Research and Development in Education (RaDEn)

Research Article

Development of SSIBL e-modules on ecology and biodiversity materials to improve critical thinking and motivation

Anggi Kusumasari [a,1] , **Evi Suryawati** [a,2,*] , **Lenny Anwar** [a,3]

[a] Master of Science Education, Postgraduate Program, Universitas Riau, Jl. HR. Soebrantas Panam No.KM. 12,5 Simpang baru, Panam, Kota Pekanbaru, Riau 28293 Indonesia.
[1]anggikusumasari6953@grad.unri.ac.id; [2]evi.suryawati@lecturer.unri.ac.id* ; [3]lenny.anwar@lecturer.unri.ac.id
*Corresponding author

Citation: Kusumasari, A., Suryawati, E., Anwar, L. (2024). Development of SSIBL e-modules on ecology and biodiversity materials to improve critical thinking and motivation. *(RaDEn), 4*(2), 1066-1082. https://doi.org/10.22219/raden.v4i2.33775

Received: 23 May 2024
Revised: 15 September 2024
Accepted: 19 September 2024
Published: 21 November 2024

Abstract: The development of SSIBL-based E-modules is motivated by the importance of critical thinking skills and learning motivation in science learning that must be possessed by students. It was found that the limited teaching materials used as well as critical thinking skills and student learning motivation were still in the low category in science learning. This study aims to test the effectiveness and feasibility of SSIBL-based E-modules on ecology and biodiversity material for Indonesian junior high school students, especially at SMPN 23 Pekanbaru. The type of research used is development research with the ADDIE method. The results of the validation of the SSIBL-based E-module assessment by material experts obtained an average score of 3.72 with a very feasible category. The results of the assessment validation by pedagogical experts amounted to 3.97 with a very feasible category. The results of the assessment validation by media experts amounted to 3.95 with a very feasible category. The effectiveness of the E-module with the MANOVA test obtained a sig value of 0.000. This means that there are differences in critical thinking skills and learning motivation between the experimental class using the SSIBL-based E-module and the control class that does not use the SSIBL-based E-module. Based on the results of this SSIBL-based E-module research, it is recommended that it can be used to improve students' critical thinking skills and learning motivation.

Keywords: e-modules; Indonesian ecology and biodiversity; SSIBL

1. Introduction

Education has a very important contribution in creating intelligent individuals and having quality human resources. The 21st century is characterized by the rapid development of information technology (Indarta et al., 2021). The industrial revolution 4.0 in education is referred to as 21st century learning (Sidi, 2020). The use of technology to date has covered all lines of life including education. This situation implies that education is faced with a formidable challenge (Amahoroe et al., 2020). Among these challenges are critical thinking skills (Supeno et al., 2019; Supeno et al., 2020).

In fact, students' critical thinking skills are still low and intermediate (Noerfatimah et al, 2022). Currently, the quality of science education in Indonesia is not optimal, so improvements are needed. According to the results of PISA (Program For International Student Assessment) in 2015 Indonesia was ranked 74th out of 70 countries. In 2018 Indonesia ranked 73rd out of 78 countries. This shows that there is a decline in science skills and the average science skills in Indonesia are still in the low category. The need to improve learning that requires students to think critically and innovatively in the learning process so that in the future they can face educational problems. Emphasize the importance of competencies to improve quality to face the challenges of the 21st century (Schleicher, 2019). Critical thinking skills are essential in the age of information and technology. Critical thinking skills are considered a vital skill for the 21st century, so it is an educational outcome desired by educators (Tosuncuoglu, 2018).

Critical thinking skills are thinking skills on a problem that conditions students to think reflectively by involving cognitive processes (Juliyantika & Batubara, 2022;

Wijayanti et al., 2023). Students are said to have critical thinking if they have the ability to answer a problem and the answer is productive, evaluative, and reflective. (Haryanti, 2017; Nasihah & Lesmono, 2019).

Although it has very urgent benefits, the facts about students' critical thinking skills are still in the unsatisfactory category. Research results Meryastiti et al., (2022) shows that in science learning, students' critical thinking skills are generally in the medium and low categories. Firdaus and Wilujeng, (2018) in his preliminary research stated that the cause of students' low critical thinking skills in understanding concepts is because students are accustomed to receiving explanations of concepts, theories, and facts directly by educators without familiarizing with the science process. Students are not accustomed to doing the process in constructing a concept based on facts so that learning is more teacher-centered.

Based on the results of the needs analysis, students' critical thinking skills are still not maximally trained, 56.5% of students are still unable to measure the data given by the teacher during science learning, 71.4% of students are still unable to distinguish true and false data given by the teacher during science learning and 51% of students are still unable to determine the conclusion of a statement given by the teacher during the science learning process. Science teachers have not fully trained students' critical thinking skills, where 66.7% of science teachers rarely train the ability to measure data, 77.8% of science teachers rarely train students' skills in formulating conclusions and 66.7% of science teachers rarely train students' skills in realizing unwritten conjectures or prejudices during science learning. 66.7% of teachers still use printed books and 55.6% of teachers have not integrated science and technology during science learning.

Natural Science is a way of finding out and studying nature and everything in it. Science is not only mastery of a collection of knowledge in the form of concepts, facts, and principles, but is more systematic and scientific (Havina et al., 2021). Science concepts in junior high school are integrated according to the characteristics of science subjects which are a collection of chemistry, biology, physics, and earth and space science (Eka et al., 2022). Thus, science learning should be directed towards the acquisition of knowledge about science and the development of various critical thinking skills.

Based on the results of interviews with one of the science teachers at State Junior High School 23 of Pekanbaru obtained information that the material Ecology and Biodiversity of Indonesia is classified as having many concepts that must be understood by students. This material is classified as difficult because it requires a lot of memorizations and the concepts contained in the material are interrelated. So that students must be able to know the difference from each characteristic of the given concept (Kamaruddin et al., 2021). Students' difficulties in understanding Indonesian Ecology and Biodiversity material are also evidenced by the low daily test scores of students in class VII State Junior High School 23 of Pekanbaru.

