JPPIPA 10(8) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of an E-Module Based on Social Scientific Issues (SSI) to Improve Critical Thinking and Environmental Care Skills on Green Chemistry Material Using the Fliphtml5 application

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Received: June 14, 2024
Revised: August 16, 2024
Accepted: August 25, 2024
Published: August 31, 2024

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DOI: 10.29303/jppipa.v10i8.8102

Abstract: This research aims to develop a valid and reliable e-Module based on socio-scientific issues in green chemistry and to evaluate its impact on students' environmental care and critical thinking skills. The Research and Development (R&D) method was employed using the ADDIE model, which includes five phases: analysis, design, development, implementation, and evaluation. Data were collected through interviews, student questionnaires, validation sheets, and user response questionnaires. Small-scale trials were conducted via one-on-one tests and user response assessments, involving three students with varying abilities, three teachers, and 30 students from SMAN 2 Siak Hulu, SMAN 2 Tambang, and SMAN 1 Bangkinang Kota. The e-Module received validation ratings of 92% from material experts and 99% from media experts, classifying it as highly valid. The one-on-one test provided feedback for improving certain e-Module components. User responses were highly positive, with teachers giving a 92.1% rating and students 96.6%. The paired t-test revealed a significant improvement in environmental care and critical thinking skills, with the experimental group achieving a high N-Gain value of 0.71, while the control group reached a medium category with an N-Gain of 0.42.

Keywords: Critical Thinking Skills; E-module; Environmental Care; Green ChemistrySocio-Scientific Issues

Introduction

The learning approach or model is the method chosen by educators to convey learning material to students to facilitate and accept learning material so as to achieve learning objectives (Fihani, 2021). Efforts that can be made to improve students' critical thinking skills are by implementing the Social Scientific learning model Issue (SSI), referring to research conducted by Anjar Putro Utomo, Erlia Narulita, and Rizky Nur Izza Billah shows that there is a difference in the average value of critical thinking ability between the experimental class and the control class. So the application of the SSI-based learning model has an effect on students' critical thinking abilities (Utomo, Narulita, Nur, & Billah, 2020)

The implementation of learning with Social Scientific Issues (SSI) stimulates moral, intellectual, ethical development and awareness between science and social life. SSI-based learning also helps develop thinking skills in developing problems related to science. Increasing thinking abilities is in line with students' scientific thinking skills to determine and make decisions based on theories and facts discovered by students. Social Scientific Issue (SSI) -based learning prioritizes learning resources from the community that are easily found, such as green chemistry, by developing literacy from the ability to process ideas so that students are able to form more complex or integrated thought patterns with the scientific concepts being studied so as to form a conclusion on concepts, principles and facts in

How to Cite:
Rasyih, H., Noer, A. M., & Rasmiwetti, R. (2024). Development of an E-Module Based on Social Scientific Issues (SSI) to Improve Critical Thinking and Environmental Care Skills on Green Chemistry Material Using the Fliphtml5 application. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 6059–6069. https://doi.org/10.29303/jppipa.v10i8.8102

solving problems related to scientific issues (Winarni, 2022) .

The application of 21st century learning provides key competencies for students to be able to face the challenges of the industrial revolution 4.0, these competencies include (1) communication skills , (2) collaboration skills , (3) critical thinking and problem solving skills (critical thinking and problem solving), and (4) creativity and innovativeness , to be able to achieve this competency, students are required to have high-level thinking abilities to be able to help solve problems in learning or individual assignments (Utami, Sismawarni, Hamid, & Kusumaningtyas, 2020). Apart from that, environmental care or a caring attitude towards the environment is also very necessary, because this ability is a combination of students' attitudes, knowledge and skills to preserve the environment, prevent damage and provide alternative solutions related to environmental problems.

The government realizes how important it is to build an environmentally caring character for the younger generation. Therefore, the government has made a policy regarding the implementation of environmentally caring character education in schools. According to the Ministry of National Education, environmental care character (2010) is an attitude and action that always strives to prevent damage to the surrounding natural environment and develops efforts to repair natural damage that has occurred. The attitude structure consists of three components that support each other, namely the cognitive component (beliefs), the affective component (feelings), and the conative component (tendency to act). If one of the three attitude components is manipulated, it will affect the other components, causing an attitude change mechanism to emerge.

