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Development of CIRCSA-Based E-module on Virus Materials to Improve Students' Critical Thinking and Scientific Literacy

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ABSTRACT

Developing technology-based teaching materials, such as e-modules, is an effective method for training students' thinking abilities, such as critical thinking and scientific literacy. ***Objective:*** This research aims to assess the characteristics, feasibility, and students' responses to developing an e-module of viral material based on the CIRCSA learning model. ***Method:*** The ADDIE development framework, including analysis, design, and development, was used to conduct this research. The scope of this research is limited to assessing the feasibility of the CIRCSA-based e-module characteristics, materials, media, and students' responses on small-scall trials. ***Results:*** Data analysis revealed that the CIRCSA-based e-module that integrates critical thinking and scientific literacy achieved an very valid criterion. The feasibility of materials and media obtained a very valid category. Additionally, students' responses to the e-module usage resulted in a very good category. ***Novelty:*** Developing CIRCSA-based e-modules to improve students' critical thinking and scientific literacy has never been done before.

INTRODUCTION

Biological science in high school plays an important role due to its significance as a life science (Adonu et al., 2021). The scope of biology materials includes facts, concepts, theories, or generalizations that explain living things, life phenomena, and the environment (Sudarisman, 2015; Suryaningsih, 2017). Viruses are one of the biological materials taught in high school. In early 2020, a virus named SARS-CoV-2 caused a global pandemic that affected human life critically (Bracko & Simon, 2022). Therefore, it is essential to emphasize virus concepts to students. However, virus material is one of the biology materials that is difficult for students to understand because it consists of abstract and complex concepts (Firmanshah et al., 2020; Irfana et al., 2018; Hadiprayitno et al., 2019).

The achievement of learning biology in virus material is the ability to develop solutions to problems relating to viruses at the local, national, or global level (Kemendikbud, 2017). To achieve these learning outcomes, students must have higher-order thinking skills, including critical thinking skills and scientific literacy (Suhirman et al., 2020). Furthermore, critical thinking skills and scientific literacy are important skills that students should have in the 21st century (Aiman & Hasyda, 2020; Rahayu, 2017). Critical thinking and scientific literacy abilities promote a person's comprehension of science concepts as well as their capacity to think critically and apply scientific principles to real-life situations, which improves their command of real-life skills (Yuliati, 2020;

Muhibbuddin et al., 2020). However, some research findings indicate that Indonesian students have low critical thinking skills and scientific literacy (Puspita et al., 2017; OECD, 2019). The results of the needs analysis at one of the high schools, State Senior High School 9 Semarang, revealed that students' scientific literacy and critical thinking abilities were not at their optimum. Furthermore, students' interest in biology learning is essential to increase, especially in complex subjects like viruses. The fact that viruses have mechanisms dependent on the host's metabolism, have less complicated structures and are tinier than bacteria makes them an abstract subject in biology (Saputri & Widyaningrum, 2016). The concept of virus material can be delivered meaningfully to students if the learning process prepares them to use scientific knowledge to analyze issues related to viruses (Chion & Adúriz-Bravo, 2022; Paudel, 2020).

Technological advances nowadays can facilitate teachers' ability to provide creative and innovative learning resources or teaching materials (Monkovic et al., 2022). Innovative, contextual, and interesting teaching materials will enable students to learn more effectively and develop higher levels of thinking (Suryawati & Osman, 2018). Providing effective teaching materials is an essential component of the learning process (Ravista et al., 2021). One type of teaching material that contains a set of planned, whole, and systematic learning experiences to help students master specific learning competencies is a module (Harahap & Fauzi, 2017; Resita & Ertikanto, 2018). With the help of the e-module, limited time in class to achieve learning goals can be fulfilled through a learning process independent of each student (Puspitasari, 2019). In addition, e-modules can also be integrated with learning models to provide a series of planned activities to achieve learning objectives and develop thinking skills (Rahmadani & Sunarmi, 2023). Students tend to be more motivated to learn when they are using e-modules because they contain animation, video, audio, images, and formative quizzes (Prasetyo et al., 2021; Prasetya, 2021). E-modules can also be integrated with learning models to provide a series of planned activities to achieve learning objectives and develop thinking skills (Rahmadani & Sunarmi, 2023).