The difficulty of students in understanding Indonesian Ecology and Biodiversity material is also due to the utilization of supporting learning media as a learning resource. This is in accordance with the needs analysis found 65.3% of teachers still use printed books. This is supported by the study of Dewi and Izzati, (2020) that teachers only use learning media in the form of thematic books provided by the government, so students easily feel bored and cause students to be inactive during learning activities. Based on the results of the analysis of student needs, 66.7% of students do not like the various problems given during science learning, 77.8% of students quickly despair when learning science, 55.1% of students prefer to depend on other friends during learning, 59.2% of students do not like to solve problems during science learning. This lack of student motivation also causes students' critical thinking skills to be low.

To overcome these problems, teachers should be able to develop teaching materials that are active, innovative, and interactive in the learning process. Teaching

materials are one of the important elements in learning. The existence of teaching materials will help educators design learning and help students master learning competencies (Kamaruddin et al., 2021). Then the module development is needed. The module developed is an E-module based on the learning model. Based on the results of interviews at students at state junior high school 23 Pekanbaru may use Notebooks, laptops and computers during learning. The role of learning media can be explored in delivering learning messages to stimulate students' thoughts, feelings and emotions. By adjusting the messages and information presented in the learning media to suit the needs and abilities of students, they can be more involved in the learning proces (Yuliani & Setiawan, 2023; Rahma & Sami, 2022).

E-modules process the parts contained in a typical printed module. The comparison is only in the physical delivery of the E-Module which uses a computer device (Laksmi et al., 2021; Sri et al., 2022). Model integration must be aligned with teaching materials.

SSIBL learning model that accommodates the stages of engagement with scientific issues and the process of complex learning activities. SSIBL was first piloted in a European training program for 79 pre-service teachers in 2018 (Levinson, 2018; Knippels & Harskamp, 2018). There are 3 basic pillars of the SSIBL model namely: civic education, socioscience issues and inquiry learning. *Socio Scientific Issues* (SSI) aims to develop perspectives that enable students to critically reflect on science and technology through understanding and problem solving and grow into citizens with the capacity and character to respond thoughtfully to related issues (Sadler & Zeidler, 2022). Socio Scientific Issues (SSI) teaching contributes to improving students' understanding of the nature of science and technology, character and citizenship (Erna & Alimin, 2023). The importance of Biology teaching materials that include elements of the SSIBL approach can lead to scientific and moral thinking in completing every event that takes place in real life (Noerfatimah & Yusup, 2022). Teaching materials based on inquiry models with socioscientific issues are also able to improve critical thinking skills (Ilfiana et al., 2021). Teaching with social issues can provide opportunities for students to understand the relevance of science to everyday personal and social problems and students' improvement in decision-making skills (Ratnawati, 2022).

Some relevant studies on the application of the (SSIBL) model only discuss the application of student worksheet the SSIBL model to improve problem solving skills and science literacy (Noerfatimah & Yusup, 2022; Yiannis & Kyza, 2023). So that critical thinking skills are not the center of attention in previous relevant studies. Whereas critical thinking skills are very important to study, in order to analyze students' critical thinking skills directly on the E-module based on Socio Scientific Inquiry Based Learning. Therefore, the purpose of the research is to see the feasibility and effectiveness of E-modules based on Socio Scientific Inquiry Based Learning on Indonesian ecology and biodiversity material to improve critical thinking skills and learning motivation, especially at students at state junior high school 23 Pekanbaru, Riau.

2. Materials and Methods

The research approach used in this research is research and development (R&D) with the ADDIE method which consists of the stages of Analyze, Design, Develop, Implement, Evaluate. The type of data in this study consists of primary data and secondary data. The population in this study were all seventh-grade students of students at state junior high school 23 Pekanbaru in the 2024/2025 school year. The sampling technique uses Random Sampling Technique or simple random Simple Random Sampling is the taking of sample members from a population that is carried out randomly without regard to the strata in the population (Sugiyono, 2019). E-module products developed with the ADDIE model with the Analyze stage, analyzing

student needs, curriculum and materials. The Design stage is carried out designing E-modules. The Development stage is carried out E-module development and product validation by material, media, pedagogical experts. Then proceed with one-on-one testing, practicality and testing of evaluation instruments. At the Implementation stage, the E-module was implemented using the quasi-experimental method. The Evaluation stage is carried out product evaluation and revision to determine the success of the developed E-module. The data analysis techniques used are student and teacher needs analysis, SSIBL-based E-module validation data analysis, practicality test data analysis, SSIBL-based E-module effectiveness test data analysis. The type of scale used is the Likert Scale with a score of 1-4. Likert Scale assessment categories such as Table 1. The lattice of validation instruments by material, media and pedagogical experts is as follow Table 2. The grid of validation instruments by pedagogical experts follows in Table 3, and the grid of validation instruments by pedagogical experts in Table 4.

Table 1. Likert Scale Rating Categories

No	Likert Scale	Rating Category
1.	4	Strongly Agree
2.	3	Agree
3.	2	Disagree
4.	1	Strongly disagree

Resource: (Sugiyono, 2019).

Table 2. Grids of Validation Instruments by Material Experts

No	Assessment Aspect	Total Assessment Items	Item Number
1	Indicator of material suitability	7	1,2,3,4,5,6,7
2	Indicator of material accuracy	3	8,9,10,
3	Language Indicator	2	11,12

Adaptation: (Saraswati & Linda, 2019; Sukariasih & Salim, 2019)

Table 3. Grid of Validation Instruments by Pedagogical Experts

No	Assessment Aspect	Total Assessment Items	Item Number
1	Presentation indicators	7	1,2,3,4,5,6,7
2	Indicator model SSIBL	5	8,9,10,11,12
3	Indicators of critical thinking	5	13,14,15,16,17

Adaptation: (Nasir, 2023; Darmaji et al., 2019)

Tabel 4. Grid of Validation Instruments by Pedagogical Experts

No	Assessment Aspect	Total Assessment Items	Item Number
1	Design indicators	6	1,2,3,4,5,6
2	Technique indicators	5	7,8,9,10,11

Adaptation: (Nasir, 2023)

The data analysis technique for validation results was carried out by finding the average score of the assessment results from the validator. The criteria for the validity of the SSIBL-based E-module as a whole as in Table 5.

