JPPIPA 10(Special Issue) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

Development of Natural Science E-Module Based on ICARE Model Integrated with SETS Approach to Improve Students' Critical Thinking Skills

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Received: May 29, 2024
Revised: July 4, 2024
Accepted: August 25, 2024
Published: August 31, 2024

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DOI: 10.29303/jppipa.v10iSpecialIssue.7817

Abstract: This research aims to develop and determine the validity, practicality and effectiveness of natural science e-modules based on ICARE model integrated with SETS approach to improve junior high school students' critical thinking skills. The development model used in this research is the ADDIE model. The instruments used by researchers were validation sheets, teacher and student practicality sheets and critical thinking skills questions. The e-module validation result was 0.93 with a valid category. The practicality results of the e-module by teachers and students were 91.57% and 90.53% in the practical category. The results of the effectiveness of the e-module seen from students' critical thinking skills obtained an N-Gain score of 0.69 in the medium category. So, it is concluded that the natural science e-module based on ICARE model integrated with SETS approach is declared valid, practical and effective for improving students' critical thinking skills.

Keywords: Critical thinking skills; E-module; ICARE model; SETS approach

Introduction

The 21st century is called the century of knowledge and the century of information technology. In all areas of life, such as technology, communication, information, economics, transportation, and others, there has been very rapid change in this century. So that the impact that can be felt is progress in all aspects of life using technology. To live a harmonious life, humans must follow technological and scientific developments (Afifah et al., 2023; Harefa, 2019). Therefore, advances in science and technology must be balanced by all educational institutions. In the 21st century, everyone is expected to have various skills to be able to compete in the face of changing times which are increasing rapidly every day. Students must have 4C skills according to the demands of the 21st century (Husniyah & Ramli, 2023; Pramita & Yulkifli, 2023). These skill demands can be met if the provision of education prepares students to master the various skills needed. Critical thinking, collaboration and communication are steps to achieve 21st century learning goals. There are skills that students must have, known as 4C skills, including critical thinking (Alfa & Asrizal, 2023; Novisya & Desnita, 2020).

Critical thinking is very much needed in the 21st century as a higher order thinking skill. Critical thinking skills in students are useful for knowing how to get information correctly and accurately. This is especially important when using social media so that students can avoid hoaxes circulating (Jasmi et al., 2023; Santoso et al., 2021). In everyday life, this skill can encourage someone to make the right decisions and avoid deception and manipulation of information. In the academic world, critical thinking skills are needed to develop better academic skills such as problem-solving abilities, creative thinking and analytical thinking skills. At school, in life and in the world of work, students need skills, knowledge and attitudes that emphasize 21st

How to Cite:
Jasmi, L., & Yulkifli. (2024). Development of Natural Science E-Module Based on ICARE Model Integrated with SETS Approach to Improve Students' Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(SpecialIssue), 89–99. https://doi.org/10.29303/jppipa.v10iSpecialIssue.7817

century competencies (Asrizal & Festiyed, 2020; Wati et al., 2022). For this reason, schools must be able to prepare their students to enter this century. Learning activities in schools must be aimed at achieving the skills needed by 21st century education. As a result of developments in this century, learning resources have become more dynamic and the learning process has become unlimited, so that the world of education is able to answer all the skills needs and challenges that arise in the 21st century. The process for developing these skills consists of stages including problem analysis, hypothesis building, evaluation and discussing results (Ahmad et al., 2021; Desnita et al., 2022). Therefore, educational programs are more structured with the curriculum will be taught to students.

The implementation of the independent curriculum is designed to form quality people and break the chain of education crises occurring in Indonesia. In the independent curriculum, learning to think critically is a challenge for both teachers and students. All members of the learning community in the independent curriculum are encouraged to think critically through imagination, scientific reasoning, and reflection and application of thought topics to reality. Therefore, the actual concept of critical thinking in the educational sphere should be considered by teachers and students at the primary and secondary levels. Teachers must be able to master the material and present it in an interesting way as well as the ability to motivate students to be able to learn independently (Firmansyah & Rusimamto, 2020; Isnaini et al., 2022). Teachers need teaching materials to control the effectiveness of learning (Asrizal et al., 2019; Septiani & Yulkifli, 2021).