The SSI approach is almost the same as the problem-based approach, where the learning process is carried out by introducing contextual problems, but the difference lies in the problem being developed, if in the problem-based approach, the teacher has presented the problem in the form of questions to students, whereas in SSI the problem must be developed by students themselves by developing various aspects, both science itself, economics, morals and others. In using the SSI approach, the problem or social issue raised must have criteria, namely: (1) have a scientific basis (2) involve opinion formation (3) are often seen by the media (4) information is still lacking (5) aim at local, national, and global which has a political and social framework (6) has ethical values and considerations (7) has an understanding of possibilities related to events in the surrounding environment. The SSI approach makes learning more effective in aspects of daily life with the pros and cons and social issues in society. so that learning with SSI can increase students' curiosity and can develop students' critical thinking towards issues and problems in the real world (Triani, Maryuningsih, Ilmiah, & Biology, 2020) .

Social Scientific Issues (SSI) is something new for Indonesia, so it is difficult to find SSI-based teaching materials, this statement is supported by research conducted by Rostikawati and Anna in 2016, the results of the research show that from the analysis carried out on 5 books, they have not met the percentage of learning stages SSI-based (Nazilah & Rosidi, 2018) . Therefore, teaching materials are needed that are designed to stimulate students' ability to construct knowledge independently. Teaching materials that can be developed are e -modules.

Modules are teaching materials that can be used by students to learn according to their own absorption rate, apart from that, modules support students to get to know students' strengths and weaknesses through modules with repetition of material that has not been mastered. Referring to the explanation from the Directorate of Educational Personnel (2008), modules are teaching materials that are prepared completely and systematically, where the module functions as a companion book (Sofiana & Wibowo, 2019) .

Chemistry is a branch of natural science (IPA) that studies the structure, composition, properties and changes in matter and the energy that accompanies these changes. In life we encounter many related chemical materials, so chemistry is very important to study along with the development of science and technology. However, in reality, chemistry is very difficult for students to learn, because not only do they learn theory, but students are also encouraged to make it happen in real life (Halalutu et al., 2019) . Apart from chemistry material being difficult for students to understand, one chemistry material that has never been taught and will only be implemented in the 2022/2023 academic year in the independent curriculum is green chemistry. Green chemistry is related to how to design chemical products and processes to reduce or eliminate the use of chemicals that are harmful to humans, animals and the environment in which we live. Green chemistry is a chemical approach that aims to maximize efficiency and minimize harmful effects on human health and the environment.

Green chemistry is a new material in the independent curriculum, looking at the learning principles in the independent curriculum, where learning is designed taking into account the current stage of development and level of achievement of students, according to learning needs, and reflecting the characteristics and development of diverse students so that learning becomes meaningful and fun, then learning is oriented towards a sustainable future. Based

on this learning principle, green chemistry is important to learn because learning green chemistry is oriented towards a sustainable future. Green chemistry is often also called sustainable chemistry, this field of chemistry cannot be confused with environmental chemistry, because green chemistry focuses more on the environmental impact of chemistry, as well as the development of sustainable practices that are more environmentally friendly. Therefore, green chemistry is very important to study because the main goal of the green chemistry approach is to create better and safer chemical substances and simultaneously be able to choose the safest and most efficient way to synthesize these substances and reduce the chemical waste produced. Students stated that chemistry teachers rarely link chemistry learning with green chemistry. Green chemistry material will be very compatible with the SSI learning model, because this model focuses on controversial material such as green chemistry topics.

