other e- modules on other variables, such as scientific reading skills, and critical thinking abilities are evident.

Author contributions

The authors made significant contributions to the study's conception and design. The authors were in charge of data analysis, interpretation, and discussion of results. The final manuscript was read and approved by the authors.

Funding

There was no specific grant for this research from any funding organization in the public, private, or nonprofit sectors.

Conflict of interest

The authors declare that there is no potential conflict of interest.

Data availability statement

All data are available from the authors.

REFERENCES

Afrilya, N., Afrianis, N., & Nurhadi. (2022). Pengaruh penerapan pendekatan socio scientific issuesterhadap kemampuan literasi sains siswa pada materi minyak bumi. *JRPK: Jurnal Riset Pendidikan Kimia*, *12*(1), 10–19. https://doi.org/10.21009/JRPK.121.02

Amdayani, S., Dibyantini, R., Darmana, A., & Dalimunthe, M. (2022). Development of socio-scientific issues based reaction rate module and science literacy oriented. *Proceedings of the 4th International Conference on Innovation in Education, Science and Culture, ICIESC 202*2, (pp. 1–6). https://doi.org/10.4108/eai.11-10-2022.2325292

Armas, A. R. K., Ramlawati, & Muhammad Syahrir. (2019). Hubungan Antara Literasi Sains Dengan Prestasi Belajar Peserta Didik Pada Pembelajaran Kimia Kelas Xi Mipa Sma Negeri Se-Kota Makassar. *Chemistry Education Review (CER)*, *2*(2), 67–75. https://doi.org/10.26858/cer.v2i2.8950

Azizah, H. P., Hafiza, N., & Ilhami, A. (2022). Pengembangan e-modul ipa smp berbasis socio scientific issues (SSI) : Systematic Review. *Jurnal Pendidikan Indonesia*, *2*(4), 35-43. http://www.jurnal.penerbitwidina.com/index.php/JPI/article/view/206

Boslaugh, S., & Watters, P. A. (2008). *Statistics in a nutshell*. O'Reilly Media. https://doi.org/10.1080/10691898.2000.12131286

Cloonan, M. R., Cloonan, D. J., Lynn Schlitzkus, L., & Fingeret, A. L. (2020). Learners with experience in surgical scrub benefit from additional education with an interactive e-learning module. *Journal of the American College of Surgeons*, *231*(4), e196. https://doi.org/10.1016/j.jamcollsurg.2020.08.521

Dalaila, I., Widiyaningrum, P., & Saptono, S. (2022). Developing e-module based on socio-scientific issues to improve students scientific literacy. *JISE*, *11*(3), 292–301. http://journal.unnes.ac.id/sju/index.php/jise

Dalimunthe, M., & Ginting, R. J. (2022). Pengembangan modul berbasis problem based learning dengan pendekatan saintifik pada materi asam-basa. *Jurnal Inovasi Pembelajaran Kimia*, *4*(2), 177–190. https://doi.org/10.24114/jipk.v4i2.38991

Desriani, Z., & Franzia, E. (2017). Peranan desain komunikasi visual dalam perancangan buku motivasi "dibesarkan oleh satu". *In Prosidding Seminar Nasional Cendekiawan,* (pp. 285–290).

Fatmianeri, Y., Hidayanto, E., & Susanto, H. (2021). Pengembangan Modul Elektronik Berbasis Differentiated Instruction untuk Pembelajaran Blended Learning. *Jurnal Ilmiah Pendidikan Matematika*, *10*(1), 50–62. http://doi.org/10.25273/jipm.v10i1.8709

Firdaus, R., & Pahlevi, T. (2022). The development of problem-based learning e-modules on correspondence materials. *JINOTEP (Jurnal Inovasi Dan Teknologi Pembelajaran): Kajian Dan Riset Dalam Teknologi Pembelajaran*, *9*(2), 145–157. https://doi.org/10.17977/um031v9i22022p145

Genisa, M. U., Subali, B., Djukri, Agussalim, A., & Habibi, H. (2020). Socio-scientific issues implementation as science learning material. *International Journal of Evaluation and Research in Education*, *9*(2), 311–317. https://doi.org/10.11591/ijere.v9i2.20530

Ginting, F. A., Syahputra, R. A., Purba, J., Sutiani, A., & Dibyantini, R. E. (2022). Pengembangan modul berbasis discovery learning terintegrasi literasi sains pada materi laju reaksi. *Jurnal Inovasi Pembelajaran Kimia*, *4*(2), 167–176. https://doi.org/10.24114/jipk.v4i2.35671

Kementerian Pendidikan dan Kebudayaan. (2017). *Materi pendukung literasi sains*.

