



Revolutionizing Science Learning: A CRT Based E-Module Integrating Javanese Gamelan to Foster Critical Thinking

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ABSTRACT

Purpose of the study: Developing an e-module based on Culturally Responsive Teaching integrated with Javanese gamelan on the material of wave vibrations for grade eight junior high school, to train students' critical thinking skills and increase the relevance of learning to local culture. Based on the low level of students' critical thinking skills, it can be seen in the 2022 PISA results with an average score of 383.

Methodology: Research and Development with a 4-D development model (define, design, develop, disseminate). The study involved expert validation, limited trials, and field trials on students of Junior high school 6 Ngawi. Data were collected through critical thinking ability tests, student and teacher response questionnaires, and statistical tests using SPSS and Microsoft Excel.

Main Findings: The e-module is feasible and effective for training students' critical thinking skills. Independent sample t-test revealed significant differences between the experimental and control groups, with the percentage of the practicality questionnaire reaching 90%, indicating a positive response from students and teachers to the e-module.

Novelty/Originality of this study: The uniqueness of this research lies in the integration of physics concepts with local wisdom of Javanese gamelan in an interactive e-module. The Culturally Responsive Teaching model allows learning to be more contextual, interesting, and relevant for students, while contributing to cultural preservation through science education.

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1. INTRODUCTION

Education plays an important role in forming competitive and knowledgeable human resources.[1]. One of the major challenges of 21st century education is to prepare students with the critical thinking skills essential for evidence-based problem solving and decision making [2], [3]. In the context of learning Natural Sciences, critical thinking is the main key to understanding scientific concepts and applying them in everyday life. Science learning is learning that emphasizes the scientific process and seeks out cause-and-effect phenomena that occur in nature [4]. Natural Science is a science that studies nature that is observed carefully and precisely. Science is a learning that emphasizes factual knowledge, and theories about nature that are worth studying, useful, and continue to develop according to the times, and apply globally and universally [5]. Based on this understanding, science learning can be interpreted as a science that studies theories about nature, factual or real knowledge, phenomena and causes and effects that occur in nature, and emphasizes the scientific process.

The essence of science learning is learning that is not just memorizing facts but learning that emphasizes scientific concepts and the ability to think critically and solve problems through scientific processes [6]. The scientific process is a series of scientific discovery activities through several stages of systematic scientific methods. The learning process emphasizes the scientific process according to constructivism theory. Constructivism theory is a belief that emphasizes that knowledge is the result of the efforts of the learner himself [7]. Teachers help students learn more, students also have the opportunity to actively use their own chosen learning strategies.

The results of the Programme for International Student Assessment (PISA) study show that the critical thinking skills of Indonesian students are still relatively low [8]. The 2022 PISA report, the average score in science obtained by Indonesian students was 383, lower than the achievement in 2018 which was at 389 [9]. Many students in Indonesia have difficulty in doing the PISA test, Indonesian students are only able to complete up to level 2, while PISA has levels 1-6 [10]. Previous research that supports critical thinking skills in Indonesia is still low. Lack of innovation in science learning causes low critical thinking skills [11]. This decline emphasizes the need for innovation in learning methods that are more interactive and based on real experiences [12]. Observation results at Junior high school 6 Ngawi, science teachers said that science learning uses lecture methods, students take notes, and work on questions. This method has not created a real, meaningful learning experience, and is still abstract. This statement is supported by previous researchers, research at Junior high school 3 Trenggalek which has been carried out, obtained data, students get scores below minimum completion criteria of 97% [13]. Based on the presentation of the science teacher of Junior high school 6 Ngawi, students' critical thinking skills are low. The results of the critical thinking ability test that supports it, obtained an average percentage of 19%. According to the science teacher, when the learning process students do not respond well and are bored, the cause is inadequate practical tools and only using textbooks from the Ministry of Education and Culture. The textbooks have shortcomings, namely poor physical quality due to repeated use, limited number of books, content that does not relate to life, difficult to understand language, and lack of interactive activities.