Based on the results of interviews and student response questionnaires with chemistry teachers and students at SMA Negeri 2 Siak Hulu, SMA Negeri 2 Tambang, and SMA Negeri 1 Bangkinang Kota, information was obtained that students' critical thinking abilities were still very low, teaching materials or media were often used are handbooks, PowerPoint, learning videos, E-MODULES and no one has ever used e -modules based on Social Scientific Issues. Based on the student response questionnaire, the results obtained were that students felt that if they only listened to the teacher's explanation, they would not be able to fully help them understand chemical material, so media was needed to support students' understanding of the chemical material being taught. The learning media preferred by students was learning media. electronic. Students do not understand the chemistry learning concepts they are studying and are not able to relate them to everyday life. One electronic media that can be used is fliphtml5. The fliphtml5 media application is a web-based digital publishing platform that allows users to create various publications, such as magazines, brochures, catalogs, and so on. Fliphtml5 can be accessed via the internet, and can convert pdfs or images into page flip book-like content. Innovative flipbook learning media such as e -modules that will be developed are made with fliphtml5 software. Fliphtml5 is a kind of professional page turning software for converting PDF files into digital publishing pages. Fliphtml5 has a template design and features such as backgrounds, control buttons, hint bars that give the flipbook appeal and provide an interactive effect so that the user is opening it like a physical book when reading. This is because there is an animation effect when scrolling to the next page, this effect displays the impression of turning pages which is usually done in printed books.

This research aims to produce an e- Module based on socio-scientific issues on valid and reliable green chemistry material and knowing the increase in Environmental Care and critical thinking skills of students on green chemistry material

Method

Research on the development of e -modules based on socio-scientific issues (SSI). designed using a mixed -method approach with a quasi-experimental research design through pretest-posttest, non-equivalent control group design, and the ADDIE development model. This development research was carried out at SMAN 2 Siak Hulu in the even semester of the 2022-2023 academic year. The trial was carried out at SMAN 2 Siak Hulu, SMAN 2 Tambang, and SMAN 1 Bangkinang Kota in May 2023. In the development stage, the entire population of students in class X of SMAN 2 Siak Hulu, SMAN 2 Tambang, and SMAN 1 Bangkinang Kota were used. who has studied green chemistry. For the purposes of small-scale product testing, namely one-on-one testing involving 3 class XI students at SMAN 2 Siak Hulu who have high, medium and low academic levels. User responses involved 3 teachers and 30 students in class XI of SMAN 2 Siak Hulu, SMAN 2 Tambang, and SMAN 1 Bangkinang Kota, and 1 experimental class was used. Then the population in the large-scale trial was all students in class X at SMAN 2 Siak Hulu. The sample used was 30 class X students of SMAN 2 Siak Hulu. The sampling technique in this research used a purposive sampling technique , (Sugiyono, 2017) states that purposive sampling is a sampling technique with certain considerations.

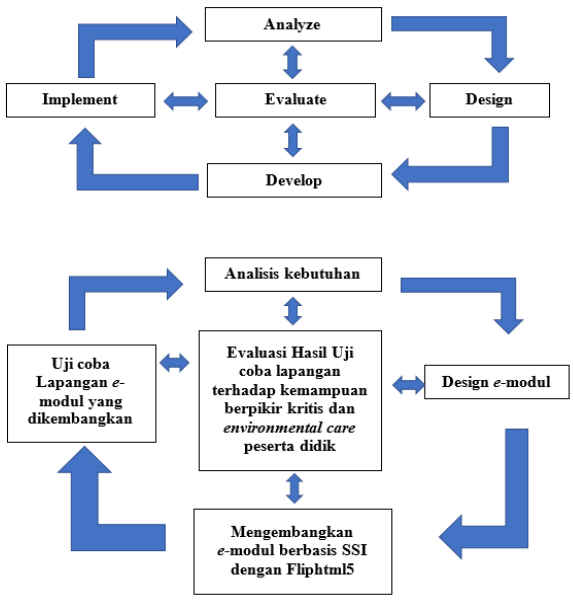

Figure 1. ADDIE Learning Model Scheme

The data collection techniques used were interviews, questionnaires, validation sheets, teacher response questionnaires, student response questionnaires, description tests of students' critical thinking abilities, description tests of students' environmental care abilities, and documentation.

Validation Sheet Analysis

The validation assessment was carried out by 6 expert lecturers as validators, namely 3 material experts and 3 media experts. Giving meaning and making decisions about product quality e - based LKPD PBL integrated ethnoscience using the flip builder application in redox will use the achievement level conversion in Table 1.