Biology learning processes necessitate a learning model that can discover facts, understand concepts, and solve issues that arise in the environment (Marpaung et al., 2021; Sunarsih et al., 2020). The Cooperative Integrated Reading and Composition Scientific Approach (CIRCSA) is a group learning model that encourages students to read, analyze, and write about the ideas in an article that is connected to the subject (Ristanto et al., 2020). As a result, the purpose of this research is to create an electronic module based on the CIRCSA learning model to enhance scientific literacy and critical thinking. The developed e-module will also be assessed for its characteristics and feasibility in improving scientific literacy and critical thinking.

RESEARCH METHOD

Research Design

The CIRCSA-based e-module was developed and designed to assist students in improving their critical thinking and scientific literacy skills. Development of a CIRCSA-based E-module using R&D design by applying the ADDIE model that refers to Branch (2009) The ADDIE development model consists of five steps: analysis, design, development, implementation, and evaluation. This research was conducted only until the development step and assessment of characteristics, feasibility, and student responses to the developed CIRCSA-based e-module. The characteristics and feasibility of the material in the e-module were assessed by a material expert, which consisted of one lecturer and two teachers. Furthermore, the feasibility of media was assessed by a material expert, which also consisted of one lecturer and two teachers. An overview of the steps involved in developing this e-module is presented in Figure 1.

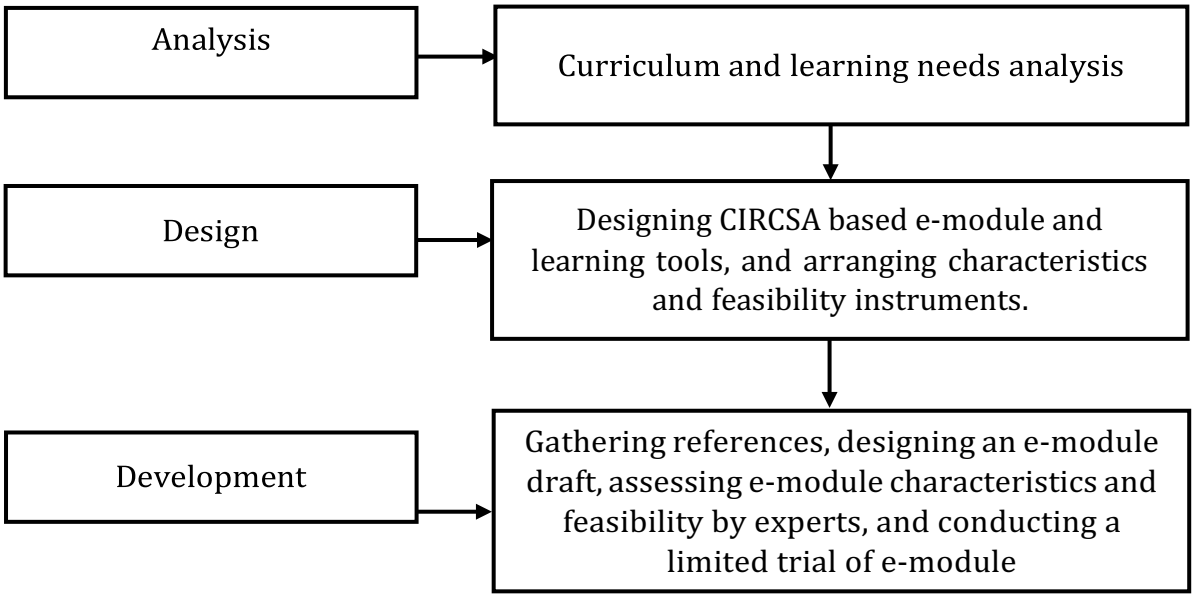

Figure 1. E-module development steps

Instrument and Data Analysis

The instrument used in this study is a questionnaire that measures the characteristics and feasibility of the material and media and the students' responses to the e-module. All assessment items are rated on a five-point Likert scale. Data from the characteristics, feasibility, and student response questionnaires are then analyzed using the formula (1).

$$V = \frac{TSe}{TSh} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Notes:
V = Validity percentage
TSe = Total score given by validators
TSh = Maximum score

The average percentage results of characteristics and feasibility data are interpreted into several categories presented in Table 1. An e-module is considered feasible if it obtains a minimum score percentage in the 'valid' category.