Teaching materials in the form of modules are very necessary for students in the learning process [14]. A module is a set of learning tools used to ensure the smooth running of the learning process and is based on the curriculum and in printed form [15]. Based on this understanding, it can be concluded that a learning module is a printed module. The science teacher conveyed that the situation in the field such as at Junior high school 6 Ngawi really needed teaching materials that could help students in learning and were easily accessible at any time. E-module is an innovation in teaching materials that uses electronic media [16]. Electronic modules (E-modules) are independent learning materials that are systematically structured to achieve specific learning objectives and are presented electronically and can be accessed at any time [17]. E-modules are an innovation in education in the form of presenting learning materials that were originally in printed form into electronic form and can be accessed via smartphone, computer or laptop [18]. The characteristics of e-modules can be accessed easily and flexibly through electronic devices, the content can be changed directly, can use interactive video or simulation features, and low production costs. The benefits of e-modules are increasing accessibility, interactivity, time efficiency, flexibility, and reducing costs. The learning model that is in line with this is a model that has critical reflection syntax. A model that provides real experience in learning. Based on previous researchers who conducted direct observations in Ngawi, there are not many schools that connect regional culture with science learning [19]. Meanwhile, many researchers only focus on digitalization without linking it to local culture [20]. Therefore, teaching materials that involve culture and digitalization are needed. Therefore, the Culturally Responsive Teaching model is suitable for e-modules.

The Culturally Responsive Teaching (CRT) model offers a solution to increase student engagement in learning through the integration of local culture [21] [22]. Culturally Responsive Teaching (CRT) based learning attempts to link academic concepts with cultures that are close to students' lives, so that they can understand the material in a more contextual and applicable way [23]. One form of implementation of Culturally Responsive Teaching is the development of interactive e-modules that integrate local culture, such as Javanese gamelan, in science learning, especially in vibration and wave material. The syntax of the model is self-identification, cultural understanding, collaboration, critical reflection, and transformation construction [24].

This study develops and evaluates an e-module based on Culturally Responsive Teaching (CRT) integrated with Javanese gamelan to train critical thinking skills of junior high school students not only contributing to innovation in science learning, but also strengthening the connection between science and local culture in the context of Indonesian education. This study also aims to determine the characteristics, feasibility, practicality, and effectiveness of an e-module based on Culturally Responsive Teaching (CRT) integrated with Javanese gamelan.

2. RESEARCH METHOD

This study uses the Research and Development (R&D) method with the 4-D model (define, design, develop, disseminate) from Thiagarajan et al.[25] to develop e-modules based on Culturally Responsive Teaching (CRT). The research sample was junior high school students, with a purposive sampling technique.

Define Stage, The define stage serves to collect research information through literature studies, teacher interviews, and student needs analysis. The results are summarized to determine the specifications of the objectives and contents of the Culturally Responsive Teaching (CRT)-based e-module. **Design Stage,** The design stage includes planning and creating e-modules based on Culturally Responsive Teaching (CRT). Media, visual formats, and content are selected to ensure material alignment. The product was developed using Canva and Heyzine Flipbooks. **Development Stage (Develop),** The develop stage includes expert validation to assess the feasibility of the Culturally Responsive Teaching (CRT)-based e-module and design testing. Validation is carried out by expert lecturers, the results of which are used for revision. Limited and field trials are carried out along with tests of validity, reliability, difficulty, and item discrimination. **Dissemination Stage (Disseminate),** The distribution stage was carried out on a limited basis in one school to measure the achievement of objectives and the effectiveness of the e-module product based on Culturally Responsive Teaching (CRT).

The instruments needed for data collection are needs analysis instruments in the form of teacher interview instruments and student needs analysis questionnaires. Theoretical feasibility test instruments in the form of material validation questionnaires, media validation questionnaires, language validation questionnaires. Practicality test instruments in the form of teacher response questionnaires, and student response questionnaires.