Table 1. Validity Criteria for Validator Assessment Questionnaire Data

Percentage (%)	Criteria
81-100	Very feasible / very valid / does not need to be revised
61-80	Eligible / valid / no need for revision
41-60	Inadequate / invalid / needs revision
21-40	Not feasible / invalid / needs revision
< 20	Very inappropriate / very invalid / needs revision

(Arikunto, 2010)

Analysis of Teacher Response Questionnaires

The teacher response questionnaire assessment was carried out by 3 chemistry teachers to obtain teachers' responses to the use of PBL-based Ethnoscience-based e-LKPD teaching material products on redox material in the chemistry learning process. The results of the average score from the teacher response questionnaire that were obtained were then converted into qualitative data to determine the criteria for using PBL-based Ethnoscience - based e -LKPD which can be seen in Table 2.

Table 2 Questionnaire Response Criteria Interval

Percentage (%)	Criteria
81-100	Very good
61-80	Good
41-60	Good Enough
21-40	Not good
< 20	Very Not Good

(Arikunto, 2010)

Analysis of the Influence of Teaching Materials

After the data is collected, the next stage is analyzing the data and interpreting the results. Data analysis was carried out with the aim of seeing whether the proposed hypothesis was accepted or rejected. The data analysis stage includes:

a. Normality test

The normality test aims to see whether the data is normally distributed or not. The normality test can be carried out using the Kolmogrov-Smirnov test using SPSS 26.

b. Hypothesis Test

Hypothesis testing in this research was carried out on data on students' character values and conservation attitudes. Hypothesis testing in this research is the t test which can be carried out if the data obtained is normally distributed. Independent sample t-test hypothesis testing was carried out with the help of SPSS V 23.

Result and Discussion

Analysis

Initial analysis at this stage carried out observations and interviews with three chemistry teachers who taught at schools that had implemented the independent curriculum, namely SMAN 2 Siak Hulu, SMAN 2 Tambang, and SMAN 1 Bangkinang Kota. The interview results showed that chemistry lessons were considered difficult and less interesting. This can be caused because chemistry is related to complex material and requires intellectual intelligence and greater effort to understand it (Susilaningsi, 2019) . According to Akram, (2017) the lack of student interest in chemistry can be caused by several factors, including the methods used by teachers in the learning process that are not in accordance with the methods preferred by students. This problem is a challenge that teachers must face in presenting chemistry lessons to students, so that the selection of teaching materials, methods and learning models is an important thing that must be considered.

The results of interviews with chemistry subject teachers from the three schools stated that students' interest in learning was still low so that the learning carried out was not optimal. The continued use of teaching materials that are less interesting and have not been linked to everyday life can be a cause of low critical thinking abilities. Apart from that, the use of learning media that is inadequate and does not involve students will make them quickly bored while learning (Dawati, 2019)

Design

At the planning stage there are aspects of the media design that will be developed. E -Module design based on a socio-scientific issues approach as a form of solving problems found in the preliminary analysis research phase. The instrument used to assess the quality of teaching materials is a questionnaire which contains an assessment of teaching materials in the form of an E - Module based on this socio-scientific issues approach. In

this stage, researchers create a product assessment questionnaire instrument grid. The contents of the E - Module prototype based on a socio-scientific issues approach are prepared referring to indicators of competency achievement and learning materials that have been described at the curriculum analysis stage. Contents of the E -Module taken from sources, namely high school/MA chemistry books, college chemistry books and the internet that are relevant to green chemistry material. The design of the e-module display based on a socio-scientific issues approach is carried out by preparing a storyboard. A storyboard is a series of diagrams that show the sequence of display and visualization of ideas from the prototype created, so that it can provide an overview of the resulting prototype (Kunto Imbar, 2021) . The sequence of e-module display design that has been carried out can be explained as follows:

1) E-module cover page display design

e-module cover page was created using the Photoshop program by utilizing the polygon tool menu , clipping mask , blending and type tool. The cover page consists of: (a) e-module title; (b) Name of subject, class and semester; (c) Tut Wuri Handayani, Riau University and K-13 logo; (d) Image depicting the title of the e-module or course; (e) Author's identity.