Using technology requires teacher creativity to make the learning process easier, including by creating electronic teaching materials so that it can be accessed by students not only at school but can also be accessed anywhere. Some of the impacts of the learning process that utilizes technology are increasing knowledge and skills for teachers and students, as well as improving the quality of learning so that learning is more practical and effective (Aprianka et al., 2021; Ramadhani et al., 2019). Therefore, teaching materials that can be accessed via the internet are the most important things prepared by teachers in the learning process.

Research from the PISA in 2022 shows that Indonesia is ranked 68th; mathematics with a score of 379, science with a score of 398, and reading with a score of 371. The PISA 2022 assessment focuses on students' abilities in mathematical reasoning. The PISA 2022 results are stated to be the first large-scale study to show student performance data around the world due to the impact of the Covid-19 pandemic. The result is that over the last four years (2018-2022), student performance has experienced a sharp decline overall in disciplines such as mathematics, reading and science. Overall, PISA 2022 results were lowest in reading and mathematics, as well as in 2006 in science (OECD, 2023).

In children aged 15 years, critical thinking skills have not been explored optimally, this is known from the PISA assessment scores which have decreased. The low HOTS thinking ability of students shows that the quality of learning in schools is still low. These PISA results show the magnitude of the challenges in the Indonesian education system. This includes the need to improve learning approaches and develop curricula, with an emphasis on 21st century skills such as critical thinking.

After observing the 8th grade students from SMPN 1 Mapat Tunggul Selatan, SMPN 2 Mapat Tunggul Selatan, SMPN 3 Mapat Tunggul Selatan, dan SMPN 4 Mapat Tunggul Selatan, it was discovered that the factors were causing science learning to be less than optimal at school. The student observation questionnaire carried out contained statements related to science learning and students were asked to provide assessments or responses to each question that adjusted to the reality in the field. From the results of the observation analysis at the four schools, it can be seen that the causes of science learning in schools are not yet optimal, including the ineffective implementation of learning models in schools, the limited learning resources available in schools and the lack of optimal critical thinking skills in schools.

Based on ideal conditions and field conditions, we found a gap with expectations. This gap shows that there is something that needs to be investigated. The solution to overcome this problem is to provide suggestions to teachers to use varied teaching materials and attract students' interest in learning, so that critical thinking skills can be applied optimally. One type of teaching material is interactive multimedia (Mufit & Fauzan, 2019; Putri & Mufit, 2023). Teaching materials can be packaged in e-module form because various types of technology can be used in designing e-modules. Some of the disadvantages of printed modules are that they are less interactive, they feel monotonous in presenting the material, and historical messages cannot be conveyed through videos, animations and images (Herawati & Muhtadi, 2020; Meldrawati et al., 2023). This is different from e-modules designed by teachers because the content studied can be controlled according to the curriculum and e-modules can be accessed using devices such as smartphones and laptops because they are designed in electronic form. Therefore, in the digitalization era of the 21st century, it will be easier to create learning modules (Dewi et al., 2023; Pinontoan et al., 2021).

Research by Asrizal et al. (2023) shows that the module has a very high influence on improving students' critical thinking abilities. E-modules are alternative electronic teaching materials for teachers in delivering learning to students (Rianti & Simamora, 2023; Wiratama & Margunayasa, 2021). E-module is a systematic learning media presented in electronic form so that students can learn independently (Sofyan et al., 2019; Yulkifli et al., 2022). Modules that are interesting and contain a combination of guidebooks, multimedia and online sites are really needed by students (Alperi, 2019; Risma & Yulkifli, 2021).

To form critical thinking skills through problems faced by students with direct experience (Adhelacahya et al., 2023; Pramita & Yulkifli, 2023). These skills can be developed with the help of teachers by utilizing learning models that can encourage the formation of critical thinking skills. Many studies show that there is a positive impact through the use of the ICARE model. Amalee et al. (2010) utilize the ICARE stages to create fun learning for students and make teachers active motivators and facilitators. One study that uses the ICARE model is Saputri et al. (2022). The results of this study found that the ICARE model was effective in increasing critical thinking skills. This is shown through students' enthusiasm for learning and material that is easy for students to understand. However, this research is limited to physics learning in high school. Other research was conducted by Putri et al. (2023) in the form of developing a SETS-based e-module which proved that the e-module was effective in increasing critical thinking skills. However, this research is still limited to 8th grade junior high school science learning on additives and addictive substances.

Based on this explanation, there is a gap between the actual reality and the ideal reality that is expected in achieving educational goals. Cause of critical thinking skills are very important, researchers are interested in developing a natural science e-module based on ICARE model integrated with SETS approach to improve the critical thinking skills.

