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Development of an Ethnoscience-Based Physics E-Module to Improve Students' Critical Thinking Skills

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ABSTRACT: This research is a type of Research and Development (R&D) employing the 4-D development model. The objectives of this study are to: (1) analyze the content validity of the ethnoscience-based physics e-module developed; (2) analyze the responses of educational practitioners regarding the quality and practicality of the ethnoscience-based physics e-module; and (3) analyze the effectiveness of using the developed ethnoscience-based physics e-module. The hypothesis testing was conducted using a quasi-experimental design with a posttest-only control group design in two classes, namely the experimental class (36 students) and the control class (36 students). The instruments used in this study included the validation sheet for the ethnoscience-based physics e-module, a practitioner response questionnaire, and a validated critical thinking skills test for students. Based on the analysis results, the following conclusions were obtained: (1) the ethnoscience-based physics e-module developed in this study is valid in terms of content feasibility, presentation, graphics, and language; (2) practitioners' responses to the developed ethnoscience-based physics e-module fall into the practical category, indicating that practitioners gave positive responses toward the module; and (3) there is a significant difference in the critical thinking skills test results between students taught using the ethnoscience-based physics e-module and those who were not. This is evident from the hypothesis testing, which shows that the t-count is greater than the t-table (4.68 > 1.99), meaning there is a significant difference in students' critical thinking skills between those taught using the ethnoscience-based physics e-module and those taught without it in class XI of SMAN 5 Kendari.

KEYWORDS: E-modulphysics, ethnoscience-based, critical thinking skills

I. INTRODUCTION

Education plays a crucial role in developing superior and competent human resources, particularly in facing global challenges in the modern era. Critical thinking skills are a crucial 21st-century competency essential for facing global challenges. Critical thinking refers to the way a person filters, analyzes, and questions any information they encounter. The importance of critical thinking skills through the educational process is to foster independence, the ability to acquire information, integrate knowledge, and solve various problems, enabling students to compete globally in line with current developments (Hasnan, 2020). Critical thinking skills are crucial for students because they help them analyze, solve problems, and make informed decisions in various situations. Through critical thinking, students can differentiate between true and false information, identify valid arguments, and find creative solutions to problems.

Furthermore, critical thinking also strengthens the ability to adapt and take appropriate action based on evidence and facts, rather than solely on assumptions or the opinions of others. However, the 2018 PISA results showed that Indonesia ranked 7th lowest out of 78 countries, indicating that students' critical thinking skills are still very low (Puslitjakdkbud, 2021). This low level of critical thinking skills impacts students' ability to solve problems that require in-depth analysis, particularly in physics.

Physics, as a branch of science, is often considered difficult by students due to its abstract nature and its theoretical concepts that require in-depth understanding. This is in line with the results of an interview with a physics teacher at SMAN 5 Kendari regarding the difficulties faced by students in the learning process, especially in physics. It was found that most students do not like physics because it is considered a difficult subject. In addition, students' critical thinking skills are still relatively low, especially in analyzing the relationship between physics and local wisdom or local culture. The lack of teaching materials that highlight local wisdom, especially in the surrounding environment, is one of the obstacles for students in analyzing how scientific concepts can be applied. This is a challenge in the world of education, where students still have difficulty integrating the context of science with their local context. One solution that can be implemented to improve critical thinking skills is to integrate ethnoscience-based learning.

Ethnoscience-based learning can be a solution to these problems, as it integrates scientific concepts with local wisdom, thus providing relevant and contextual learning. Furthermore, this ethnoscience-based learning is important to develop because it

presents problems that require critical thinking to solve. Students are also trained to evaluate information, compare solutions, and make logical decisions. With this approach, students not only master theory but also see how physics concepts are applied in everyday life, encouraging them to think more critically and analytically. For example, the concept of heat transfer can be explained through the process of making regional specialties, such as kambose in Southeast Sulawesi. However, this potential has not been widely utilized in formal learning, including in physics. The integration of ethnoscience can not only increase the relevance of learning but also respect local cultural heritage and strengthen student identity, especially in today's digital era.