There are 3 data analysis techniques at the development stage, namely analysis of the results of the feasibility test, analysis of the practicality test, and analysis of the effectiveness test. **Theoretical Feasibility Test Results Analysis Technique,** The theoretical feasibility test is seen from the feasibility questionnaire and checked based on the Likert scale guidelines. The validation results are analyzed using the formula:

$$\text{Percentage} = \frac{\text{Totale Score}}{\text{Maximum Score}} \times 100\% \dots (1)$$

Then classified based on the following eligibility criteria [26]:

Table 1. Eligibility Criteria	
Percentage (%)	Criteria
85 – 100	Worthy of the predicate very good
65 – 84	Worthy of a good predicate
45 – 64	Worthy of a good predicate
0 – 44	Not feasible

Empirical Feasibility Test Results Analysis Technique. The empirical feasibility test technique is described as, **Validity Test,** Validity testing is an evaluation process to ensure the validity of a measurement instrument in a relevant context [27]. The results of the validation of the question items by experts were analyzed using the formula of the total score divided by the maximum score multiplied by 100%. Then, it was analyzed with the following validity criteria [28]:

Table 2. Validity Criteria	
Validity Criteria	Validity Level
85% $100\% < V \leq$	Very valid
70% $85\% < V \leq$	Valid
50% $70\% < V \leq$	Less valid
$V \leq 50\%$	Invalid

Reliability Test, Reliability testing evaluates the consistency of research instruments to ensure stable results on the same object [29]. The reliability test was analyzed with the help of the SPSS application with the Cronbach's Alpha coefficient as an indicator of consistency if $0.80 \leq r_i \leq 1.00$ very high and $0.60 \leq r_i \leq 0.80$ high. Then, classified based on the following criteria [30].

Table 3. Reliability Criteria

Reliability Coefficient	Criteria
$0.80 \leq r_i \leq 1.00$	Very high
$0.60 \leq r_i \leq 0.80$	Tall
$0.40 \leq r_i \leq 0.60$	Currently
$0.20 \leq r_i \leq 0.40$	Low
$0.00 \leq r_i \leq 0.20$	Very low

Difficulty Test, The difficulty test is used to measure the level of difficulty or how difficult the question items are. The formula used is the average score divided by the maximum score. Then the degree of difficulty is determined based on the following levels of difficulty [31].

Table 4. Difficulty Level Criteria

Reliability Coefficient	Criteria
0.00 – 0.30	Difficult
0.31 – 0.70	Currently
0.71 – 1.00	Easy

Discriminatory Power Test, The discriminatory power test is a method to evaluate how well a question can distinguish between able and unable test takers. This test is the average score of the upper class minus the average score of the lower class, then divided by the maximum score. Then analyzed with the criteria 1) $0.00 \leq D \leq 0.20$ (Poor), 2) $0.21 \leq D \leq 0.40$ (Fair), 3) $0.41 \leq D \leq 0.70$ (Good), 4) $0.71 \leq D \leq 1.00$ (Very Good)[31]. Practicality Test Results Analysis Technique, The results obtained from the questionnaire with a Likert scale were then analyzed using the equation of the total score divided by the maximum score, then multiplied by 100%. After obtaining the percentage results, they were classified according to the following practicality criteria [32].

Table 5. Practicality Criteria

Percentage (%)	Criteria
80 – 100	Very Practical
66 – 79	Practical
56 – 65	Quite Practical
40 – 55	Less practical
30 – 39	Not Practical

Effectiveness Test Analysis Techniques, This study uses an independent sample t-test (Independent Sample T-Test). Independent-Samples T-Test (Independent sample t-test) is used to test 2 classes, 1 class with treatment and 1 class without treatment.[33]. Before conducting a t-test, a normality and homogeneity test must be performed as a prerequisite. Then, test the effectiveness with a t-test assisted by the SPSS application.

