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Integration of Gamelan Ethnophysics E-Module to Improve Science Literacy of Sound Wave Materia

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ABSTRACT

Quality education is characterized by the good science literacy skills of students. However, PISA results show that the science literacy of students in Indonesia is still low, which is caused by less interesting learning and lack of interactivity. One relevant solution is to develop contextual and interactive physics learning tools by integrating local wisdom. Therefore, this study aims to develop and test the validity of the physics module based on gamelan local wisdom and determine the response of students to its use to improve science literacy: This research employed the Research and Development approach utilizing the ADDIE framework, which includes Analysis, Design, Development, Implementation, and Evaluation. The product developed was a physics e-module integrated with Gamelan local wisdom which was validated by experts and tested on students. Results: The module obtained a very valid category from the aspects of content, language, and design. Learners' responses showed that the module was interesting, easy to understand, and improved science literacy skills. Novelty: The integration of gamelan as a form of ethnophysics in the physics module provides a contextual learning experience and encourages the preservation of local culture. This study analyzed the validity and students' response to the physics module based on gamelan.

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INTRODUCTION

A developed education can produce quality human resources. Quality human resources have good literacy skills (Nurtanto et al., 2020; Pramana et al., 2021; Tien et al., 2020). In addition, literacy skills can be an indicator of SDG 4, so education in Indonesia is of high quality (Haneman & Robinson, 2022; Tyagi et al., 2020). The relevant literacy skills in the 21st century are science literacy skills (Kennedy & Sundburg, 2020; Winarni et al., 2020). Therefore, it is necessary to adjust learning strategies to improve science literacy skills with the curriculum

The curriculum in Indonesia emphasizes learning with the Era 5.0 society approach. The Era 5.0 society approach focuses on socio-culture (Sudibjo et al.,2019; Suprapto et al., 2021). Therefore, it is necessary to apply and provide a global problem in the era of 5.0 society in learning each material (Xu et al., 2021; Hysa et al., 2021). In addition, learning in the 21st century is not only a global problem but must be able to relate to social and cultural problems in the era of society 5.0 which re ects technological developments and social interactions (Al-Emran & Al-Shara, 2022).

Indonesia's acquisition of science literacy scores within 12 years has always been in the bottom fth. PISA results for Indonesian students in 2022 are still below the average science scores of OECD countries (Rohmaya et al., 2023). Students' science literacy skills are low due to uninteresting learning content. In addition, the factor of low literacy skills of students can occur because the learning media used is less interactive (Kruk et al., 2022; Derakhshan et al., 2021). Therefore, it is necessary to make an interactive learning tool, one of which is in physics learning.

Physics is a branch of science that studies concepts about natural phenomena that have a relationship with human life (Krenn et al., 2022). This strengthens the relationship between physics education and the understanding of natural concepts. Tanggira (2022) underline conceptual understanding in physics pedagogy, which signi es its signi cance as a foundation for effective learning. Understanding physics through authentic concepts is more likely to enhance students' experiences and skills in grasping the natural environment (Planinic et al., 2019). According to Deta (2024) and Damarsha (2024) providing local wisdom phenomena in physics learning can add contextual problems so that students will seek this information through literacy.

Integrating local wisdom into physics education is essential, as it contains numerous physics concepts. Local wisdom can be introduced through physics because the subject explores natural phenomena, making it possible to incorporate traditional knowledge into the curriculum (Almuharomah et al., 2019). According to Hidayaatullah (2021), ethnoscience has the potential to be integrated with creative educational methods within educational institutions, thereby contributing to the improvement of students' abilities in scientific literacy. One example of an ethnophysical concept found in the local environment is the topic of waves and sound (Damarsha et al., 2024). Therefore, there is a need for learning tools that integrate local wisdom to improve science literacy.

Previous research states that it is necessary to develop learning tools such as modules in physics learning (Fadieny & Fauzi, 2021; Chyntia et al., 2023). So, it is necessary to develop modules by integrating local wisdom. The purpose of using the local wisdom-based physics module is so that students can be directed according to learning objectives so that students' awareness of preserving and developing their environment also includes growing along with the physics material they receive (Erlangga, 2022). This research seeks to create a physics unit that incorporates the traditional knowledge associated with gamelan physics. Then the problem of this research is as follows:

1. What is the validity of the physics module integrated with gamelan local wisdom?
2. How do students respond to the physics module integrated with gamelan local wisdom?