In the digital era, the use of educational technology has become a major trend in learning development. One teaching material that implements the use of technology is the e-module. E-modules are a type of teaching material that can be used as an interactive and flexible learning aid equipped with various elements to enable students to improve their understanding and engagement (Sukatin, 2023). The use of e-modules in the learning process is important to develop because advances in information and communication technology have opened up significant opportunities for creating innovative learning media. With features such as text, images, videos, and simulations, e-modules can present learning materials that are more dynamic, engaging, and easy for students to understand. Furthermore, e-modules allow students to learn independently anytime and anywhere, making them the perfect solution to meet learning needs in the digital era.

The integration of physics, ethnoscience, and technology in the form of e-modules is expected to significantly improve the quality of physics learning in schools. Ethnoscience-based physics e-modules are designed to provide a holistic learning experience and support the development of students' critical thinking skills. The synergy between e-modules, ethnoscience, and critical thinking skills lies in their ability to create meaningful learning. E-modules provide a flexible and interactive digital platform, while ethnoscience enriches the content with relevant local wisdom. Through this approach, students are encouraged to explore, analyze, and evaluate various phenomena based on physics concepts. Thus, students not only gain a deeper understanding of physics but also develop critical thinking skills in a cultural context close to everyday life.

For this e-module to be truly useful, it must meet three main criteria: valid, practical, and effective. Valid means that the content of the e-module must be materially correct and in accordance with learning needs, so that it can be trusted and used in physics learning. Practical means that the e-module is easy to use by teachers and students, both in terms of appearance, accessibility, and implementation in the classroom without the need for additional complicated tools or guides. Meanwhile, effective shows that this e-module really helps students achieve learning objectives, such as improving critical thinking skills well. By meeting these three criteria, the e-module can ensure the learning process becomes more interesting, easy, and beneficial for students. Therefore, researchers are interested in conducting a study entitled: "Development of an Ethnoscience-Based Physics E-module to Improve Students' Critical Thinking Skills".

II. METHOD

The type of research used in this study is research and development. The development model used in this study is 4D which consists of four stages, namely: 1) define, 2) design, 3) develop, and 4) disseminate. Research and Development (R&D) in this study refers to a systematic process carried out to design, develop, and test an ethnoscience-based physics e-module that aims to assist students in learning. This study uses a practitioner response questionnaire to assess the practicality of the developed ethnoscience- based physics e-module. In addition, data were collected through a critical thinking skills test with reference to the indicators formulated by Facione, namely interpretation, analysis, and inference.

The data analysis techniques used in this study are divided into two, namely analysis related to the instruments used in the study and analysis of data obtained during the study. The instrument analysis used is the calculation of Aiken's content validity (Aiken's V). The analysis of the data from this study is divided into two, namely: 1) descriptive statistical analysis which includes the calculation of the mean, maximum score, minimum score, variance, standard deviation, and frequency distribution. 2) inferential statistical analysis using the independent sample t-test which is preceded by a prerequisite test consisting of a normality test and a homogeneity test.

III. RESULTS AND DISCUSSION

RESULTS

Content Validity Test

Aiken's V index analysis is an expert/specialist agreement index regarding the suitability of an item with the indicator measured using that item. The validity criteria are based on the criteria used, namely if $V \geq 0.4$ then it can be said to be valid. The results of the content validity coefficient analysis test of the expert agreement index can be seen in Table 1 below.

Table 1 Validity Analysis Test of Ethnoscience-Based Physics E-module

Aspect	Total Validity Item Score	V	Category
Content Eligibility	12.50	0.78	Valid

Presentation Eligibility	12.67	0.79	Valid
Language Eligibility	13.00	0.81	Valid
Graphical Eligibility	6.67	0.83	Valid

Source: Processed Primary Data (2025)

Based on the table above, it can be seen that in the aspect of content feasibility, the total score of validity items is 12.50 with a validity index (V) and an average score of 0.78 so that it is in the valid category, for the aspect of presentation feasibility, the total score of validity items is 12.67 with a validity index (V) and an average score of 0.79 so that it is in the valid category. Furthermore, for the aspect of language feasibility, the total score of validity items is 13.00 with a validity index (V) and an average score of 0.81 so that it is in the valid category, then for the aspect of graphic feasibility, the total score of validity items is 6.67 with a validity index (V) and an average score of 0.83 so that it is in the valid category.