Table 5. Criteria for Validation of SSIBL-based Science E-Modules

No	Average Score Interval	Criteria
1	3.41-4.00	Very Valid
2	2.81-3.40	Valid
3	2.01-2.80	Less Valid
4	1.00-2.00	Invalid

Source: (Sugiyono, 2014)

The student response questionnaire grid can be seen in Table 6 and the teacher response questionnaire can be seen in Table 7.

Table 6. Student Response Questionnaire Grid

No	Assessment Aspect	Total Assessment Items	Item Number
1.	Attractiveness	6	1,2,3,4,5,6
2.	Ease of Use	4	7,8,9,10
3.	Benefits	6	11,12,13,14,15,16

Adaptation: (Agustia, 2022)

Table 7. Teacher Response Questionnaire Grid

No	Assessment Aspect	Total Assessment Items	Item Number
1.	Practicality	5	1,2,3,4,5
2.	Presentation	5	6,7,8,9,10
3.	Benefits	5	11,12,13,14,15

Adaptation: (Putri et al., 2023)

The data analysis technique for student and teacher practicality tests was carried out by calculating the percentage of the average score of practicality for each indicator, based on the results of student and teacher responses. The percentage of the average score of practicality obtained is then interpreted based on the criteria as in Table 8.

Table 8. Criteria for Practicality of SSIBL-based Science E-Modules for Students and Teachers

No	Practicality Percentage (%)	Category
1	$P \leq 20$	Not Practical
2	$20 < P \leq 40$	Less Practical
3	$40 < P \leq 60$	Practical enough
4	$60 < P \leq 80$	Practical
5	$80 < P \leq 100$	Very Practical

Adaptation: (Riduwan, 2007)

The data analysis technique for testing the effectiveness of SSIBL-based E-modules to improve students' critical thinking skills was carried out by finding the average score of each student's critical thinking skills posttest and calculating the percentage of the average score for each critical thinking indicator studied presented in Table 9.

Table 9. Intervals and Categories of Critical Thinking Ability

Percentage Score (%)	Category
85 < X ≤ 100	Very Critical
76 < X ≤ 85	Critical
60 < X ≤ 76	Critical Enough
55 < X ≤ 60	Less Critical
≤ 54	Not Critical

Source: (Sugiyono, 2014)

Data collection on student learning motivation was carried out using a student learning motivation questionnaire. Furthermore, the percentage score of the student motivation questionnaire results was analyzed according to the following criteria in Table 10.

Table 10. Categories of Student Learning Motivation

Percentage Score (%)	Category
85 ≤ p < 100	Very High
71 ≤ p < 85	High
56 ≤ p < 70	Medium
41 ≤ p < 55	Low
0 ≤ p <40	Very Low

Source: (Sunarto, 2017)

The inferential data analysis technique was conducted to see the effectiveness of the SSIBL-based E-module to significantly improve students' critical thinking skills. Inferential statistical analysis in this study used the help of the SPSS 24 for Windows program with a confidence level of 95%. First, the prerequisite test was carried out which included normality test and homogeneity test. After the prerequisite test is carried out, it will be continued with hypothesis testing.

3. Results

Research and development of E-modules based on Socio-Scientific Inquiry Based Learning (SSIBL) on Ecology and Biodiversity of Indonesia class VII SMP is carried out through the stages of validity testing, practicality testing, and E-module effectiveness testing to improve students' critical thinking. The stages of developing an E-module SSIBL on Indonesian Ecology and Biodiversity Material using the ADDIE development model which consists of the stages of Analyze, Design, Development, Implementation, Evaluation.

3.1 Analyze

The results of the needs analysis are that there are various basic problems faced by teachers and students in carrying out science learning. It was found that the material of Indonesian ecology and biodiversity is a material that is difficult for students to understand. Students' critical thinking skills at state junior high school 23 Pekanbaru have not been maximally trained. Students' motivation in learning science is low. Learning media that are often used by teachers in learning science are students worksheet and printed books. The dominant learning method applied by teachers is the lecture and question and answer method. E-modules based on Socio-Scientific Inquiry Based Learning are needed in science learning to improve critical thinking skills and student motivation.

3.2 Design

The design stage consists of several activities, namely designing the format, designing learning in SSIBL-based E-modules, designing SSIBL-based E-modules and research instruments consisting of student and teacher needs analysis questionnaires, validation sheets, one-on-one trial interview sheets, student and teacher practicality sheets, and critical thinking skills tests on Indonesian ecology and biodiversity material.

3.3 Develop

The activities carried out at the develop stage consisted of several activities, namely making a complete E-module, can be seen in Figure 1, Fugure 2, and Figure 3. The complete SSIBL-based E-module was completed, then tested for feasibility with an expert validity test, and tested the practicality of the E-module which consisted of a one-on-one trial, and a practicality test based on the responses of students and science teachers. In addition, at this stage the posttest questions were also tested on Indonesian ecology and biodiversity material by conducting item validity tests and instrument reliability tests.

1) Complete SSIBL-based E-module Creation
   Based on the design of the initial draft of the SSIBL-based E-module at the design stage, at this development stage the researcher continued to make the complete E-module for 6 meetings. Thus, producing SSIBL-based E-modules that are ready to be tested for validity and practicality.
2) SSIBL SSIBL-Based E-module Validity Test Results
   The results of the SSIBL-based E-module validation on the material aspect are shown in the following Table 11, Table 12, and Table 13.

Table 11. SSIBL-based E-module Validation Results on Material Aspects

No	Assessment Aspect	Validation Result Score	
		Average	Criteria
1	Material Suitability	3.92	Very Valid
2	Accuracy of Material	4.00	Very Valid
3	Language	3.25	Very Valid
	Average Validation Score	3.72	Very Valid

Table 12. Results of SSIBL-Based E-module Validation on Pedagogical Aspects

No	Assessment Aspect	Validation Result Score	
		Average	Criteria
1	Presentation	3.92	Very Valid
2	SSIBL Model	4.0	Very Valid
3	Critical Thinking	4.0	Very Valid
Average Validation Score		3.97	Very Valid

Table 13. Results of SSIBL-Based E-module Validation on Media Aspects

No	Assessment Aspect	Validation Result Score	
		Average	Criteria
1	Design	4.0	Very Valid
2	Use Technique	3.90	Very Valid
	Average Validation Score	3.95	Very Valid