Table 1. Validity criteria

Intervals (%)	Category
85.01-100.00	Very valid
70.01-85.00	Valid
50.01-70.00	Valid enough
01.00-50.00	Invalid

(Akbar, 2013)

The validated e-modules are tested on small-scale students to determine student responses to the use of e-modules. A small-scale trial involved ten students of class XI MIPA of State Senior High School 9 Semarang. The student response percentage toward the e-module is calculated using the formula below:

$$V = \frac{gained\ item\ score}{maximum\ score} \text{ x } 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The percentage results of students' response data are interpreted according to several categories presented in Table 2.

Table 2. Student response category

Intervals (%)	Criteria
81-100	Very good
61-80	Good
41-60	Good enough
21-40	Not good
0-20	Not very good

(Riduwan, 2013)

RESULTS AND DISCUSSION

Results

A CIRCSA-based e-module on virus materials can be accessed at https://bit.ly/44o3gcV. The e-module contained three sub-chapters of virus material: virus characteristics, virus replication, and the role of viruses. The findings of this research regarding the stages of analysis, design, and development are described as follows:

Stage of Analysis

This step includes the process of examining needs and curricula. Merdeka's curriculum is currently being implemented in schools. The 2013 curriculum-based textbook and the

printed materials are the learning resources that students use during biology sessions. According to students, those learning sources are less attractive because the images aren't colored and the practice questions don't train thinking skills. Students require learning resources that relate material to real-life facts, have clear and colorful pictures, be easily accessible, and include animation.

Stage of Design

The design stage involved designing a CIRCSA-based e-module, developing learning tools, and arranging instruments to assess the e-module's characteristics and feasibility. The main characteristics of a CIRCSA-based e-module are that it contains aspects of the CIRCSA learning model. In addition, this e-module also contains a feature that facilitates students' critical thinking and scientific literacy. The cover display is presented in Figure 2, while the features of the e-module are presented in Figure 3.