Method

The development model used in this research is the ADDIE model. In the ADDIE model there are 5 stages, namely analysis, design, development, implementation and evaluation (Azriyanti & Syafriani, 2023; Elti et al., 2024). When compared to other models, each stage of ADDIE is very simple and systematic so it is easier to understand and apply this model. Product development will be more effective and dynamic by using the ADDIE model as a reference (Dewi & Suniasih, 2023; Kurnia et al., 2019). The ADDIE model created by Branch has stages as shown in Figure 1.

At the analysis stage, researchers conducted an analysis of e-module needs and material on the topic of pressure in substances. At the design stage, the design and contents of the e-module are created according to the model used. At the development stage, the e-module is prepared, validated and revised after validating the e-module. At the implementation stage, practicality tests were carried out on teachers and students. Data collection instruments used validation sheets, teacher and student practicality sheets and critical thinking skills questions.

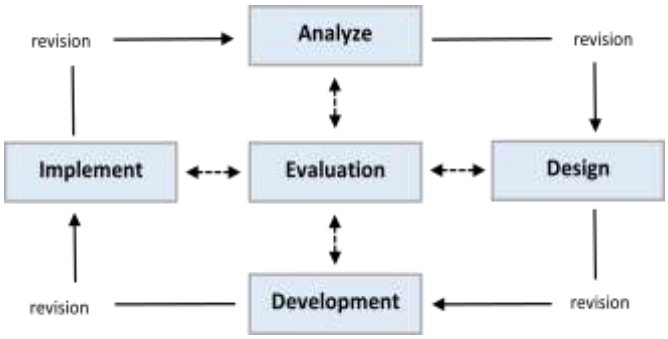

Figure 1. ADDIE development model stages

Data analysis technique by analyzing the results of e-module validation by 3 lecturers as validators at Padang State University majoring in physics education. The validity instrument used consists of 4 aspects; appropriateness of content, presentation, language and graphics with alternative answers following a Likert scale. Next, determine validity using the Aiken's V formula. The validity category is viewed from the Aiken's V coefficient with the expert validation category ≥ 0.6 classified as valid and ≤ 0.6 classified as invalid (Azwar, 2015).

The practicality analysis technique is useful for analyzing data resulting from observations of the implementation of teacher response questionnaires and student response questionnaires. The e-module practicality category based on the final value calculation is declared practical if the practicality value is ≥ 60% and impractical if the practicality value is ≤ 60% (Azwar, 2015).

Analysis of the effectiveness of using the natural science e-module based on ICARE model integrated with SETS approach used to improve students' critical thinking skills. Critical thinking is analyzed using answers to questions given to students. Analysis of the effectiveness of the e-module was carried out using the N-Gain test. According to Hake (1999), the size of the $\langle g \rangle$ factor can be calculated using the following equation.

$$\langle g \rangle = \frac{\langle \text{Spost} \rangle - \langle \text{Spre} \rangle}{100\ \% - \langle \text{Spre} \rangle} \quad (1)$$

The symbols $\langle Spost \rangle$ and $\langle \text{Spre} \rangle$ represent the individual pretest and posttest average scores expressed in percent. The classification of effectiveness values used in this research lies in the value range $0.3 \leq \langle g \rangle < 0.7$ dan $\langle g \rangle > 0.7$. The size of the factor $\langle g \rangle$ can be seen in Table 1 (Hake, 1999).

Table 1. Gain Category

Interval	Category
$\langle g \rangle > 0.7$	High
$0.3 \leq \langle g \rangle < 0.7$	Medium
$\langle g \rangle < 0.3$	Low

Result and Discussion

The initial stage of research begins with the analysis stage. The analysis stage aims to identify problems found by students in the learning process. This analysis stage includes literature study and field study. Literature studies include previous research and relevant research. Literature studies are aimed at searching for relevant research as references in research. The use of the ICARE model to improve students' critical thinking has been found in previous research, however this research was still limited to certain subject matter and only referred to the learning model. Therefore, in this research the integration of the SETS approach was added.

Meanwhile, the field study included observations and interviews with science subject teachers at the school. Student analysis consists of a questionnaire for determining student characteristics and a questionnaire for analyzing student needs. This analysis was carried out using a student observation questionnaire which contained statements related to science learning and students were asked to provide an assessment or response to each question according to the reality that occurred in the field. Observation questionnaire indicators to determine student characteristics consist of student interests, attitudes, motivation and learning styles. Based on the student characteristics questionnaire on the learning interest component, it shows that students' low learning interest in natural science learning. Students stated that innovative learning activities can motivate students in learning and make them actively involved in learning, so that learning can be student centered while the monotonous learning process makes students feel bored in learning, this has an impact on the learning process that occurs in the classroom.