3. RESULTS AND DISCUSSION

This study produces an e-module based on Culturally Responsive Teaching (CRT) integrated with Javanese gamelan, designed to train students' critical thinking skills on vibration and wave material in grade VIII of junior high school. The application of this model can train students' critical thinking skills and introduce culture to students [34]. The application of this model is able to hone students' critical thinking skills while introducing them to cultural elements [35]. The development of e-modules follows the 4-D method (Define, Design, Develop, Disseminate) which aims to ensure the characteristics, feasibility, practicality, and effectiveness of teaching materials.

3.1. Define Stage

Initial analysis was conducted through observation, interviews with science teachers at Junior high school 6 Ngawi, and distribution of student needs analysis questionnaires. The results of the observation found that the science learning method is still centered on the teacher, dominated by the lecture method, so that students do not have the opportunity to develop critical thinking skills. In addition, the results of the initial test showed an average percentage of students' critical thinking skills of 19%, indicating the need for innovation in teaching materials that are more contextual and interactive. The results of interviews with science teachers revealed that the textbooks currently used have limitations, namely that they are physically inadequate, limited in number, not flexible, and do not specifically train students' critical thinking skills. Furthermore, the teacher said that students face difficulties in learning wave vibrations because the teaching materials are not interesting,

inadequate facilities, and abstract materials. The science teacher said that the students' scores on the material are still below the minimum completion criteria. This statement is in accordance with the research at Junior high school 3 Trenggalek which has been carried out, the data obtained is that students get scores below the minimum completion criteria by 97% [13]. Most of the factors that influence students' difficulties in understanding the concept of vibrations and waves in physics are due to their abstract nature [36]. Students find it difficult to imagine if there are no teaching materials because the material on wave vibrations is invisible [37]. Based on the student needs questionnaire, 92% of students stated the need for more interactive teaching materials that are connected to local culture. Therefore, CRT was chosen as a learning model that can train the relevance of learning to the cultural context of students and support the development of critical thinking skills [34].

3.2. Design Stage

This e-module was developed using the Canva and Heyzine Flipbooks applications. The module design considers visual aspects, font selection, layout, and video integration, interactive quizzes, and illustrations related to Javanese gamelan to enrich students' learning experiences. Interactive teaching materials are not only material but can be combined with local wisdom to train students' critical thinking skills [38]. In addition, the Culturally Responsive Teaching (CRT) based e-module contains exercises so that it can be used to train students' critical thinking skills. Utilizing interactive flipbooks in the science learning process, especially simple machines, is considered effective in training students' critical thinking skills [10]. Science teaching materials are not just material, but can be combined with local wisdom and are able to train students' critical thinking skills [38]. Science teaching materials are not limited to material alone, but can be integrated with local wisdom to develop students' critical thinking skills [14].

3.3. Development Phase

Design e-modul based on Culturally Responsive Teaching (CRT) validated by expert validators. Material validator, media validator, and language validator. Based on Figure 1, the diagram can be described that the aspect of breadth and completeness of the material gets a percentage of 90%. The aspect of truth in terms of science gets a percentage of 85%. The aspect of conformity with national education standards and applicable curriculum gets a percentage of 100%. The aspect of conformity with the development of science and technology gets a percentage of 92%. The aspect of presentation gets a percentage of 86%. Therefore, the e-module is declared feasible with a very good predicate. The following are the validation results from several experts.