Practitioner Expert Assessment of the Quality of Ethnoscience-Based Physics E-modules

The practitioner assessment was calculated by looking at the percentage of practitioners in each aspect: appearance, material presentation, media operation, and media usability. Practitioner assessments of the physics e-module were obtained from a practitioner assessment questionnaire completed by physics teachers from high schools (SMA/MA) in Southeast Sulawesi province. The results of the analysis for each practitioner are presented in Table 2 below.

Table 2 Results of Practitioner Assessment of the Quality of Ethnoscience-Based Physics E-module Development

Aspect	Ideal Score	Acquisition Score	(%)	Category
Appearance	440	421	95.7	Interesting
Presentation of Material	400	377	94.3	Structured
Media Operations	80	77	96.3	Practical
Benefits of Media	120	110	91.7	Beneficial
Average			94.5	Practical

Source: Processed Primary Data (2025)

The analysis of the results of the practitioner assessment in Table 2 shows that the ethnoscience-based physics e-module was assessed based on four aspects, namely appearance, material presentation, media operation, and media benefits. When viewed from the appearance aspect, the ethnoscience-based physics e-module obtained a score of 421 out of an ideal score of 440, with a percentage of 95.7% which is included in the attractive category. This indicates that the visual design of the ethnoscience-based physics e-module is considered capable of attracting users' attention, has a consistent layout, and aesthetics that are suitable for learning media. In the aspect of material presentation, the ethnoscience-based physics e-module obtained a score of 377 out of an ideal score of 400, or 94.3%, and is included in the structured category. This means that the material in the ethnoscience-based physics e-module is arranged systematically and is easy to understand.

Meanwhile, in terms of media operation, the media obtained a score of 77 out of an ideal score of 80, with a percentage of 96.3%, indicating that this media is very practical and easy to use without causing confusion for users. In general, the validator gave a consistent assessment on this aspect. Furthermore, in terms of media benefits, the ethnoscience-based physics e-module obtained a score of 110 out of an ideal score of 120, or 91.7%, and is included in the useful category. This indicates that the media is considered capable of supporting the learning process and improving student understanding.

In general, practitioners gave an assessment for each aspect starting from the appearance aspect, presentation of material, media operation, and media benefits to be above 50% which means it is practical and gave a positive response to the ethnoscience-based physics e-module that has been developed..

The Effectiveness of Using Ethnoscience-Based Physics E-Modules to Improve Critical Thinking Skills

The results of the critical thinking skills test of students on the material of temperature and heat in class XI.4 which was used as an experimental class consisted of 36 students. After carrying out descriptive analysis calculations, the classification of the categorization of the critical thinking skills test for the experimental class can be seen in table 3 below.

Table 3 Categories of Critical Thinking Skills Test Results of Students in the Experimental Class

Statistics	Post-test
Maximum ideal score	30
Minimum ideal score	0
Empirical maximum score	29
Empirical minimum score	17

Average	24.22
Median	24.13
Mode	26
Variance	10.06
Standard Deviation	3.17

Source: Processed Primary Data (2025)

The data from the results of the critical thinking skills test of students in the experimental class can be categorized into 5 categories as shown in table 4 below.

Table 4 Critical Thinking Skills Test Results Categories in Experimental Class

Value Interval	Frequency	Percentage	Assessment Categories
$X > 22,5$	27	75%	Very high
$17,5 < X \leq 22,5$	7	19.44%	Tall
$12,5 < X \leq 17,5$	2	5.56%	Currently
$7,5 < X \leq 12,5$	0	0%	Low
$X \leq 7,5$	0	0%	Very Low
Amount	36	100%	

The category of students' critical thinking skills test results presented in Table 4.4 shows that of the 36 students who participated in learning using the ethnoscience-based physics e-module, 27 students with a percentage of 75% were in the very high category. Furthermore, there were 7 students with a percentage of 19.44% in the high category, and there were no students in the low and very low categories. Thus, it can be concluded that the tendency of the results of the critical thinking skills test of students in the experimental class was in the very high category, so that the use of the ethnoscience-based physics e-module was effective in improving students' critical thinking skills.