Figure 1. Cover SSIBL E-module

Figure 2. Contents SSIBL E-module

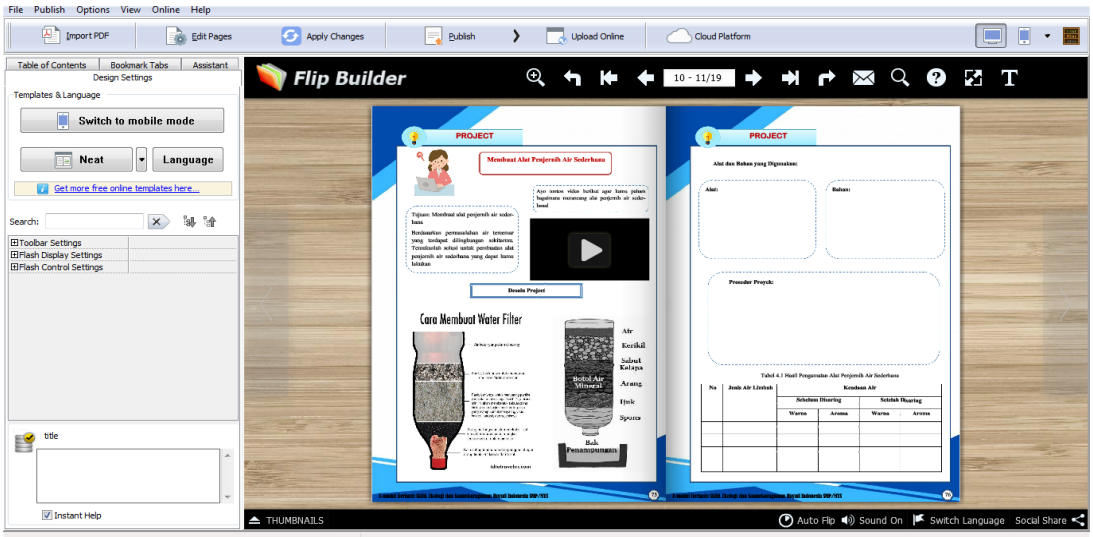

Figure 3. Project in SSIBL E-module

3) One-on-One Test
The difficulty of students using the E-module is that the sound contained in the video is less clear so a speaker is needed, students who are not yet proficient in using the E-module with professional pdf must be guided by the teacher.
4) Student Practicality Test Results
Practicality Test Results of SSIBL-Based E-module by Students follow in Table 14.

Table 14. Practicality Test Results of SSIBL-Based E-module by Students

No	Assessment Aspect	Validation Result Score	
		Average	Criteria
1	Attractiveness	91.25	Very Practical
2	Ease of Use	91.25	Very Practical
3	Benefits	93.54	Very Practical
	Average Practicality Score (%)	92.01	Very Practical

5) Teacher Practicality Test Results
Practicality Test Results of SSIBL-Based E-module by Teachers follow Table 15.

Table 15. Practicality Test Results of SSIBL-Based E-module by Teachers

No	Assessment Aspect	Validation Result Score	
		Average	Criteria
1	Practicality	93.33	Very Practical
2	Presentation	88.32	Very Practical
3	Benefits	93.99	Very Practical
	Average Practicality Score (%)	91.66	Very Practical

6) Critical Thinking Ability Test Instrument Results
Reliability Test Results of Critical Thinking Ability Test Instrument presented in Table 16.

Table 16. Reliability Test Results of Critical Thinking Ability Test Instrument

Variables	Cronbach's Alpha	Conclusion	Category
Critical Thinking	0.751	Reliabel	High

3.4 Implement

The activities carried out at the implement stage are field trials of the use of SSIBL-based E-modules that are already valid and practical in science learning.

1) Normality Test
Normality Test Results of Critical Thinking Ability and Learning Motivation of Experimental and Control Classes presented in Table 17.

Table 17. Normality Test Results of Critical Thinking Ability and Learning Motivation of Experimental and Control Classes

Variables	Significance Value		Conclusion
	Experiment	Control	
Critical Thinking Ability	0.052	0.195	Normal
Learning Motivation Questionnaire	0.200	0.200	Normal

2) MANOVA Test
a. M Box Test.
The results *M Boxs Test* presented in Table 18.

Table 18. Results *M Boxs Test*

Test	F	Sig
M boxs test	2.379	0.068

b. Uji Test of Between Subjects Effect.
The results of Between Subjects Effects presented in Table 19.

Table 19. Results *of Between Subjects Effects*

Source	Dependent Variable	F	Sig.
SSIBL-based E-module	Critical Thinking	21.815	0.000
	Learning Motivation	38.906	0.000

c. MANOVA Test.
The results *Multivariate Test* (MANOVA) presented in Table 20.

Table 20. Test Results *Multivariate Test* (MANOVA)

Effect		F	Sig
Class	Pillai's Trace	0.450[b]	.000
	Wilks' Lambda	0.050[b]	.000
	Hotelling's Trace	0.819[b]	.000
	Roys's Largest Root	0.819[b]	.000

4. Discussion

Research and development of E-modules based on Socio-Scientific Inquiry Based Learning (SSIBL) on Ecology and Biodiversity of Indonesia class VII SMP is carried out through the stages of validity testing, practicality testing, and E-module effectiveness testing to improve critical thinking and student motivation. The results of the needs analysis found that there are various basic problems faced by teachers and students in carrying out science learning. Indonesian ecology and biodiversity material is material that is difficult for students to understand, this is because the material is complicated which requires a clear understanding of the concept The next problem is that students' critical thinking skills have not been trained to the fullest. In accordance with the study Mulyani, (2023) students' critical thinking skills are still classified as less critical 57.43%. The lack of student involvement in learning causes students' critical thinking skills to be less trained. Without practice and habituation, critical thinking skills cannot be obtained in a short time (Ilfiana, 2021).

In the learning process, educators can implement critical thinking skills as a trigger for students to develop critical thinking and problem solving skills (Firdaus, 2018). Learning with environmental issues is the development of critical thinking and environmental problem-solving skills. Critical thinking skills need to be known in relation to students' environmental knowledge (Mulyani, 2023). Teaching materials that incorporate the SSIBL model can bring out scientific and moral thinking in completing every event that takes place in real life, so that science learning becomes more meaningful. In addition, students can understand more in terms of context, increase argumentation skills, reasoning skills and increase empathy for others (Noerfatimah & Yusup, 2022).