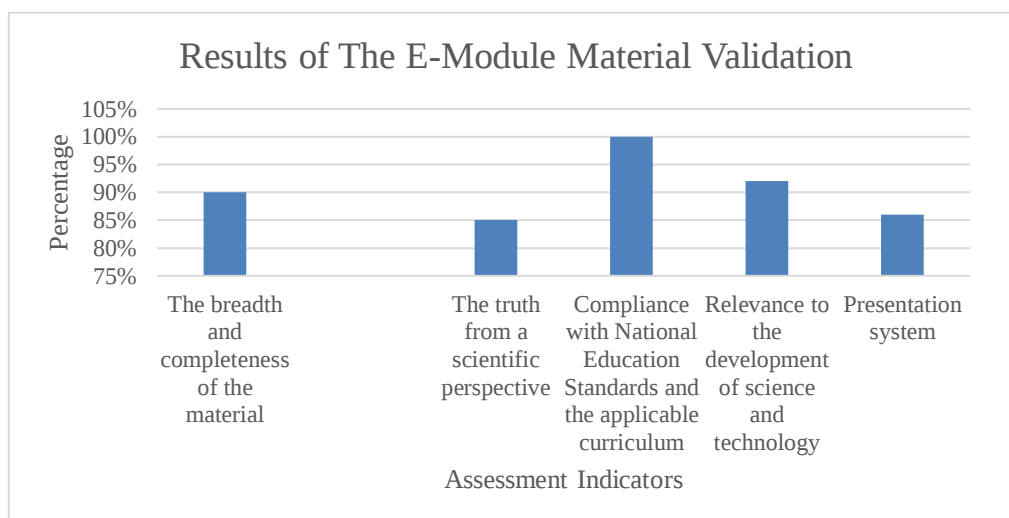


Figure 1. Bar Chart of Material Validation Results

Next, media validation is carried out by media experts. The results of media validation are as follows:

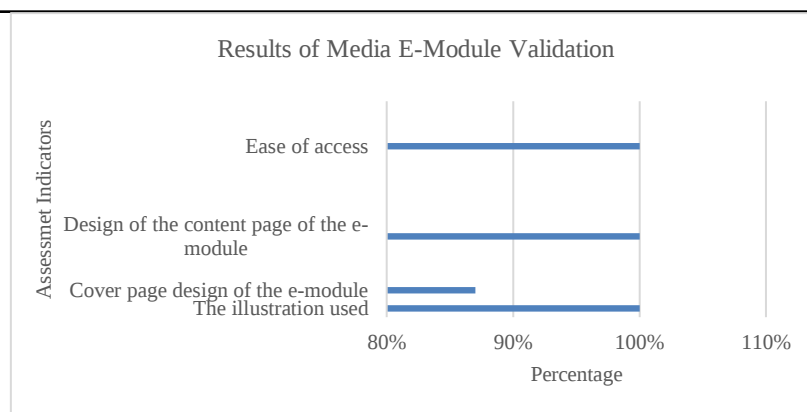


Figure 2. Bar Chart of Media Validation Results

Based on the validation resultsmedia experts can describe the aspects of Illustration used, aspects of the design of the e-module content page, and aspects of ease of access obtained a percentage of 100%. The aspect of the design of the e-module cover page obtained a percentage of 87%. So it can be stated that the e-module is worthy with a very good predicate. Furthermore, language validation is carried out on the language expert language validator. Here are the results:

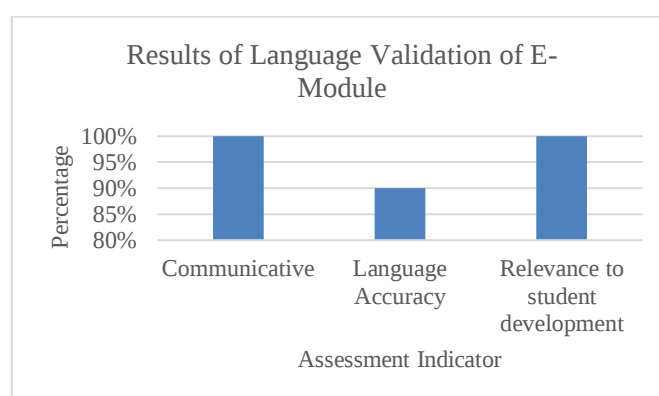


Figure 3. Bar Chart of Language Validation Results

Based on the results of language validation, it can be described that the aspect of language accuracy obtained a percentage of 90%. The communicative aspect and suitability with student development obtained a percentage of 100%. Therefore, the e-module based on Culturally Responsive Teaching (CRT) was declared feasible with a very good predicate. The e-module based on Culturally Responsive Teaching (CRT) was developed in accordance with the validator's recommendations to be of better quality [39]. Furthermore, the results of the test of the validity of the question items obtained aspects of content, language, and writing of questions obtained a percentage of 92.5%. So the question items are categorized as valid