The results of the critical thinking skills test of students on the material of temperature and heat in class XI.10 which was used as a control class consisted of 36 students. After calculating the descriptive analysis, the classification of the categorization of the critical thinking skills test for the experimental class can be seen in table 5 below.

Table 5 Categories of Critical Thinking Skills Test Results of Students in the Control Class

Statistics	Post-test
Maximum ideal score	30
Minimum ideal score	0
Empirical maximum score	29
Empirical minimum score	15
Average	21.41
Median	20.5
Mode	20
Variance	13.59
Standard Deviation	3.69

Source: Processed Primary Data (2025)

The data from the results of the critical thinking skills test of students in the Control class can be categorized into three categories as shown in table 6 below.

Table 6 Categories of Critical Thinking Skills Test Results in the Control Class

Value Interval	Frequency	Percentage	Assessment Categories
$X > 22,5$	14	38.89%	Very high
$17,5 < X \leq 22,5$	18	50%	Tall
$12,5 < X \leq 17,5$	4	11.11%	Currently
$7,5 < X \leq 12,5$	0	0%	Low
$X \leq 7,5$	0	0%	Very Low
Amount	36	100%	

The categories of critical thinking skills test results of students in the control class displayed in Table 6 show that out of 36 students, 14 students (38.89%) were in the very high category, 18 students (50%) were in the high category, and 4 students (11.11%) were in

the medium category. Furthermore, there were no students in the low and very low categories. Thus, it can be concluded that the results of the critical thinking skills test of students in the control class tended to be in the high category.

Hypothesis Testing

After the prerequisite analysis tests are met (data is normally distributed and homogeneous), the next step is to test the hypothesis. The hypothesis testing in this study uses an independent sample t-test to see whether there is a difference in the critical thinking skills test results of students taught using the ethnoscience-based physics e-module and students who are not taught using the ethnoscience-based physics e-module. The calculation for this hypothesis test uses the t-test with a 95% confidence level. The hypothesis formulation is as follows.

H_0: There was no difference in the results of the critical thinking ability test of students who were taught using ethnoscience-based physics e-modules with students who were not taught using ethnoscience-based physics e-modules.

H_1: There is a difference in the results of the critical thinking ability test of students who were taught using ethnoscience-based physics e-modules with students who were not taught using ethnoscience-based physics e-modules.

The basis for decision making in this research hypothesis test is if $t_{hitung} > t_{tabel}$ then there is a significant difference between the results of the critical thinking skills test of the experimental class and the control class or H_0 rejected. The results of the hypothesis test of the critical thinking skills of students taught using the ethnoscience-based physics e-module with students who were not taught using the ethnoscience-based physics e-module can be seen in the following table.

Table 7 Hypothesis Testing Results of Critical Thinking Skills Test of Experimental Class and Control Class with t-Test

	Experiment	Control
n	36	36
average	24.22	20.49
S2 Variance	10.07	12.81
t_{hitung}	**4.68**	
t_{tabel}	**1.99**	

Source: Processed Primary Data (2025)

From the results of the data processing above, it can be seen that the value $t_{hitung} > t_{tabel}$ so that H_0 rejected. Based on the results of the hypothesis test processing above, it can be concluded that there is a significant difference between the results of the critical thinking skills test of students taught using*e-modul*ethnoscience-based physics with students who are not taught using *e-module* ethnoscience-based physics.

DISCUSSION

Validity of the Content of Ethnoscience-Based Physics E-modules

Validity is a standard or basis of measurement that shows accuracy (*appropriateness*), benefits (*userfulness*) and validity which leads to the accuracy of the interpretation of an evaluation procedure in accordance with the measurement objectives (Bloor, 1997). Meanwhile, according to Azwar (1996), validity is the extent to which a measuring instrument (test) is accurate and precise in carrying out its measurement function. A test is said to have high validity if the instrument carries out its measurement function accurately or provides measurement results that are in accordance with the purpose of the measurement. Therefore, it is important to know the validity of the product being developed, in this case the product being developed is an ethnoscience-based physics e-module.