From the needs analysis questionnaire, it was found that the use of technology has not been implemented in the science learning process. Students have never used technology in learning. Learning resources in schools are still limited. The learning resources used in the four schools are books and worksheets so that students only depend on these learning resources. The interview sheet for teachers contains the curriculum used, science material, student abilities, and the learning approach or model used. From teacher interviews it was found that the learning model applied in schools was still less effective. Students are not actively involved in learning. This is because the learning model applied is still a conventional model so that learning is not student centered. So, students' critical thinking skills have not been implemented optimally at school. This is because thinking activities and interactions between students are still lacking due to teachers still dominating the learning process (Astuti et al., 2021; Mahdalena & Daulay, 2020).

Initial research results in four schools show that teachers and students need the development of teaching materials to improve students' critical thinking skills. Learning processes that facilitate interaction between teachers and students and enable students to explore must be created by teachers through the use of technology (Suwastini et al., 2022; Qekaj-Thaqi & Thaqi, 2021). Creating electronic modules is one way so that students have a good interest in reading and are interested in participating in learning because electronic modules are designed in an attractive form because they include interactive products such as images, video, audio and animation and more efficient, adapted to technological advances in the 21st century (Hamid & Alberida, 2021; Widiana & Rosy, 2021).

The next stage is design. This stage consists of the activity of compiling the e-module by determining and arranging learning materials according to the learning objectives, then designing the e-module, selecting the application that will be used in creating the e-module, namely the Canva application and the FlipPDF application, and designing instruments for e-module validation. The e-module follows the stages of the ICARE model by adding SETS elements. The stages of the ICARE model consist of Introduction, Connection, Application, Reflection and Extension combined with the addition of the four elements of SETS which consist of elements of science, environment, technology and society. In this research, critical thinking indicators are used which consist of interpretation, analysis, evaluation, inference and explanation.

Several studies have proven that ICARE model and SETS approach can improve critical thinking skills. The ICARE learning model can encourage active and creative learning, as well as student centered learning through activity phases consisting of introduction, connecting, practice, reflection and evaluation (Arianti et al., 2021; Mahdian et al., 2019). The ICARE model is beneficial for

teachers and students because it emphasizes performance skills in the learning process (Chaiphugdee, 2019; Saputri et al., 2022). SETS approach is one solution in increasing student activity, motivation and learning outcomes (Ahmadi & Supriyono, 2008). The application of SETS in science learning can improve critical thinking skills (Irma et al., 2021; Siagian et al., 2023).

Next, the development stage. This stage consists of product creation and validation assessment by experts. Product creation begins with determining the teaching materials to be developed, namely e-modules that can train critical thinking skills. The e-module contains the main menu, introduction, learning activities, evaluation and answer key. The e-module also includes a bibliography and author profile. Creating e-modules begins with compiling material based on learning objectives using the Canva application. The e-module display is shown in Figure 2.

Figure 2. E-module display

The e-module cover consists of the University logo, title, learning topic, pictures of learning materials, level of education, author's name and university. The cover of the e-model is made attractive to attract readers' interest. The e-module introduction consists of instructions for use, learning outcomes and learning materials. The purpose of the components in the introduction is to present brief information to users so that learning outcomes and what will be learned can be known after studying the material. The instructions for use are useful for guiding users. The instructions for use explain the activities that students will carry out at each stage in the learning activities, where these stages follow the stages of the ICARE model and contain four elements of the SETS approach. The learning outcomes contained in the introduction have been adapted to the curriculum currently used. The learning material is substance pressure which is divided into four learning activities.

Each stage of the learning activity follows the ICARE model stages. Learning activities contain indicators of critical thinking. Critical thinking is the activity of making decisions. According to Robert Ennis, critical thinking is logical thinking that focuses on determining what to do and what to believe (Fisher, 2007). Based on this understanding, it can be seen that critical thinking is reasoned thinking where someone thinks more deeply about something for themselves and decides what should be done. In line with Fogarty and McTighe, critical thinking is thinking in a logical way, based on reason, or based on thoughts to choose decisions that are taken and believed (Kurniasari & Setyaningsih, 2020; Syafitri et al., 2021).