Because the percentage results are $85\% < V \leq 100\%$. Then a reliability test was carried out with the SPSS application, the results were 0.924, so it was said that the question items had very high reliability because $0.80 \leq r_i \leq 1.00$. The results of the test of the difficulty of the question items obtained data on questions number 1,2,4, and 9 were difficult. Questions number 3 and 9 were easy. Questions number 5, 6, 7, 8, 10 were moderate. Then a test of the item discrimination power was carried out. The results obtained on questions number 1, 2, 4, 5, 6, 7, 8, 9, 10 were categorized as good and question number 3 was sufficient.

Next, design testing was carried out, the design was tested on a limited basis to class VIII A of Junior high school 6 Ngawi. The purpose of the limited test was to obtain suggestions as a reference for improving the e-module [26]. In the trial, the results of the student response questionnaire were obtained with 23 students as respondents. It can be described that the total score is 1271 from a maximum score of 1495 so that a percentage of 85% is categorized as very practical. The following is a display of the results of the student response questionnaire analysis in the form of table 6.

Table 6. Analysis of Student Response Questionnaire

Assessment Indicators	1	2	3	4	5	6	7	8	9	10	11	12	113
Amount	93	8	98	87	103	104	95	98	100	101	100	93	111
Total	1271												
Maximum Score	1495												
Percentage	85%												
Criteria	Very Practical												

After being declared very practical, the e-module based on Culturally Responsive Teaching (CRT) can be used for field testing in class VIII B as an experimental class, namely a class that uses the e-module in the learning process. Then students work on critical thinking ability test questions and fill out student response questionnaires. In addition to class VIII B, class VIII C also works on critical thinking ability test questions. Class VIII C is a control class, a class that has never used the e-module. Then the values of the two classes are tested for normality and homogeneity as a prerequisite for the effectiveness test assisted by the SPSS application.

The normality test results obtained with the Shapiro-Wilk method which is in accordance with a sample of 50. The significance of the value in class 1, namely VIII C as a normal control class. Because the significance value of class VIII C is $0.468 > 0.05$. The significance of the value of class 2, namely VIII B as a normal experimental class. Because the significance value of class VIII B is $0.075 > 0.05$. Furthermore, the students' values are tested for homogeneity. Then the results of the homogeneity test of the students' values can be described that based on mean (based on the average value) the significance level is 0.167 categorized as homogeneous because $p > 0.05$. The test of equality of two variances is used to determine whether the distribution of data is homogeneous by comparing the two variances [40]. Since it has met the prerequisites, it can be used for independent sample t-test. The results of the SPSS-assisted t-test are as follows:

Table 7. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						One-Sided p	Two-Sided p			Lower	Upper
Mark	Equal variances assumed	1,964	.167	-7,632	49	<,001	<,001	-21,969	2,879	-27,754	-16.185
	Equal variances not assumed			-7,589	44,43	<,001	<,001	-21,969	2.895	-27,802	-16.137

Statistical tests using SPSS and independent sample t-tests showed that the experimental class, namely class VIII B, experienced a significant increase in critical thinking. The average score of class VIII B was higher than class VIII C (p -value < 0.001), which proves that the e-module based on Culturally Responsive Teaching (CRT) is effective in training students' critical thinking skills. Then, after using the e-module based on Culturally Responsive Teaching (CRT), science teachers and class VIII B students responded to the e-module. Responses were collected from teacher response questionnaires and student response questionnaires to obtain data in the form of assessments and suggestions.