2) E-module content display design

e-module content display was designed using Publisher 2013 by utilizing the shape menu , shape fill , text box and background. The order of content display in the e-module consists of introduction, core and conclusion.

a) The introductory part consists of: (1) Foreword; (2) Table of contents; (3) Introduction; (4) SSI approach; (5) e-module description; (6) steps for use; (7) learning outcomes.
b) The core part is 4 learning activities in the e-module according to the material that will be provided in the learning process. The display sequence in e-modules 1-4 consists of: (1) Competency achievement indicators; (2) Learning Objectives; (3) Material description; (4) Conclusion; (5) Independent Assignment; (6) Practice Questions.
c) The closing section is a bibliography which is a reference for the material in the e-module.

Development

The development phase involves two processes: prototyping and material validation.

1) The prototyping process

The Prototyping Process is the process of realizing the design in a storyboard that has been previously designed into an e-module prototype based on a socio-scientific issues approach to the actual appearance. Application for developing teaching materials with the help of Publisher 2013 in such a way that it is interesting in presenting learning materials.

Validation

The validation stage consists of material validation and media validation involving 6 expert lecturers each for the e-module based on a socio-scientific issues approach to green chemistry.

Material Validation

Assessment by 3 material validators using a validation sheet in the form of a 1-4 Likert scale. Material expert validation assessments are based on content, pedagogical, language and graphic aspects. The results of the average percentage of each aspect of the material validation assessment can be seen in Table 3.

Table 3. Percentage of Material Expert Validation Results

Rated aspect	Percentage (%)	
	Validation I	Validation II
Content Eligibility	82.6	100
Pedagogy	81	99
Language Assessment	67	98
Graphics	76	99
SSI Characteristics	82	100
Average	78	99

The material validation stage was carried out twice. In the first validation, the average percentage obtained from the 5 aspects was 78% with the valid category. Even though valid results were obtained, in the first validation suggestions were also obtained from each material validator to improve the e- Module , so that the researcher carried out revisions and a second validation in order to obtain an e-Module based on a better socio-scientific issues approach. After revisions were made based on suggestions from the validator, in the second validation the percentage rose to 99% with a very valid category.

a) Media Validation

Media validation involves 3 validators who are expert lecturers in the media field. Media validation uses a validation sheet in the form of a 1-4 Likert scale. The purpose of this media validation is to assess e-modules based on socio-scientific issues regarding green chemistry based on 3 aspects, namely e-module size , cover design and e-module content. The results of the average percentage of each aspect of the media validation assessment can be seen in Table 4.

Table 4. Results of Media Expert Validation

Rated aspect	Percentage (%)	
	Validation I	Validation II
E-module size	100	100
E-module cover design	79	98
Design e-module content	97	98
Average	92	99

The media validation stage was carried out twice. In the first validation, the average percentage obtained for the 3 aspects was 92% with the valid category. Even though valid results have been obtained, in the first validation suggestions were also obtained from each media validator for improving the e-module , so the researchers carried out revisions and second validation to obtain an e-module based on socio-scientific issues on green chemistry. which is even better. After revisions were carried out according to the validator's suggestions, in the second validation the percentage rose to 99% with a very valid category.

a. Implementation

Step this that is do media implementation deep learning learning process at school. By doing one-on-one trials, try them out small scale and large scale trials involve students to find out Student responses to e-module materials based on a socio-scientific issues approach.

1) Test each one one by one

Test one by one to e- module based on a socio-scientific issues approach involves 3 person Class XI students at SMAN 2 Siak Hulu who have studied green chemistry material in class XI is tested on one person first, then after completion it is continued with the next person, and so on. All three is participant educate which own level ability academic which different, that is tall, currently and low. The comments and suggestions given by students can be seen in Table 5.

Based on interviews with students in one-on-one tests, clarity the learning in the e- module was considered good, except that there was limited vocabulary not standard so it must be corrected. In the aspect of impact for users, participants students assess that e- modules have a positive impact on them because they can make them better understand the material presented in various content multimedia And e- module _ given Also easy used as well as in accordance with mindset participant educate. This is because the e-module has an attractive appearance, is unique, and is easy to use. The same thing was conveyed by Adawiyah & Hadisaputra (2020) Interesting teaching materials can make students more interested and motivated to participate in learning.