E-module Ethnoscience-based physics was developed and compiled to become a learning resource for students, especially in learning physics for class XI, material on temperature and heat *e-modul.* This is based on previously analyzed student needs. The selection of electronic modules is based on their ease of practical study, anywhere and anytime. Teachers can easily use them.*e-modul*. This is a companion in learning activities. In addition,*e-modul*This is also based on ethnoscience so that it can provide new knowledge and experiences for students in the learning process.

E-modul This consists of several parts, in the first part there is a cover designed with fonts, illustrations and colors that are in harmony with the characteristics*e-module* developed. The introduction section contains a foreword, table of contents, general information, subject overview, and learning activities. Furthermore, in the content section, the material presented integrates an ethnoscience-based approach, where physics concepts are connected to typical Southeast Sulawesi regional foods, namely sinonggi, kambose, kasuami, kabuto, and lapa-lapa. This approach aims to strengthen students' understanding of temperature and heat through a local cultural context that is closer to students' daily lives.

Content validity*e-module* Ethnoscience-based physics is obtained through assessment by experts. Each expert is asked to evaluate*e-modul*which has been created to find out the advantages and disadvantages of*e-modul*. The assessment data were then

analyzed using Aiken's V index analysis by looking at the validated content validity coefficient.*E-modul*Ethnoscience-based physics is said to be valid if the content validity coefficient V $\geq$0.4. The validity results of each aspect presented in Table 1 show that the average content validity coefficient is above 0.4, namely 0.80. This indicates that*e-modul*The ethnoscience-based physics developed is valid and suitable for use in the learning process. The results of this study align with research conducted by Cici Tisa Haspen et al. (2021), which showed that*e-modul*Physics based on guided inquiry integrated with ethnoscience has valid criteria with an average validation of 0.83. Therefore, it can be concluded that*e-modul*The ethnoscience-based physics developed in this research has met content validity standards and is suitable to be used as a learning resource.

Practitioner Assessment of Ethnoscience-Based Physics E-modules

Practicality refers to the extent to which a development product can be used easily and efficiently by teachers and students in the learning process. A teaching material can be said to be practical if it meets the following criteria: (1) expert and practical assessments that the device can be used with little or no revision; (2) teachers and students state that the developed device is easy to use; and (3) the results of observations of the implementation of the teaching material in the classroom are included in the good or very good category (Aleslami, 2020). The instrument used to obtain practitioners' responses to the product developed in this study, namely the ethnoscience-based physics e-module, is called a questionnaire sheet.

Practicality*e-module* The ethnoscience-based physics learning was tested through an assessment by educational practitioners, particularly high school physics teachers in Southeast Sulawesi Province. The practitioners' assessment aimed to obtain realistic and objective responses to its quality and usability in real-life learning. The instrument used was a validated questionnaire, covering several important aspects such as ease of use, clarity of presentation, appropriateness of material, and effectiveness of ethnoscience-based content delivery.

The results of the practicality assessment by practitioners show that*e-module* Ethnoscience-based physics received a very positive response. The average percentage of assessments given by practitioners was 94.5%, which falls into the "practical" category. This indicates that, in general,*e-module* The developed method meets the practical aspects of learning. The results of this study align with those of Rudi Kurniawan and Syafriani (2021), which showed that the average percentage of assessments given by practitioners was 88.3%, categorized as very practical. This similarity in research findings reinforces the use of*e-module* based on practical ethnoscience used in the learning process.