The results of the teacher response questionnaire can be described in the aspect of content presentation obtaining a percentage of 96%. The graphic aspect obtained a percentage of 100%. The Usage aspect obtained a percentage of 95%. The usefulness aspect obtained a percentage of 100%. Therefore, the e-module based on Culturally Responsive Teaching (CRT) as a whole is categorized as very practical. In addition to assessing, teachers also provide suggestions for adding practice questions for students. However, the e-module can already be used by students and makes it easier for students in the learning process. E-modules can help students learn to think critically [41].

The results of the questionnaire responses of class VIIIB students can be described that the response from students has a percentage of 90%. Therefore, the e-module based on Culturally Responsive Teaching (CRT) is categorized as very practical to be used in the learning process of science for class VIII Junior high school on vibration and wave material. The results of the questionnaire responses of class VIII B students can be seen in the following table 8.

Table 8. Results of Student Response Questionnaire Analysis

Assessment Indicators	1	2	3	4	5	6	7	8	9	10	11	12	113
Amount	99	105	105	98	100	95	106	102	104	107	100	103	115
Total	1339												
Maximum Score	1495												
Percentage	90%												
Criteria	Very Practical												

3.4. Dissemination Stage

The distribution stage of e-module products based on Culturally Responsive Teaching (CRT) was carried out in class VIII of Junior high school Negeri 6 Ngawi. The distribution of the e-module link utilized social media in the form of WhatsApp. So that students can access and study the wave vibration material independently and flexibly. The e-module can be accessed with a cellphone, laptop, or computer. In addition to students, the e-module link was also distributed to science teachers at Junior high school 6 Ngawi. The e-module is an electronic teaching material created by advances in technology and information that aims to assist learning in schools. The e-module allows students to learn independently with the help of their teachers at school or independently at home [20].

The final result of define, design, develop, and disseminate (4-D) is an e-module product based on Culturally Responsive Teaching (CRT) that is theoretically and empirically feasible, practical and effective for use in the process of learning vibrations and waves. The following are the characteristics of the e-module:

- E-modul* Based on Culturally Responsive Teaching (CRT), it has content that trains critical thinking skills so that it can train students' critical thinking skills.
- Having cultural content in the form of Javanese gamelan is associated with the science concept of vibrations and waves.
- E-modul* Based on Culturally Responsive Teaching (CRT) using picture illustrations according to the discussion as well as gamelan performance videos and pictures used to clarify the science concepts in Javanese gamelan.
- Presentation in the form of a Heyzine Flipbooks website link, so that it is easy to access and is arranged with material according to the student's level of understanding.
- E-modul* can be accessed independently.

Critical thinking training is closely related to the concept of critical reflection in the CRT model, which emphasizes the relationship between scientific and cultural concepts. Previous research on e-modules has focused more on digital aspects, such as in research [16], [17]. While the research has the novelty of integrating culture directly to make it more contextual and train critical thinking. The limitations of the study were only tested in 1 school, so a broader study is needed to see the long-term effects. Recommendations for further researchers are development with CRT models based on other cultures, such as puppetry and dance.

4. CONCLUSION

This study produced an e-module based on Culturally Responsive Teaching (CRT) integrated with Javanese gamelan to train students' critical thinking skills in vibration and wave material and provide a more contextual learning experience. The validation results showed that this e-module was feasible to use, practical, and effective in learning. The independent sample t-test proved that there was a significant difference between the experimental class and the control class, confirming that the use of CRT-based e-modules had a positive impact on students' understanding. With an interactive, flexible, and culture-based design, this e-module not only trains critical thinking skills but also strengthens appreciation for local culture. This product can be an innovation in science learning that is relevant to the needs of modern education. Suggestions for further researchers can apply other culture-based CRTs to science learning and further studies to test the long-term impact of CRT-based e-modules.

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