Khalid, L., Bucheerei, J., & Issah, M. (2021). Pre-Service teachers' perceptions of barriers to promoting critical thinking skills in the classroom. *SAGE*, *11*(3), 1–9. https://doi.org/10.1177/21582440211036094

Laili, I., Ganefri, & Usmeldi. (2019). Efektivitas Pengembangan e-modul project based learning pada mata pelajaran instalasi. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *3*(3), 306–315. https://ejournal.undiksha.ac.id/index.php/JIPP/article/download/21840/13513

Mudawamah, K. (2020). Peningkatan hasil belajar dan literasi sains siswa smpn 1 ngoro mojokerto melalui penerapan pendekatan saintifik berbasis socio-scientific issues (SSI). *Science Education and*

· *Application Journal*, *2*(2), 52. https://doi.org/10.30736/seaj.v2i2.254
Novitasari, R., Waluyo, J., & Jember, U. (2022). Chemistry e-module based on socio scientific issues (SSI) for reaction rate material to increase senior high school students' chemical literacy. *Eduvest*, *2*(9), 1811–1816. https://doi.org/10.59188/eduvest.v2i9.588
Nurmilawati, S., Agung, S., & Murniati, D. (2021). Identifikasi Pengetahuan dan kompetensi sains siswa berdasarkan socio-scientific issues (ssi) pada materi sistem koloid. *Jurnal Riset Pendidikan Kimia*, *11*(1), 11–24. http://journal.unj.ac.id/unj/index.php/jrpk/article/view/3067
Purwati, R., Suranto, Sajidan, & Prasetyanti, N. M. (2019). Problem-based learning modules with socio-scientific issues topics to closing the gap in argumentation skills. *TOJET: The Turkish Online Journal of Educational Technology*, *18*(4), 35–45. https://eric.ed.gov/?id=EJ1232267
Ramdhani, E. P., Khoirunnisa, F., & Siregar, N. A. N. (2020). Efektifitas modul elektronik terintegrasi multiple representation pada materi ikatan kimia. *Journal of Research and Technology*, *6*(1), 162–167. https://journal.unusida.ac.id/index.php/jrt/article/view/152
Sadler, T. D., & Zeidler, D. L. (2004). The morality of socioscientific issues: construal and resolution of genetic engineering dilemmas. *Science Education*, *88*(1), 4–27. https://doi.org/10.1002/sce.10101
Seruni, R., Munawaoh, S., Kurniadewi, F., & Nurjayadi, M. (2019). Pengembangan modul elektronik (e-module) biokimia pada materi metabolisme lipid menggunakan flip pdf professional. *JTK (Jurnal Tadris Kimiya)*, *4*(1), 48–56. https://doi.org/10.15575/jtk.v4i1.4672
Setyaningsih, A., Rahayu, S., Fajaroh, F., & Parmin, P. (2019). Pengaruh pembelajaran process oriented-guided inquiry learning berkonteks isu-isu sosiosaintifik dalam pembelajaran asam basa terhadap keterampilan berargumentasi siswa SMA kelas XI. *Jurnal Inovasi Pendidikan IPA*, *5*(2), 168–179. https://doi.org/10.21831/jipi.v5i2.20693
Suastrawan, K. E., Suardana, I. N., & Sudiatmika, A. A. I. A. R. (2021). The effectiveness of science e-modules for class vii junior high schools based on socioscientific issues to improve students' critical thinking skills. *Journal of Science Education Research*, *5*(2), 1–9. https://doi.org/10.21831/jser.v5i2.42877
Sukmanasa, E., Windiyani, T., & Novita, L. (2017). Pengembangan media pembelajaran komik digital pada mata pelajran ilmu pengetahuan sosial bagi siswa kelas v sekolah dasar di kota bogor. *Jurnal Pendidikan Sekolah Dasar*, *3*(2), 171–185. http://dx.doi.org/10.30870/jpsd.v3i2.2138
Sumarmi, Bachri, S., Irawan, L. Y., & Aliman, M. (2021). E-module in blended learning: its impact on students' disaster preparedness and innovation in developing learning media. *International Journal of Instruction*, *14*(4), 187–208. https://doi.org/10.29333/iji.2021.14412a
Ulfah, A., & Jumaiyah, D. (2018). Pengembangan bahan ajar mata kuliah bahasa indonesia di perguruan tinggi kabupaten lamongan. *Jurnal Inovasi Pendidikan*, *2*(1), 75–81. http://jim.unisma.ac.id/index.php/fkip/article/view/1730
Warastuti, T. M., Baedhowi, & Susilaningsih. (2017). Pengembangan bahan ajar dengan model kontekstual untuk pembelajaran ekonomi. *In Prosidding Seminar Pendidikan Ekonomi dan Bisnis (Vol. 3 No. 1).*
Zeidler, D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues*. Science Education*. https://doi.org/10.1002/sce.20048