RESEARCH METHOD

Research Design

The approach adopted in this study is Research and Development (RnD). The developmental framework employed for creating this e-module centered on ethnoscience is ADDIE. The selection of this model is based on several considerations. First, the ADDIE model is presented simply and systematically (Krisna et al., 2024).

Figure 1. ADDIE scheme

This research only focuses on 3 stages, namely the analysis, design, and development stages. Then in the design stage, a further study of the concept of physics in gamelan was carried out. In the development stage, product manufacturing and development are carried out, validity testing by material experts and media experts, and limited trials are carried out on students. Validation results are needed in this study as a tool to see the feasibility of products on Ethnophysics-based e-Module teaching materials "Gamelan" to improve the Science Literacy Skills of High School Learners.

Data Collection

The approaches utilized for gathering data in this research included the implementation of verification forms and surveys for student feedback. The validation sheets were provided to two expert validators—one specializing in media and the other in subject matter. s These documents were employed to assess the effectiveness of the created e-module, with evaluation criteria addressing media, content, and material dimensions (Septiana et al., 2024).

In addition, researchers also developed a learner response questionnaire to find out their responses to the e-modules that had been developed. This questionnaire includes several indicators, such as ease of use, appearance, attractiveness, and usefulness of the module in supporting the learning process.

The trial was conducted on a limited basis using one class as a sample, consisting of 3 students. The data from this trial was used to determine the initial effectiveness and students' responses to the use of e-modules before further development was carried out.

Data Analysis

The method of analysis employed in this study involves leveraging a quantitative approach to data examination. At the development stage, researchers conducted an initial validation process concerning certain assessment criteria as described in Table 1.

Table 1. Validation criteria

Scoring Result (%)	Validity Level
0-20	Invalid
21-40	Less Valid
41-60	Quite Valid
61-80	Valid
81-100	Highly Valid

(Andini, 2022)

After the validation process was completed, the researcher continued with the implementation of a limited trial of the learning media that had been designed. In this trial, researchers used the Exploratory Factor Analysis (EFA) method to analyze data from questionnaires lled out by students regarding their responses to the media developed (Damarsha et al., 2025). The EFA analysis requirements that must be met are as follows:

1. Data suitability test
   a. Kaiser-Meyer-Olkin (KMO): Measures sample adequacy (values > 0.5 are considered adequate).
   b. Bartlett's Test of Sphericity: Must be significant ($p < 0.05$) to ensure the correlation between variables is strong enough (Pallant, 2020).
2. Extraction factor
   a. Extraction methods such as Principal Component Analysis (PCA) or Maximum Likelihood are used to determine the number of factors.
   b. Eigenvalue > 1 (Kaiser's Criterion) and Scree Plot criteria help determine the number of relevant factors (Rezvani et al., 2024).
3. Rotation factor
   Varimax (orthogonal) or Promax (oblique) rotation is used to clarify the factor structure by minimizing complexity (Watkins, 2018).
4. Factor interpretation
   Variables with factor loading > 0.5 are considered significant in a factor (Hair et al., 2019)

RESULTS AND DISCUSSION

Analysis Stage

At this stage, Researchers carried out a review of existing literature concerning the creation of electronic modules rooted in local gamelan wisdom aimed at enhancing students' understanding of physics. The findings of the investigation are compiled in a table that encapsulates pertinent insights from multiple sources, serving as a foundation for the creation of educational materials.

Table 2. Literature review

Identity	Research Results	Advantages	Weaknesses	Suggestion
Analysis of Gamelan (Saron) Local Wisdom on the Concept of Wave and Sound Physics (Damarsha et al., 2023)	gamelan saron not only functions as a traditional musical instrument, but also has a close relationship with physics concepts, such as frequency, amplitude, resonance and sound interference. Each saron blade that has a different thickness and length will produce a different tone, which can be	The use of saron musical instruments as learning media makes it easier for students to understand physics concepts related to sound waves. In addition, this research provides a real picture of how cultural values can be revived in the world of education through science.	The research is limited to qualitative methods without being supported by quantitative data. The absence of direct measurements of the frequency, amplitude, or intensity of the sound produced by the saron blades makes the research results not yet fully comprehensive in terms of physical science.	can be developed into physics teaching tools based on local wisdom. Contextual physics learning modules or media that raise cultural elements such as saron will help teachers in delivering material more applicable and interesting.