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Table 5. Student Comments and Suggestions on the One-on-One Test

Student Code	Comments and Suggestions
HNS	Comment: 1. The e- module used is very interesting and the color combination is right, so I don't get bored quickly while studying. 2. The writing is easy to read and clear. Suggestion: More interesting picture
S.N	Comment: 1. The e- modules provided are interesting, unique and can be adequate teaching material for learning. 2. The tasks given are not too many so they are efficient in terms of processing time. Suggestion: typo words that need to be corrected
MDA	Comment: The e- module provided has a good appearance and is easier to use. Suggestion: There are several typo words that need to be corrected.
Conclusion	Comment: The e- module developed is attractive and easy to use. Suggestion: Add more attractive images and correct typos.

2) Small-scale trials

At this stage, the researcher acts as an observer and does not interact with users. Small group trial responses were obtained from 3 teachers chemistry And 30 participant educate with method give questionnaire response test try small scale. Data collection on small-scale trial responses was carried out at SMAN 2 Siak Hulu, SMAN 2 Tambang, and SMAN 1 Bangkinang Kota.

a) Teacher response questionnaire data

User responses with chemistry teacher response questionnaire data at 3 schools, namely SMAN 2 Siak Hulu, SMAN 2 Tambang, and SMAN 1 Bangkinang Kota. User responses involving teacher assessment are

carried out by first providing an e- module based on a socio-scientific issues approach , then teachers are given time to look at the e- module carefully before providing an assessment using a response questionnaire. The results of the teacher's response questionnaire are presented in Table 6.

Table 6. Teacher Response Questionnaire Data

Respondent	Percentage (%)	Criteria
Teacher 1	91.7	Very good
Teacher 2	90.3	Very good
Teacher 3	94.4	Very good
Average	92.1	Very good

Response Teacher to e- module based on an overall socio-scientific issues approach assessed very Good with achievement percentage as big as 92.1%. Results This in line with study development e- module by Apriani et al. (2021) Which obtained teacher response assessment results with an average percentage of 90% categorized as very Good.

b) Student response questionnaire data

Stages of obtaining user responses from the results of student response questionnaires involving 30 class XI Science students with 10 students each from 3 school different, that is SMAN 2 Siak Hulu, SMAN 2 Tambang, and SMAN 1 Bangkinang Kota. Collecting response questionnaire data involve students implemented by giving e- modules to students, then giving them time to assess the e- module using a response questionnaire. The results of the student response questionnaire can be seen in Table 7.

Table 7. Student Response Questionnaire Data

School	Percentage (%)	Criteria
SMAN 2 Siak Hulu	96.7	Very good
SMAN 2 Tambang	96.4	Very good
SMAN 1 Bangkinang	96.7	Very good
Average	96.6	Very good

Based on Table 7, it can be seen that the results of distributing questionnaires to obtain student responses at 3 schools obtained an average of 96.6%. This means that the e- module is based on a socio-scientific issues approach which has been developed has received a very good response from students. These results are in accordance with research on e- module development by Apriani et al. (2021) who obtained student response assessment results with an average percentage of 87% in the very good category. This shows that the e- module that has been developed is able to attract students' attention because it is considered to have an attractive appearance, making them more enthusiastic and motivated in learning, presenting material using multimedia so that it is easy to understand and more learning activities increasing student activity. Based on the results of small-scale tests, it can be concluded that the e- module is based on a socio-scientific issues approach has received a very good response from teachers and students as users. After going through the validation and small-scale testing stages, then revisions were carried out, the final product of the e- module was produced.

3) Large Scale Trials

The Large Scale Trial stage carried out is an effectiveness test product. Field trials were carried out at SMAN 2 Siak Hulu on participants Class X IPA 2 students totaling 37 people as experimental and classroom classes X Science 1 Which amount 38 person as control class.

a) Environmental care capabilities

Environmental Care data was obtained from the results of a questionnaire given to students to determine the level of environmental care ability before and after using an e-module based on a socio-scientific issues approach. This data can be seen in Table 8.