Furthermore, this positive assessment is supported by direct responses from practitioners, who stated that*e-module* This presents material with a contextual approach that is relevant to the students' daily lives. This is very important because the ethnoscience approach used in*e-module* enables students to understand physics concepts not only abstractly, but also through the local culture they are familiar with, in this case the typical foods of Southeast Sulawesi (Kasuami, Sinonggi, Kabuto, lapa-lapa, and Kambose). Therefore, it can be concluded that*e-modul*The ethnoscience-based physics developed has met the criteria for good practicality. These results also serve as an indicator that*e-modul*This is worthy of wider use in physics learning activities in high schools, especially in order to support meaningful and contextual learning.

The Effectiveness of Ethnoscience-Based Physics E-Modules in Improving Students' Critical Thinking Skills

The word "effective" comes from the English word "effective," which means success or something done successfully. Effectiveness is a key element in achieving predetermined goals or objectives in any organization, activity, or program. Effectiveness is defined as the extent to which a predetermined goal or objective is achieved. In general, effectiveness is defined as the extent to which a predetermined goal is achieved. The concept of effectiveness is always linked between expected results and actual results achieved (Mamonto, Rachman, & Kumayas, 2022).

Effectiveness refers to the extent to which the use of an ethnoscience-based physics e-module is able to improve students' critical thinking skills in accordance with the established learning objectives. Learning is said to be effective if the use of the e-module actually results in a significant increase in critical thinking skills compared to conventional learning methods. After conducting the learning process in the experimental class and the control class, where the experimental class was taught using an ethnoscience-based physics e-module while the control class was not taught using an ethnoscience-based physics e-module, it was found that there were differences in the results of the students' critical thinking skills test.

The results of this study indicate that the results of the critical thinking skills test of students taught using the ethnoscience-based physics e-module had the lowest score of 17 and the highest score of 29 with an average critical thinking skills test result of 24.22. Meanwhile, the control class that was not taught using the ethnoscience-based physics e-module had the lowest score of 15 and the highest score of 29 with an average critical thinking skills test result of 21.41. The results of the critical thinking skills test of students in the control class were lower than those in the experimental class because the material presented was still general and not linked to local culture, so students tended to receive information passively and were less encouraged to analyze or evaluate physics concepts in their daily lives. In contrast, students in the experimental class who were taught using an ethnoscience-based physics e-module gained a more contextual and relevant learning experience. This e-module integrated physics concepts with local culture, especially typical Southeast Sulawesi regional foods, which were already familiar to students. This approach not only improved understanding of the material but also encouraged students to think more critically in connecting physics concepts with

phenomena they encountered in their daily lives.

The hypothesis testing that has been carried out also shows that the value $t_{hitung} > t_{tabel}$ or 4.68 > 1.99, this means that there is a significant difference between the results of the critical thinking skills test of students who are taught using *e-modul*e ethnoscience-based physics with students who are not taught using *e-module* Ethnoscience-based physics for 11th-grade students at SMAN 5 Kendari. This aligns with research conducted by Rudi Kurniwan and Syafriani in 2021, which showed that the critical thinking skills test results of students taught with *e-module* based *guided inquiry* integrated ethnoscience is higher compared to students who are not taught with *e-modul* based *guided inquiry* integrated ethnoscience in high school physics learning. Therefore, it can be concluded that *e-module* Ethnoscience-based physics is effectively used in physics learning, especially on temperature and heat.

CONCLUSIONS

Based on the results of research and trials of ethnoscience-based physics e-modules on the critical thinking skills of class XI students at SMAN 5 Kendari, the following conclusions were obtained.

1. The results of the content validity test on *e-modul* the ethnoscience-based physics developed in this study, viewed from the aspects of content feasibility, presentation, graphics, and language, shows valid criteria, so that the e-module is suitable for use as teaching material to improve students' critical thinking skills.
2. Practitioner responses to e-modules ethnoscience-based physics The developed e-modules are in the practical category. This shows that practitioners responded positively to the e-modules.developed ethnoscience-based physics.
3. *E-module* Ethnoscience-based physics is effectively used in physics learning, especially on temperature and heat.This can be seen on phypothesis testing which shows that the value $t_{hitung} > t_{tabel}$ or 4.68 > 1.99 which means *e-module* Ethnoscience-based physics is more effective when used in physics learning compared to control classes that do not use it. *e-module* ethnoscience-based physics.

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