Identity	Research Results	Advantages	Weaknesses	Suggestion
	explained by the concepts of frequency and wavelength. The intensity of the sound depends on the amplitude of the vibrations produced when the blade is struck.			
E-Module Flipbook based on STEM Approach to Renewable Energy Topics as Physics Learning Media (Syukri *et al.*, 2024)	very high level of validity, both in terms of material and media. Validation conducted by material experts resulted in an Aiken's V score of 0.87 and by media experts of 0.85. This indicates that the module is feasible to use as physics learning media.	learning media innovations that fit the needs of the 21st century, namely media that are not only technology-based, but also invite students to actively engage in critical thinking processes and real problem solving. Flipbook as a presentation format also provides visual appeal and ease of access, enabling flexible, engaging learning and supporting independent learning.	There is no implementation stage in the ADDIE model. This makes the effectiveness of e-modules in the context of direct learning in the classroom cannot be tested empirically. In addition, the validation results mentioned some technical flaws in the module display, such as the use of a background that is too dominant, which interferes with the readability of the text, and the use of sentences that are too long and information-dense, which can make it difficult for students to understand the material.	It is necessary to continue with the limited trial stage or implementation in the classroom in order to obtain quantitative and qualitative data on the impact of using e-modules on student learning outcomes. Revisions to technical aspects such as the selection of background colors and the preparation of more concise sentences also need to be done to make the module more effective to use.
Earthquake scientific literacy profile of Indonesian first	students have a fairly good ability to explain scientific	The integration of the latest PISA 2025 assessment	There has been no development or implementation of learning	Develop a disaster literacy-based learning model that is

Identity	Research Results	Advantages	Weaknesses	Suggestion
year pre-service physics teacher (Deta *et al.*, 2025)	phenomena using their existing scientific knowledge. This is shown by their ability to answer questions that require an explanation of the earthquake phenomenon based on scientific principles. However, a significant gap was found in the aspect of decision-making.	framework makes the study relevant in a global and national context. In addition, this study provides a detailed picture of the scientific literacy profile of physics teacher candidates in the aspect of disaster mitigation, an area that is very crucial for a country like Indonesia that is prone to earthquakes.	interventions that can directly address the lack of disaster mitigation literacy.	integrated with the local context and based on an inquiry approach. The interventions designed should focus on improving scientific thinking skills, experiment preparation, and data-based decision-making and risk analysis.
The preliminary study in the development of e-Physics module integrated ethnoscience (Haspen *et al.*, 2020)	There is a mismatch between the demands of the curriculum that encourage students to be active and independent in learning and the conditions in the field, especially in terms of the use of learning media and the utilization of technology.	There is an effort to integrate elements of local culture or ethnoscience into physics learning through the development of e-modules. This approach is very relevant because it can help students understand physics concepts through real phenomena that they encounter in their daily lives. By linking science materials with local culture,	As this is still a preliminary study, this research has not yet reached the stage of product development and testing the effectiveness of the proposed e-modules. In addition, the data obtained is still descriptive and has not been supported by in-depth analysis of how ethnoscience integration is concretely carried out in the process of preparing learning materials and activities. The technical aspects	The study needs to be carried out in the form of real development of physics e-modules that integrate ethnoscience, accompanied by feasibility and effectiveness tests in the classroom. The e-module design should utilize interactive technologies such as animations, videos, and simulations that display local cultural practices related to physics phenomena.