The results of the material expert validation indicate that the description of the material presented in the SSIBL-based E-module is appropriate, accurate, up-to-date, and the language used in the SSIBL-based E-module is appropriate and easy to understand. The indicator of material accuracy obtained the highest average score, this is because the

presentation of discourse in the SSIBL-based E-module is based on facts and phenomena that are relevant to students' daily lives. Phenomena or problems presented in the SSIBL-based E-module encourage students to think of solutions that are relevant to everyday life (Noerfatimah & Yusup, 2022). SSIBL develops a perspective that allows students to critically reflect on science and technology through problem solving and grow into citizens of character (Baek et al., 2022).

SSIBL model sharpens problem-solving skills in everyday life, interaction and understanding of concepts by discussing between students and teachers. The pedagogical expert validation results indicated that the presentation of pedagogical elements in the SSIBL-based E-module was appropriate. In addition, the stages and learning activities in the SSIBL-based E-module are in accordance with the syntax of the SSIBL model, and have met the indicators of critical thinking skills. This is in line with research (Utami et al., 2023). SSI learning activities by exploring information and criticizing issues will train students' critical thinking skills. SSI represents problems in social life related to natural science (Kurniasih, A. et al., 2020).

The results of the media expert validation indicate that the design and technique of the SSIBL-based E-module are appropriate and attractive. The design indicator gets a slightly higher average score than the technique indicator. This is because the SSIBL-based E-module has an attractive design, the colors and images are appropriate and equipped with consistent learning videos. An attractive and simple design according to student characteristics has an attraction that can attract students to learn independently (Laksmi & Suniasih, 2021). Consistent text colors provide user comfort in reading the contents of the E-module. SSI-based e-modules are easy to use by students because there are videos that can be accessed via laptop and android (Waste et al., 2023).

The results of students' practicality assessment of SSIBL-based E-modules are classified as very practical criteria. This illustrates that the SSIBL-based E-module is interesting, easy to use and provides benefits to students during science learning. The benefit indicator obtained the highest percentage. This is because the SSIBL-based E-module helps students in understanding the material of Indonesian ecology and biodiversity. SSIBL-based E-modules encourage students to be more active in science learning, discover the concept of Indonesian ecology and biodiversity for themselves, foster social attitudes to protect the environment, and learning activities in SSIBL-based E-modules train students' critical thinking skills. This is in accordance with the results of the study (Waste et al., 2023).

SSI-based E-modules facilitate students in learning independently and are able to train critical thinking skills with learning activities that contain issues in everyday life that must be criticized by students. The results of the teacher's practicality assessment show that the results of the teacher's practicality assessment of the SSIBL-based E-module are classified as very practical criteria. This is in line with research Erna *et al* (2023) The learning process by applying the SSI E-module makes it easier for teachers and students will receive the material presented easily independently. The critical thinking test instrument is reliable at 0.751 with a high category, the results of a high reliability value indicate that the instrument can be used stably and consistently (Sugiyono, 2019). So, it can be said that the question items as a whole are reliable and can be used to measure students' critical thinking skills.

Indicator of inference the experimental group was in the critical category and the control group was in the moderately critical category. the control group was in the moderately critical category. Through E-module based on SSIBL in the experimental class can already draw conclusions appropriately based on information provided through tables, graphs or statements contained in the problem or students are able to determine the truth or error of the conclusion. Determine the truth or error of the conclusion. Because through SSIBL syntax, namely issue introduction and elaboration discussion, students can obtain information from an environmental issue can obtain information

from environmental issues and students can answer the questions contained in the syntax of SSIBL, namely issue introduction and elaboration discussion. answer the questions contained in the discussion and elaboration syntax. Students are able to make conclusions related to the information provided (Dwi & Setianingsih, 2023; Mulyani, 2023). In the control class students are still dominantly unable to assess the truth in a conclusion based on the information provided (Mulyani, 2023).

Indicator of Recognition of Assumptions (Recognition of Assumptions) in the experimental group is in the category of critical and the control group was in the critical category. SSIBL-based e-modules students in the experimental class were able to identify the right conjecture based on the statements given in the problem in the syntax of discussion and elaboration. SSIBL-based e-modules students in the experimental class were able to identify the right conjecture based on the statements given in the problem in the syntax of discussion and elaboration. This is in line with the study of Mulyani (2023); Havina et al., (2021) the ability to identify assumptions can increase because students are in the process of finding the best solution can increase because students in the process of finding the best solution will receive information or views and try to understand the assumptions. will receive information or views and try to understand what is presented. In the control class, some students could not answer the question correctly, where they have not been able to identify assumptions implied in a statement and assess the conjecture given.

Deduction indicators in the experimental group were in the critical category and the control group was in the critical category. control group is in the critical category. In accordance with the study of Dwi & Setianingsih (2023) students can understand the given statement. Students solve the problem by collecting all the information that matches with the statement. Students have been able to interpret the information (Havina et al., 2021). Interpretation in the experimental group was in the critical category and the control group was in the moderately critical category. the control group was in the moderately critical category. E-modules students are able to assess the evidence or decide the the truth of a statement based on information or data given through questions on SSIBL syntax, namely discussion and elaboration. In accordance with the study of Mulyani (2023) students can answer correctly where they are able to assess evidence and make decisions whether the conclusions made are based on available data. In the control class, students have not been able to understand the meaning clearly, resulting in inappropriate conclusions (Danaryanti & Lestari, 2018).

Argument evaluation indicators in the experimental group was in the critical category and the control group were in the moderately critical category. E-module students are able to evaluate the strength and weakness of an argument based on statements that have been given in the syntax of discussion and elaboration (Annisa et al., 2024). This is indicated by the fact that most of the student groups have been able to provide correct reasons (Yiannis et al., 2023), indicating that students can distinguish between arguments that are directly related or not distinguish arguments that are directly related or not to the the content of the conclusion (Havina et al., 2021).