At the introduction stage there are learning objectives and learning materials. The learning objectives are adjusted to the current curriculum, lesson material presented to see the sub-material that will be studied in each learning activity. At the connection stage there is a description of the material and example questions. Material descriptions are useful for connecting students' old knowledge with new knowledge through simple explanations in e-modules. At the application stage there is a worksheet that presents several simple experiments regarding the material being studied in each learning activity. At the reflection stage, students are asked to draw conclusions through group discussions and present them. At the extension stage there are videos and practice questions. The learning video presented contains four elements of SETS which are useful for training students' critical thinking skills. Next, validate the e-module by the validator. The e-module has been validated by 3 expert lecturers. E-module validation results are shown in Table 2.

Table 2. E-Module Validity Results

Aspect	Value	Category
Appropriateness of Content	0.91	Valid
Appropriateness of Presentation	0.90	Valid
Appropriateness of Language	0.96	Valid
Appropriateness of Graphics	0.95	Valid
Average	0.93	Valid

Table 2 shows an average value of 0.93 with a valid category. Validity in appropriateness of content, the average score was 0.91 in the valid category. This is show that the physics concepts in the material presented are correct. The learning activities presented are in accordance with the stages of the ICARE learning model. The images and videos are in accordance with the lesson material and contain elements of SETS. The validity of e-modules in terms of content components can be measured through videos and images that are appropriate to the learning material (Ernica & Hardeli, 2019; Fadieny & Fauzi, 2021). The material provided has been adapted to the current curriculum. The suitability of the material is useful in increasing motivation, interest in learning, and the willingness to study the teaching

materials being developed (Astuti et al., 2022). The systematic and detailed preparation of material regarding the concepts presented is a reflection of the appropriateness of the content of teaching materials (Fauziah et al., 2023; Sari et al., 2020).

Validity in appropriateness of presentation, the average score was 0.90 in the valid category. In presenting the e-module, the concept of the material presented is clear, systematic and refers to the learning objectives. Systematic learning materials provide a complete map of the abilities that students must have (Prastowo, 2011). In line with research results which state that the material in the module must be presented coherently and systematically so that it can be used as a reference (Fitriyah et al., 2023; Susilawati, 2020). The e-module contains example questions and exercises to train students' critical thinking skills, and there is also a glossary containing important terms and instructions for using the e-module.

Validity in appropriateness of language, the average score was 0.96 in the valid category. This language validation aims to determine the perfection of language through language use (Ismawati & Mustika, 2021; Syahputra & Mustika, 2022). This is viewed from the linguistic aspect in developing e-modules that contain accurate sentences that represent simple delivery of information and adapted to students' abilities. The terms are in accordance with the KBBI, as well as accuracy in using punctuation. Learning materials should use language that is simple, short and does not contain double meanings that can affect the communicative language of learning resources (Sadjati, 2012). When writing, it is necessary to use vocabulary and apply punctuation correctly so that the meaning of the writing can be conveyed (Asri & Dwiningsih, 2022; Sukirman, 2020).

Validity in appropriateness of graphical, the average score was 0.95 in the valid category. The validity results are viewed from the graphical aspect, it has attractive display colors, the cover also describes the contents of the e-module and uses a combination of font size and type of writing as well as the right layout, the right spacing between lines so that it can be read clearly. Critical thinking skills can be improved through real experience by using real and colorful images in teaching materials (Fauziah et al., 2023; Riefani et al., 2020). The combination of colors and background used is designed to be comfortable and easy to read, resulting in an attractive appearance that can influence students' interest in reading (Asri & Dwiningsih, 2022; Mumpuni & Nurbaeti, 2019).

The next stage is implementation. At this stage there are practicality tests on teachers and students as well as trials on students. The practicality test is useful for obtaining e-modules that are practical and easy to use in the learning process. Practicality is the extent to which students and teachers use and apply learning materials (Sujaya et al., 2023). The practicality test in development has the function of determining whether the e-module being developed is practical for students and teachers or vice versa. Two natural science teachers at SMPN 3 Mapat Tunggul Selatan were included in this practicality test. The teacher's practicality test assessment is given through the teacher's practicality test sheet. The results of practicality tests by teachers are shown in Table 3.