Identity	Research Results	Advantages	Weaknesses	Suggestion
		learning becomes more contextual, interesting and meaningful.	of the e-module design and the form of its presentation have also not been elaborated in detail.	
Development of an ethnophysic-based module in the Mandailing Tribe, West Pasaman Regency as science teaching Materials (Walid *et al.*, 2022)	This module is considered to be able to increase student motivation, provide a better understanding of concepts, and link science material with local wisdom that is relevant to students' daily lives. This is an added value because conventional textbooks are considered boring and less contextually relevant by students.	Its innovative approach to integrating local cultural values into science materials not only teaches scientific concepts, but also strengthens cultural identity and increases the relevance of learning. The module is designed with attractive visuals, illustrations that support understanding, and a content structure that is in accordance with the basic competencies of the curriculum. Validation conducted by various parties also strengthens the credibility of the products produced.	Secondly, although students' and teachers' responses were positive, the number of respondents was limited (10 students and 2 teachers), which may not be representative enough of the actual user population. Secondly, although student and teacher responses showed positive results, the number of respondents was still limited (10 students and 2 teachers), which may not be enough to represent the variation of the actual user population.	continue the development process to a broader trial stage and examine the impact of using the module on significantly improving learning outcomes. In addition, it is also recommended to expand the scope of materials and ethnoscience from other tribes to enrich culture-based learning resources that can be applied in the national curriculum.

In addition to the literature review, at this stage, a descriptive analysis was also conducted, which consisted of many activities. First, subject analysis. To and out the needs required for the subject that is used as the object of development, this activity is carried out. Second, the analysis of CP, ATP, and indicators. Third, the analysis of student characteristics. The characteristics oflearners must be analyzed because they affect whether or not the product is communicative (Pebriansyah et al., 2024). Analyzing learner characteristics aims to determine the unique characteristics of each learner (Sari et al., 2024). Thinking ability, learning habits, access to

technology and information, and economic conditions are learner characteristics that should be considered. Fourth, analyze the learning environment. The purpose of this analysis is to find out how the student's learning environment is, especially at school (Bujuri, 2023). Factors included in the learning environment analysis are learning support facilities, interaction between learners, and the comfort of the learning space (Wulandari et al., 2024).

Design Stage

Gamelan is called gangsa, which has a physical meaning as a musical ensemble whose instruments (ricikan) are dominated by components made of metal (bronze) and tuned with two systems, namely slendro barrel and pelog barrel (Sunarno et al., 2024). Apart from being entertainment, gamelan is also a real phenomenon that can be used to study physics concepts.
The frequency of the sound produced on the gamelan can be obtained using the following physical equation. The frequency of the sound produced in musical instruments can be obtained using the following physical equation:

$$f_p = \frac{\Delta f}{2} \ldots\ldots(1)$$

The strength of the sound produced is commonly referred to as sound intensity. Sound intensity is the energy carried by waves in unit time per unit area (Damarsha et al., 2023). So, it can be written as:

$$I = \frac{P}{A} \quad \ldots\ldots(2)$$

E-modules are designed using professional ip pdf software which is saved in exe form so that it can be accessed of ine. Here are some designs of e modules based on ethnoscience gamelan sound wave material. The cover of the e-module displays the title of the material, the author's identity, the class and phase of the e-module user, and the corresponding Javanese local wisdom image, namely gamelan. The e-module cover can be seen in Figure 2 below.

Figure 2. E-module cover

The e-module based on local wisdom includes comprehensive reading materials related to the topic of sound waves. Additionally, it features animated videos that can be played online, providing flexibility and making it easier for students to learn in various situations.