Ability Students' learning motivation in the control group was in the moderate category. The description of each indicator can be explained as follows. Indicators of desire and desire success in the experimental group was in the high category and the control group is in the medium category. In accordance with the study of Santoso et al., (2020) the desire and desire to succeed because students are more active when participating in the learning process. active when participating in the learning process. High learning motivation (Ilfiana et al., 2021).

Indicators of the existence of encouragement and needs in learning in the experimental group are in the high category and the control group is in the medium category. high and the control group is in the medium category. Increased learning motivation is also supported by quizzes and evaluations contained in the E-module. so

that feedback appears when students solve each problem given by the teacher. given by the teacher. This is in line with the research of (Alfiansyah et al., 2022). quizzes contained in interactive multimedia can foster student interest in following the learning process. students in following the learning process.

Indicators of the existence of hopes and ideals the experimental group was in the high category and the control group was in the medium category. the control group is in the medium category. Increased learning motivation due to the presentation of the problem in the syntax of the introduction of the issues contained in the E-module so that students tend to relate science learning to real-life examples. with real examples in everyday life. In addition, students also in developing, analyzing and evaluating the results of problem solving (Kharomah et al., 2023). Learning with SSIBL encourages student participation and discussion throughout the learning activities from asking questions, conducting investigations, proposing solutions and taking action (Levinson, 2018).

Indicator of the existence of activities that are interesting activities in learning in the experimental group are in the high category and the control group is in the medium category. high category and the control group was in the medium category. Increased motivation. The increase in learning motivation is also supported by the attractive appearance of the E-module. This is in accordance with the study of (Rahmayanti & Andayani, 2023). E-modules are interactive easy to navigate, allows displaying or loading images, audio, video, and animation and is equipped with formative tests or quizzes that allow for automatic feedback.

Indicators of a conducive learning environment the experimental group was in the high category and the control group was in the medium category. the control group was in the medium category. The increase in learning motivation is due to the use of interactive E-modules that students use in learning well. The use of E-Modules can support communication between teachers and students so that learning becomes more memorable and meaningful (Ilfiana et al., 2021).

5. Conclusion

SSIBL-based e-modules have been successfully developed using the ADDIE development model which consists of Analyze, Design, Develop, Implement, Evaluate. SSIBL-based E-modules have gone through expert validation stages which show that SSIBL-based E-modules are valid in material, pedagogical and media aspects. Furthermore, SSIBL-based E-modules have gone through the stages of one-on-one trials and student and teacher practicality tests which show that SSIBL-based E-modules are easy to use by students and teachers in learning Indonesian ecology and biodiversity materials. SSIBL-based e-modules have been implemented in learning ecology and biodiversity of Indonesia class VII junior high school and effectively used to improve students' critical thinking skills and learning motivation. Based on the results of the manova test, it is known that there are significant differences in critical thinking skills and motivation between the experimental and control groups.

Authors Contribution: A.K is the lead researcher and author of this article. A.K was in charge of collecting data, making needs questionnaire instruments, research response questionnaires, material, media and pedagogical expert validation, critical thinking questions and learning motivation questionnaires. In addition, A.K also developed and tested research products, and played a role in data processing. Not only that, A.K is also the author of the draft article. E.S and LA are the second and third authors of the article as well as supervisors who direct researchers in research and article writing.

Conflict of Interest: Authors declare there are no conflicts of interest.

Ancknowledgements: Thank you to the leaders and teachers at state junior high school 23 Pekanbaru, Riau who have provided opportunities and service facilities while carrying out research and thank you to the supervisor who has guided me in completing this article.

6. References

Alfiansyah, M. F., Adi, E. P., & Soepriyanto, Y. (2022). Pengembangan multimedia interaktif ipa dengan fitur feedback untuk siswa kelas VIII. *Jurnal Kajian Teknologi Pendidikan*, *5*(1), 22–31. http://journal2.um.ac.id/index.php/jktp/index

Annisa, M., Budimansyah, D., Hidayat, M., Winarti, A., & Muchlas, F. (2024). What can we learn from one-to-one trials in instructional design? A case from module development. *Research and Development in Education*, 4(2), 816–826. https://doi.org/10.22219/raden.v4i2.35763

Amahoroe, R. A., Arifin, M., Solihin, H., Ambon, U. P., & Indonesia, U. P. (2020). Penerapan desain praktikum berbasis stem pada pembuatan tempe dari fermentasi biji nangka *(Artocarpus heterophyllus)* untuk meningkatkan literasi sains siswa SMK. *Molluca Journal of Chemistry Ecucation. 10*(2), 89–100. https://doi.org/10.30598/MJoCEvol10iss2pp89-100

Baek, S., Shin, H., & Kim, C.-J. (2022). Development of a climate change ssibl-steam program aligned to the national curriculum for SSI elementary school in Korea. *Asia-Pacific Science Education*, *8*, 109-148. https://doi.org/10.1163/23641177-bja10047

Danaryanti, A., & Lestari, A. T. (2018). Analisis kemampuan berpikir kritis dalam matematika mengacu pada watson-glaser critical thinking appraisal pada siswa kelas VIII SMP negeri di Banjarmasin Tengah tahun pelajaran 2016/2017. *EDU-MAT: Jurnal Pendidikan Matematika*, *5*(2). https://ppjp.ulm.ac.id/journal/index.php/edumat/article/view/4631

Darmaji, D., Kurniawan, D. A., & Irdianti, I. (2019). Physics education students ' science process skills. *International Journal of Evaluation and Research in Education (IJERE)*. *8*(2), 293–298. http://doi.org/10.11591/ijere.v8i2.16401.