Table 3. Results of Practicality Analysis of Science E-Modules by Teachers

Aspect	Score (%)	Description
Easy to use	92.50	Practical
Efficiency of learning time	86.67	Practical
Benefit	95.55	Practical
Average	91.57	Practical

Table 3 shows that the practicality of the e-module by teachers has an average score of 91.57%. So, it can be said to be practical in science learning and can be used to improve students' critical thinking skills. Grade 8 students at SMPN 3 Mapat Tunggul Selatan were included in this practicality test. Practicality test assessments by students are given through student practicality test sheets. The results of practicality tests by students are shown in Table 4.

Table 4. Results of Practicality Analysis of Science E-Modules by Students

Aspect	Score (%)	Description
Easy to use	90.67	Practical
Efficiency of learning time	89.33	Practical
Benefit	91.60	Practical
Average	90.53	Practical

Table 4 shows that the practicality of the e-module by teachers has an average score of 90.53%. So, it can be said to be practical in science learning. This means that e-module can be used for learning. Effectiveness tests are useful for measuring students' critical thinking abilities. Critical thinking skills are measured using assessment indicators such as interpretation, analysis, evaluation, inference and explanation (Facione, 2011). To see students' critical thinking abilities before and after using the natural science e-module in learning, it is reviewed through pretest and posttest scores. Furthermore, the N-Gain data processing of students' critical thinking skills are shown in Table 5.

Table 5. N-Gain Data Processing Students' Critical Thinking Skills

Indicator	Pretest Score	Posttest Score	⟨g⟩
Interpretation	53.33	94.17	0.88
Analysis	46.67	85.83	0.73
Evaluation	43.88	76.67	0.58
Inference	51.67	89.17	0.78
Explanation	48.55	75.44	0.52
Average			0.69

Based on Table 5, the N-Gain analysis carried out obtained an N-Gain value of 0.69. This states that critical thinking skills are in the medium category. This explanation can show that critical thinking skills are declared effective because the average value is above 75 and the N-Gain test carried out is in the medium category. So the natural science e-module based on ICARE model integrated with SETS approach is declared effective in improving students' critical thinking skills.

The next stage is Evaluation. Evaluation has two stages. First, the evaluation is obtained from the revision results of each ADDIE development step. At the analysis stage, revisions were made to the instruments used in observation activities. At the design stage, several revisions were made to the e-module. At the development stage there is an assessment and revision of the e-module. At the implementation stage, it was carried out to see the effectiveness of the e-module for assessing students' critical thinking skills. Second, the final evaluation of the development of the e-module. This evaluation produces an e-module which is valid, practical and effective for improving critical thinking skills.

E-Module is an electronic teaching material that is proven to improve critical thinking skills. Based on the research results of Paramitha et al. (2021), it was found that alternative teaching materials that are easy and practical for teachers to improve students' critical thinking skills are electronic modules. 85% of teachers stated that electronic modules were needed for the learning process and 75% of students stated that electronic modules were interesting to use for learning.

Another research conducted by Riana (2021) shows that the ICARE-based science learning module integrated with the SETS approach to human respiratory system material developed has criteria that are very feasible and practical for use as a learning module. Another research by Yevira et al. (2023) state that the SETS-based science e-module was very good for improving critical thinking skills.

Conclusion

Based on research results, the natural science e-module based on ICARE model integrated with SETS approach to improve students' critical thinking skills has a valid category. This is viewed from four aspects of validation assessment which include appropriateness of content, presentation, language and graphics. The natural science e-module based on ICARE model integrated with SETS approach to improve students' critical thinking skills has a practical category of practical results by teachers and students in the aspects of easy to use, efficiency of learning time and benefits. The natural science e-module based on ICARE model integrated with SETS approach is effective for improving students' critical thinking skills. The effectiveness of the e-module on critical thinking skills can be seen from each critical thinking indicator consisting of interpretation, analysis, evaluation, inference and explanation. From these results it is concluded that the natural science e-module based on ICARE model integrated with SETS approach is declared valid, practical and effective for improving students' critical thinking skills.

Acknowledgments

I would like to thank everyone involved in writing this article and to the JPPIPA editorial staff who have provided the opportunity to publish this article.

Author Contributions

This research provides a learning contribution in the form of a student e-module with the ICARE learning model integrated with the SETS approach which can be used by teachers in junior high schools (SMP). The main author was involved in the entire creation of this media and article. The second author contributed to the writing of this scientific work, namely guidance on ideas, conception, data collection, analysis and interpretation of results as well as preparation of the article manuscript.

Funding

There was no external funding for this research.

Conflicts of Interest

The authors declare that there is no conflict of interest in carrying out and publishing this article.

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