Table 8 Data on the results of students' environmental care abilities

Environmental care capability indicators	Before SSI e-module	After SSI e-module	Percentage (%) Before	After
Environmental care	72	92	69	72
Reducing plastic use	62	79	59	61
Waste management according to type	64	75	61	62
Reduction of carbon emissions	86	100	78	77
Energy savings	73	87	70	73
Composite Average Percentage (%)	71	87	67	69

Table 8 shows that students' environmental care abilities obtained a combined average percentage of 71% before using the e-module based on a socio-scientific issues approach and increased to 87% after using the e-module. This data shows that students' environmental care abilities increase after taking part in learning using e-modules based on a socio-scientific issues approach. Data from normality test data for environmental care capabilities can be seen in Table 9.

Table 9 Normality Test Results for Environmental Care Capability Data

Environmental Care Capability Data	Kolmogorov-Smirnov Statistics	df	Sig.
previous experiments	0.150	37	0.059
experiment after	0.154	37	0.061
control before	0.131	38	0.100
control after	0.135	38	0.079

Table 9 shows that the data values for students' environmental care abilities before and after using the e-module each obtained a significance value of >0.05. This means that the data on students' environmental care abilities is normally distributed because it has a sig value> 0.05. Based on these results, the environmental care capability hypothesis test will be carried out with parametric statistics using the independent sample t test. Hypothesis test results data on students' environmental care abilities can be seen in Table 10.

Table 10 Hypothesis Test Results Environmental Care Capability Data

		F	Sig.	t	df	Sig. (2-tailed)
Mark	Equal variances assumed	5.085	0.027	8.515	72	0.000
	Equal variances not assumed			8.515	58.005	0.000

Table 10 shows the results of the hypothesis test for environmental care capability data using the paired t test obtained a significance value of 0.000. This means that Ha $_{is}$ accepted because the sig value is <0.05, so it can be stated that there is a significant difference from the application of e- modules based on a socio-scientific issues approach to the environmental care abilities of class X students at SMAN 2 Siak Hulu. Based on this statement, it can be concluded that e- modules based on a socio-scientific issues approach have an influence on students' environmental care abilities in green chemistry material. The results of this research are in line with research by Munifatun Muthoharoh, et al (2017) that the application of the socio-scientific issues e- module has an effect on students' environmental care abilities as seen from the environmental care abilities which increase after participants use the e- module in chemistry learning.

The results of measuring critical thinking skills can be presented in the form of descriptive statistics in the form of average values (mean) and improvements for both the control class and the experimental class. These results can be presented in Table 11.

Table 11 Descriptive Statistics Value of critical thinking skills

	Experimental Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Sample	37	37	38	38
Average	60.51	88.62	60.66	77.18
Min Value	54	80	54	70
Max Value	64	96	64	80

Based on the data in table 11, it can be seen that the total sample for the experimental class was 37 people and the control class was 38 people. The average score of the experimental class before learning was 60.51 and increased to 88.62 in the average score after learning. The average score of the control class before learning was 60.66 and increased to 77.18 in the average score after learning. The highest score in the experimental class before learning was 64 and after learning was 96, while the lowest score before learning was 54 and after learning was 70. The highest score in the control class before learning was 64 and after learning was 80, while the lowest score before learning is 64 and after learning is 80. The results of the normality test for each variable are as follows (Table 12).

Table 12 Normality test of critical thinking skills

Class		Kolmogorov-Smirnov Sig.	Conclusion
Pretest	Experiment	0.052 _	Normal Distribution
	Control	0.139 _	Normal Distribution
Posttest	Experiment	0.066 _	Normal Distribution
	Control	0.058 _	Normal Distribution

Based on the significance level in table 12 which has been presented for the normality test, it shows that the pretest and posttest critical thinking ability scores for the control and experimental classes are normally distributed, this is indicated by a significance level of more than 0.05 or p>0.05. So it can be concluded that all data is normally distributed. Based on the results of these prerequisite tests, parametric testing can be continued so that the data will be analyzed using the Independent Sample T-Test

Table 13T-test of critical thinking skills

Class		N	Mean	elementary school	t-test for equality of means F	t	df	Sig. (2-tailed)	Conclusion
Pretest	Experiment	37	60.51	2.725	0.003	0.229	73	0.819	Ha Accepted (There are differences)
	Control	38	60.66	2.734					
Posttest	Experiment	37	88.62	4.468	8.609	13.596	73	0.000	
	Control	38	77.18	2.598					

Based on the results of the Independent Sample T-Test statistical test above, the sig (2-Tailed) t test value for students' critical thinking skills is 0.000. Because the sig (2-Tailed) value is <0.05, H0 is rejected and Ha is accepted. Thus, it can be concluded that there is a significant difference in students' critical thinking skills between the experimental class and the control class. The increase in students' critical thinking skills in the control and experimental classes can be seen through calculating the normalized gain scor. The analysis results are shown in the following Table 14.