Dewi, M. D., & Izzati. (2020). Pengembangan media pembelajaran powerpoint interaktif berbasis rme materi aljabar kelas VII SMP. *Jurnal Ilmiah Pendidikan Matematika*, *8*(2), 217-226. https://doi.org/10.11591/ijere.v8i2.28646

Dwi, F., & Setianingsih, R. (2023). Analisis kemampuan berpikir kritis siswa smp dalam menyelesaikan soal aljabar mengacu pada watson glaser critical thinking appraisal. *Jurnal Ilmiah Pendidikan Matematika*, *11*(3), 904–923. https://doi.org/10.26740/mathedunesa.v11n3.p904-923

Eka, L., Nulhakim, L., & Suryani, D. I. (2022). Pengembangan e-modul berbasis flip pdf professional"tema global warming sebagai sumber belajar mandiri siswa kelas VII. *Journal of Science Education*, *6*(2), 338–345. https://doi.org/10.33369/pendipa.6.2.338-345

Erna, M., Alimin, M., Lee, H., Suryawati, E., Albeta, S.W., Priyambada, G. (2023). Enhancing Indonesian college students' views of social responsibility of scientists and engineers: The enact model intervention. *Eurasia Journal of Mathematics, Science and Technology Education* (EJMST), *19*(3), 1-11. https://doi.org/https://doi.org/10.29333/ejmste/13000

Firdaus, M., & Wilujeng, I. (2018). Pengembangan LKPD inkuiri terbimbing untuk meningkatkan keterampilan berpikir kritis dan hasil belajar peserta didik. *Inovasi Pendidikan IPA*, *4*(1), 26–40. https://doi.org/http://dx.doi.org/10.21831/jipi.v4i1.5574

Haryanti, Y. D. (2017). Model problem based learning membangun kemampuan berpikir kritis siswa sekolah dasar. *Jurnal Cakrawala Pendas*, *3*(2), 57–63. doi: 10.31949/jcp.v3i2.596.

Havina, P. M., Fahmi, & Wahyuningsih, E. (2021). Efektivitas perangkat pembelajaran ipa untuk melatihkan keterampilan berpikir kritis peserta didik SMP pada materi

pokok listrik statis. *Journal Of Banua Science Education*, *2*(1), 79–84. https://doi.org/10.20527/jbse.v1i2.13

Ilfiana, A., Widodo, W., & Setiarso, P. (2021). The improvement of student's critical thinking skills through the development of science learning material based socioscientific issues with interactive multimedia-assisted on gadget. *Jurnal Penelitian Pendidikan IPA*. *7*(4), 1-12. https://doi.org/10.29303/jppipa.v7i4.764

Indarta, Y., Jalinus, N., Abdullah, R., Samala, A. (2021). 21st Century skills: TVET dan tantangan abad 21. *Edukatif: Jurnal Ilmu Pendidikan*, *3*(6), 4340-4348. https://doi.org/https://doi.org/10.31004/edukatif.v3i6.1458

Juliyantika, T., & Batubara, H. H. (2022). Tren penelitian keterampilan berpikir kritis jurnal pendidikan dasar di Indonesia. *Jurnal BASICEDU, 6*(3), 4731–4744. https://doi.org/https://doi.org/10.31004/basicedu.v6i3.2869

Kamaruddin, N., Azis, A. A., & Taiyeb, A. M. (2021). Pengembangan elektronik modul (e-modul) berbasis socio scientific issue (SSI) terintegrasi flip Pdf corporate edition pada materi biologi kelas XI Sekolah Menengah Atas. *Thesis.* Universitas Negeri Makassar 1–11. http://eprints.unm.ac.id/id/eprint/20998

Kharomah, S., Mulyati, Y., Fajar, M., Fardhani, I., & Hamimi, E. (2023). Enhancing students' science outcomes through problem -based interactive flipbook e-module. *Research and Development in Education*, 4(2), 788–803. https://doi.org/10.22219/raden.v4i2.34572

Knippels, M. P. J., & Harskamp, M. Van. (2018). An educational sequence for implementing socio-scientific inquiry-based learning (SSIBL). *School Science Review, 100* (371), 46-52. https://www.fi.uu.nl/publicaties/literatuur/2018_knippels_harskamp_ssi.pdf

Kurniasih, A., A. K., Santoso, D. R., Kadafi, A. R., Dari, W., & Husin, A. I. (2020). TAM method and acceptance of COVID-19 website users in Indonesia. *In Journal of Physics: Conference Series,* 1641, no. 1, page 01202. https://doi:10.1088/1742-6596/1641/1/012020

Laksmi, N. L. P. A., & Suniasih, N. W. (2021). Development of e-comic learning media based on problem based learning on water cycle material in science content. *Scientific Journal of Education and Learning*, *5*(1), 56. http://dx.doi.org/10.23887/jipp.v5i2

Levinson, R. (2018). Introducing socio-scientific inquiry-based learning (SSIBL). *100* (December), 31–35. https://www.fi.uu.nl/publicaties/literatuur/2018_knippels_harskamp_ssi.pdf

Meryastiti, V., Ridlo, Z. R., & Supeno, S. (2022). Identifikasi kemampuan berpikir kritis pada pembelajaran ipa siswa SMP Negeri 1 Glenmore Kabupaten Banyuwangi. *Jurnal Saintifika*, *24*(1), 20–29. https://doi.org/10.19184/saintifika.v24i1.29659

Mulyani, S. C. (2023). Profil Critical Thinking Appraisal For Environmental Science (Cta-Es) Siswa Kelas XI IPA SMA Negeri Kota Pontianak. *Jurnal Ilmiah Edukatif 9* (2), 136–147. https://doi.org/10.37567/jie.v9i2.2510

Nasihah, E. D., & Lesmono, A. D. (2019). Pengaruh tutor sebaya dalam pembelajaran problem based learning terhadap keterampilan berpikir kritis fisika siswa SMA. *Jurnal Pendidikan Fisika. 8* (1), 44–57. https://doi.org/https://doi.org/10.23917/jpis.v30i2.11011

Nasir, M. (2023). Perancangan dan analisis multimedia mobile learning berbasis augmented reality untuk meningkatkan prestasi fisika. *International Journal of Information and Education Technology. 13* (6), 993–1000. https://doi.org/10.18178/ijiet.2023.13.6.1897

Noerfatimah, F., & Yusup, I. R. (2022). LKPD berbasis socio-scientific inquiry based learning (ssibl) untuk meningkatkan keterampilan pemecahan masalah siswa. *Jurnal BIOEDUIN*. *12 (2)*, 120-136. https://doi.org/10.15575/bioeduin.v12i2.23022

Putri, Havina., U., & Fahmi., E. W. (2023). Efektivitas Perangkat Pembelajaran IPA Untuk

Melatihkan Keterampilan Berpikir Kritis Peserta Didik SMP Pada Materi Pokok Listrik Statis. *Journal Of Banua Science Education*, *1*(2), 79–84. http://jbse.ulm.ac.id/index.php/JBSE/article/view/13