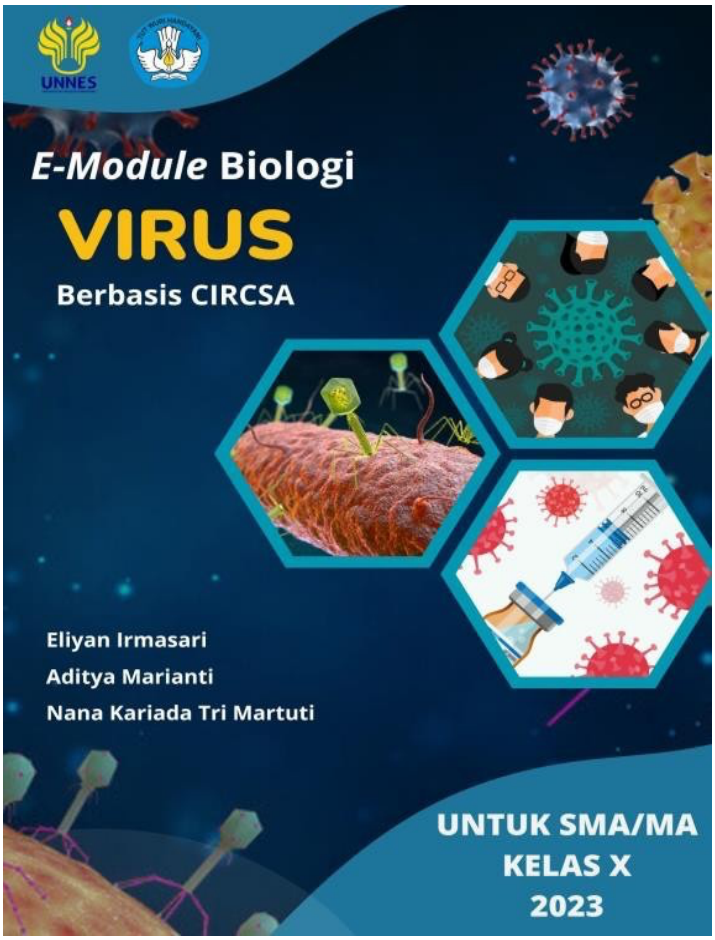

Figure 2. Cover of e-module

Figure 3. Feature display of e-module

Stage of Development

The development stage involved several processes, including 1) finishing the draft of the e-module, 2) assessing characteristics, materials, and media by the validation team, and 3) conducting a limited trial of the e-module. The characteristics of the e-module were assessed by validators to ensure CIRCSA, critical thinking, and scientific literacy aspects were present. An overview of the e-module characteristics assessment results is presented in Table 3.

Table 3. Results of Characteristics Assessment

Aspect Assessed	Average Score (%)	Category
CIRCSA component	93.33	Very valid
Critical thinking	86.67	Very valid
Scientific literacy	88.33	Very valid

The feasibility assessment of the e-module consists of material and media assessments. Material feasibility assessment consists of three aspects, including content, presentation, and language. The results of the E-module material feasibility assessment are presented in Table 4.

Table 4. Results of Material Feasibility Assessment

Aspect Assessed	Average Score (%)	Category
Content	89.44	Very valid
Presentation	91.11	Very valid
Language	91.11	Very valid
Overall score	**86.7**	**Very valid**

Media feasibility consists of three assessment aspects, namely presentation, language, and graphic aspects. The results of the e-module media feasibility assessment are presented in Table 5.

Table 5. Results of Media Feasibility Assessment

Aspect Assessed	Score (%)	Criteria
Presentation	91.2	Very valid
Language	88.3	Very valid
Graphics	91.3	Very valid
Overall score	**90.3**	**Very valid**

A small-scale trial of the e-module aims to determine whether students can fully comprehend the instructions, materials, and features presented in the e-module. The results of the student response questionnaire data analysis are presented in Table 6.

Table 6. Results of Student Responses to Small-Scale Trials

Aspect Assessed	Score (%)	Criteria
Presentation	86,7	Very good
Content	87,8	Very good
Language	84,4	Very good
Use	88,9	Very good
Overall score	**86.9**	**Very good**

Discussion

A CIRCSA-based E-module on virus materials has been developed, as presented in Figures 2 and 3. The steps of the CIRCSA learning model that were integrated into this e-module were adapted from Djamahar (2018). This E-module is also designed to be self-instructional, self-contained, stand-alone, adaptive, and easy to use. The integration of the CIRCSA learning model into the e-module intends to facilitate students' construction of concepts through articles. The CIRCSA learning model combines elements of reading, analyzing articles, group discussions, and a scientific approach (Ristanto et al., 2020). The CIRCSA learning model combines elements of reading, analyzing articles, group discussions, and a scientific approach (Ristanto et al., 2020). Elements of the CIRCSA learning model embedded in the e-module include group discussion activities (cooperative), reading, writing, observation, exploration, association, and communication. The assessment result for the integrated CIRCSA component on the E-module gets a percentage score of 93.33%, which includes very valid categories (Table 3).

CIRCSA-based e-modules on virus material also incorporate critical thinking aspects based on Ennis (2018) and scientific literacy aspects based on Rusilowati (2018). The critical thinking aspect consists of 1) elementary clarification; 2) interference; 3) advanced clarification; and 3) strategy and tactics. Meanwhile, the scientific literacy aspect consists of 1) science as the body of knowledge, 2) science as a way of investigating, 3) science as a way of thinking, and 4) the interaction of science, technology, and society. All aspects of critical thinking and scientific literacy skills are represented as features of the e-module (Figure 3). According to the assessment result, aspects of critical thinking skills and

scientific literacy get scores of 86.67% and 88.33%, respectively, which are considered very valid categories (Table 3). These findings suggest that the e-module included activities that can develop students' critical thinking abilities and scientific literacy. Rahmawati et al. (2022) state that students' thinking skills could be trained in the learning process through media, teaching materials, and assessment instruments that reflect thinking skills. However, the validator suggests that the number of questions to train critical thinking skills should be increased.