Table 14 Data on improving learning outcomes in the experimental and control classes

Class	Average N-Gain Score	Category	Frequency	Percentage (%)
Experiment	0.71 (high)	Tall	23	62
		Currently	14	38
		Low	0	0
Amount			37	100
Control	0.42 (medium)	Tall	0	0
		Currently	35	92
		Low	3	8
Amount			38	100

Based on the results of the analysis above, it can be seen that the average gain score for students' critical thinking skills in the control class is 0.42, which is included in the medium category. Meanwhile, the average gain score for critical thinking skills in the experimental class is 0.71 and is included in the high category, so it can be concluded that there is a difference in critical thinking skill scores between the control class and the experimental class. In the experimental class there was an increase in learning outcomes with an average N-Gain of 0.71. This value is included in the high category ($0.30 \leq N - Gain \leq 0.70$).

b. Evaluation

The evaluation stage in this research can be carried out at each stage of ADDIE. Evaluation aims to analyze data obtained from research results, namely (1) analysis in the form of initial analysis, student analysis, curriculum analysis, material analysis, (2) compiling instruments for assessing the quality of teaching materials, product design (storyboard), preparation of materials, collection of tools and materials, (3) development in the form of material and media expert validation and (4) implementation in the form of one-on-one trials, limited trials and field trials. The final results of the evaluation stage show that the product developed in the form of an e- module is very valid, received a good response from teachers and students and can improve critical thinking skills (Marlina, 2022).

This research is also not free from several obstacles in the field, especially for e- modules based on a socio-scientific issues approach. Through e- modules based on a socio-scientific issues approach, students are guided to organize all the knowledge they already have and the conditions that exist in life to solve a problem (Septianita, 2023). Learning becomes more meaningful and students will be able to develop their abilities in applying the concepts they have according to the situation in which the concepts are applied. This is in accordance with the theory of meaningful learning which prioritizes the importance of associating experiences (Illeris, 2014), certain phenomena, as well as all facts obtained by students into concepts they have previously had (bagia, 2023). Students' problem solving skills are influenced by intelligence. Students with higher intelligence will find it easier to improve their problem solving abilities (Ausubel, 2012). In addition to improving problem solving skills, they will indirectly improve critical thinking skills. The use of e- modules can help students discover concepts (Hidayah, 2018). Compared to conventional methods, learning using the socio-scientific issues method improves critical thinking skills (Yustina, 2021). Furthermore, the existence of e-modules in the form of task sheets that are structured and made interesting in such a way will motivate students when studying so that they are able to improve their problem solving skills (Malik, 2023). This is in line with research on the use of e- modules in contextual learning which influences significant differences in pre-test and post-test scores on Environmental Care and students' critical thinking skills.

Based on this, students can improve students' critical thinking skills through e- modules based on a socio-scientific issues approach, with this students can practice high-level thinking processes and develop skills in gathering information and understanding related to green chemistry.

Conclusion

Based on the research results, it can be concluded that the developed e-Module is highly valid, as indicated by validation ratings of 92% from material experts and

99% from media experts. The e-Module received very positive feedback from both teachers and students, with user responses rated at 92.1% and 96.6%, respectively. The large-scale testing demonstrated that the e-Module significantly improved students' environmental care and critical thinking skills, as evidenced by the paired t-test results (significance value of 0.000). The N-Gain value for the experimental group was 0.71, indicating a high category improvement in critical thinking skills, while the control group achieved a medium category with an N-Gain of 0.42. These findings confirm that the e-Module effectively enhances students' environmental care and critical thinking abilities in green chemistry material.

Author Contributions
All authors have made significant contributions to the completion of this manuscript.

Funding
This research received no external funding

Conflicts of Interest
The authors declare no conflict of interest.

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