Rahma, H., & Sami, S. (2022). Development of monopoly learning media based on joyful learning model on natural sciences and social material. *Research and Development Journal of Education*, *4*(1), 237–251. https://doi.org/10.22219/raden.v4i1.32594

Rahmayanti, B. F., & Andayani, Y. (2023). Validasi e-modul IPA berbasis socio-scientific issue (SSI) untuk meningkatkan motivasi belajar dan literasi sains peserta didik. *Journal of Classroom Action Research*, *5*(3), 293–299. https://doi.org/10.29303/jcar.v5i2.4614

Ratnawati, E. (2022). Penerapan learning cycle-5E berkonteks ssi untuk meningkatkan penguasaan konsep siswa pada materi larutan penyangga. J*urnal Inovasi Pendidikan Matematika dan IPA. 2*(4), 431–437. https://doi.org/10.51878/science.v2i4.1765

Riduwan. (2007). Skala pengukuran variabel-variabel penelitian. Alfabeta. Bandung

Sadler, T. D., & Zeidler, D. L. (2022). *The Significance of Content Knowledge for Informal Reasoning Regarding Socioscientific Issues : Applying Genetics Knowledge to Genetic*. *March*. https://doi.org/10.1002/sce.20023

Santoso, B., Putri, D. H., & Medriati, R. (2020). Upaya meningkatkan motivasi belajar dan kemampuan pemecahan masalah siswa melalui model problem based learning berbantu alat peraga konsep gerak lurus. *Jurnal Kumparan Fisika*, *3*, 11–18. http://dx.doi.org/10.33369/jkf.3.1.11-18

Saraswati, S., & Linda, R. (2019). Development of interactive e-module chemistry magazine based on kvisoft flipbook maker for thermochemistry materials at second grade senior high school. *Science Education 3*(10), 1–6. https://doi.org/10.17509/jsl.v3i1.18166

Schleicher. (2019). PISA 2018: Insights and interpretations. *OECD*, 3–62. http://www.educationduepuntozero.it/wp-content/uploads/2020/01/tabelleOCSEFierli.pdf.

Sidi, P. (2020). Discoblog untuk Meningkatkan Keterampilan Kolaborasi Dan Prestasi Belajar Ekonomi Bisnis Siswa Kelas X AKL 2 SMKN 1 Sukoharjo. *Jurnal Pendidikan Ilmu Sosial*. *30*(2), 70–82. https://doi.org/10.23917/jpis.v30i2.11011

Sri, W., Ridlo, Z. R., & Rina, D. N. (2022). Pengembangan media pembelajaran interaktif berbasis articulate storyline terhadap kemampuan berpikir kritis siswa smp pada materi tata surya. *Jurnal IPA Dan Pembelajaran IPA*, *6*(2), 99–110. https://doi.org/10.24815/jipi.v6i2.24624

Sugiyono. (2014). Metode penelitian & pengembangan (research and development). Alfabeta. Bandung. https://scholar.google.com/citations?view_op=view_citation&hl=id&user=MGOs5rkAAAAJ&citation_for_view=MGOs5rkAAAAJ:a9-T7VOCCH8C

Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta. Bandung. https://scholar.google.com/citations?view_op=view_citation&hl=id&user=MGOs5rkAAAAJ&cstart=200&pagesize=100&sortby=pubdate&citation_for_view=MGOs5rkAAAAJ:8dzOF9BpDQoC

Sukariasih, L., & Salim, A. (2019). The development of interactive multimedia on science learning based adobe flash CS6. *International Journal for Educational and Vocational Studies*. *1*(4), 322–329. https://doi.org/10.23917/jpis.v30i2.11011

Sunarto, R. dan. (2017). Metode dan teknik menyusun proposal penelitian untuk mahasiswa S-1,S-2 dan S-3. Alfabeta. Bandung. https://lib.fkm.ui.ac.id/detail?id=111554&lokasi=lokal

Supeno, Astutik, S., Bektiarso, S., Lesmono, A. D., & Nuraini. (2019). What can students show about higher order thinking skills in physics learning. *Iop Conference Series: Earth And Environmental Science*, *243*(1). https://doi.org/10.29303/jpft.v6i1.1053

Supeno, S., Prastowo, S. H. B., & Rahayu, M. P. (2020). Karakteristik kemampuan siswa sma dalam menyelesaikan well dan ill structured problems pada pembelajaran fisika. *Jurnal Pendidikan Fisika Dan Teknologi*, *6*(1), 1–11. https://10.1088/1755-1315/243/1/012127

Tosuncuoglu, I. (2018). Place of critical thinking in EFL. *International Journal of Higher Education 7*(4), 26–32. https://doi.org/10.5430/ijhe.v7n4p26

Utami, A. D., Kurniasih, S., & Pursitasari, I. D. (2023). Development of global warming e-module based on socio scientific issues (SSI) to improve students' critical thinking skills and sustainability awareness. *Jurnal Penelitian Pendidikan IPA*. *9 (Special Issue)*, 224–232. https://doi.org/10.29303/jppipa.v9iSpecialIssue.6008

Waste, F., Melatih, U., & Berpikir, K. (2023). Efforts to improve critical thinking skills with scientific and gender-based liveworksheets. *Jurnal Pendidikan MIPA*. *13 (1)*, 445–453. https://doi.org/10.3991/ijim.v18i09.48097

Wijayanti, P., Shabrina., & Eka, W. (2023). Profil berpikir kritis siswa dalam menyelesaikan soal pisa ditinjau dari gaya belajar. *Jurnal Mathedunesa*, *12*(1), 221–239. https://doi.org/10.26740/mathedunesa.v12n1.p221-239

Yiannis, G., & Kyza, E. A. (2023). Ostering chemistry students' scientific literacy for responsible citizenship through socio-scientific inquiry-based learning (SSIBL). *Jurnal Sustainability*, *15*(2), 1–21. https://doi.org/10.3390/su15086442

Yuliani, E., & Setiawan, D. (2023). Development of flipbook-based digital comics to improve learn- ing outcomes on simple comic material. *Research and Development Journal of Education*, *4*(1), 291–236. https://doi.org/10.22219/raden.v4i1.32280