The feasibility assessment of the e-module consists of material and media assessments. Material feasibility assessment consists of three aspects, including content, presentation, and language. Based on the assessment result (Table 4), the content aspect got 89.44%, the presentation aspect got 91.11%, and the language aspect got 91.11%. These results show that the content, presentation, and language aspects of the CIRCSA-based virus e-module are included in the very valid category. A very valid category on the feasibility aspect of content indicates that the completeness and breadth of the material correspond with learning outcomes. The feasibility of the content aspect is supported by the presentation and language aspects. The existence of supporting presentations such as additional information, articles, practice questions, and the use of appropriate language facilitate students in building the expected knowledge and skills. Reading and analyzing scientific articles allows students to gain knowledge based on recent developments, so they can apply their knowledge in real-life situations (Sapitri & Ridlo, 2021; Ristanto et al., 2018). Students' role in constructing material concepts can make learning more meaningful and empower students' thinking skills (Lufri et al., 2020; Prawita et al., 2019). Several improvements from the material validator, including the description of the material needing to be summarized again, correcting errors in writing, and the depth of the material being adjusted to the cognitive level of high school students.

Media feasibility assessment consists of three aspects, including presentation, language, and graphic aspects. According to the assessment result (Table 5), all aspects meet the valid category, with a score of 91.2% for the presentation aspect, 88.3% for the language aspect, and 91.3% for the graphic aspect. The suggestions provided by the media validator are to improve concept maps. Media aspect components are crucial to supporting content and material delivered on e-module products. Uma'iyah et al. (2023) consider that language is the most important component in determining a product's feasibility because language can facilitate the understanding of the written content by the reader. The presentation aspect relates to the systematic presentation of features, images, and videos contained in the e-module. Meanwhile, in the graphical aspect, assessed components include covers, fonts, color suitability, and margins. Presentation and graphics aspects facilitate the delivery of learning materials and stimulate student cognitive and affective processes to foster students' learning motivation (Istyadji et al., 2022; Gayatri et al., 2018).

A small-scale trial of e-modules assesses the use of aspects related to material, language, and appearance. According to Kusuma (2018) and Susilawati et al. (2023), effective teaching materials are those that have interesting pictures or illustrations and present information that is easy to understand and according to user needs. The results of the students' response questionnaire data analysis meet the valid category, with a score of 86.7% for the presentation aspect, 87.8% for the content aspect, 84.4% for the language

aspect, and 88.9% for the use aspect (Table 6). In comparison with other aspects, the language aspect receives a lower average score, but it remains in the positive category. Meanwhile, aspects of use gain the highest percentage score, which means that e-modules are practical, easy to use, increase knowledge about viral material, and attract students' curiosity. These results are consistent with Amelia et al. (2022), who state that e-learning modules have the potential to increase motivation and motivate students to acquire knowledge and develop their cognitive abilities. Students have generally responded positively to the use of e-modules; however, some slight improvements need to be made in sentence structure to facilitate understanding. According to student responses, this e-module is feasible for large-scale testing.

CONCLUSION

Fundamental Finding: A CIRCSA-based e-module on virus material delivers very valid results based on its characteristics and feasibility assessment. Students' responses to this e-module in small-scale trials also include very good categories. The characteristics and feasibility of e-modules help students develop the capacity to learn the subject matter on their own and develop their critical thinking and scientific literacy. **Implication:** CIRCSA-based E-modules on virus materials can be implemented for large-scale trials or as alternative teaching materials in biology classes. **Limitation:** This e-module needs to be revised according to the validator's suggestion before being implemented in a large-scale trial. **Future Research:** CIRCSA-based e-modules can be used to train other skills, such as problem-solving and creative thinking. Additionally, the CIRCSA learning model applies to other biological materials.

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