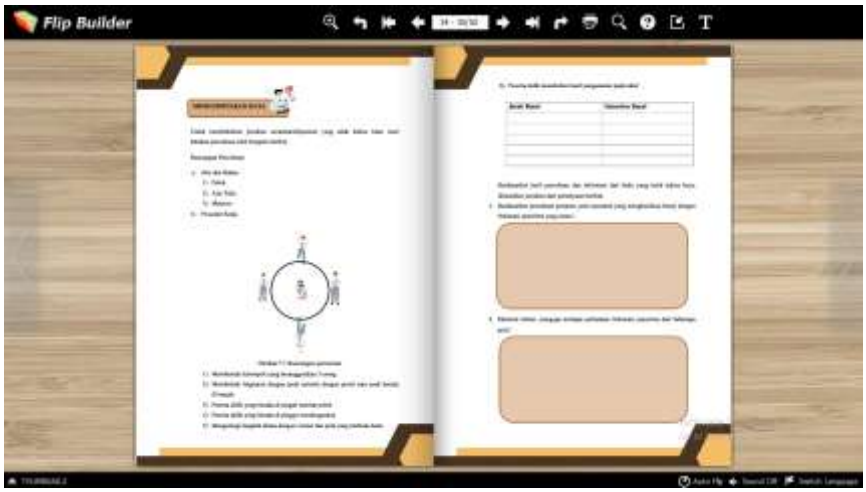

Figure 3. Physics edutainment

This e-module is also equipped with LKPD in the form of game investigations whose concepts have a relationship with sound wave material and local wisdom physics. In this LKPD, researchers provide fun physics learning by combining the concept of sound wave physics with a simple game. With the LKPD in the form of game investigations, the learning atmosphere of students becomes more relaxed but the material can be accepted by students and makes physics learning not only related to formulas and numbers (Nggermanto, 2024).

In the Learner Worksheet (LKPD), physics learning is designed to be more fun and easy to understand through a contextual approach that involves educational games. One of the games presented is related to the material of sound intensity. This game is speci cally designed to help learners understand how the distance to the sound source affects the intensity or strength of the sound received by the listener.

Through this activity, students are invited to make direct observations by varying the distance between the sound source and the listener. They then record the difference in perceived sound intensity at each distance. In this way, students not only learn the theory but also experience for themselves how the intensity of sound decreases as the distance from the source increases, by the applicable laws of physics. This game not only strengthens concept understanding, but also trains observation skills, critical thinking, and collaboration among students (Munawaroh, et al., 2024). This approach makes physics learning more alive and relevant to everyday experiences while fostering curiosity and a spirit of scienti c exploration (Ansya et al., 2024).

Development Stage

The development stage is the stage where all the required components are assembled according to their respective designations (Fatimatuz, 2024). Development is carried out based on the previously planned design stage. The activities carried out at the development stage will be described as follows. At this stage, researchers conducted validity tests on expert validators. The validity aspects assessed were attractiveness, content suitability, media quality, and language (Tamam et al., 2024). The validity results obtained from the validity test as shown in Table 2. The results obtained show that on average almost all aspects have very valid criteria. This indicates that the developed media can be used for limited trials on students. This limited trial is used to evaluate the e-module developed so that it can be further developed and can be generalized (Yuliana et al., 2023). Based on the results of validation and limited trials, researchers expect constructive input to improve the e-module in subsequent studies.

Table 3. Validation test results

Aspects	Validator 1	Validator 2	Average	Criteria
Media quality	82%	90%	86%	Highly valid
Content suitability	64%	84%	74%	Valid
Language	80%	95%	88%	Highly valid
Serving	79%	96%	88%	Highly valid

According to the comprehensive findings from the validation examination conducted by two specialists concerning media components, content quality, presentation features, and language criteria, the gamelan ethnoscience-centered e-module formulated for enhancing science literacy is categorized as highly valid, achieving an average score of 84% out of a possible 100%. The e-module can be considered suitable if it satisfies the classifications of highly valid, valid, and fairly valid with a score of ≥51%. This indicates that the developed physics e-module has met the established requirements for media, content, presentation, and language. Consequently, it can be concluded that the gamelan ethnoscience-based e-module designed to bolster students' science literacy abilities is appropriate, although it does require some adjustments.

Evaluation Stage

At this stage, the researchers evaluated the results of the developed e-module. The first evaluation is the result of the validator evaluation. The results of the improvement suggestions from the validators are written in Table 4.

Table 4. Validator suggestions

Validator	Sugesstion
	More emphasis is needed on the ethnophysics aspect so that the connection with local culture is more visible, and it is recommended to add quizzes or interactive activities to improve students' physics literacy.

Based on the suggestions from the validator, the result is to add game activities related to the concept of sound wave physics. Physics learning in the current era needs to be directed not only at mastering abstract concepts but also at its connection with the local cultural context. This approach is known as ethnophysics, which is an integration between physics and local wisdom that develops in the culture of the community. Ethnophysics provides space to interpret physical phenomena not only from a western scientic perspective but also from the empirical experiences of local communities that are often hereditary. In addition, to strengthen learners' physics literacy, it is important to include interactive elements such as digital-based quizzes, educational games, or simple simulations. This interactivity is proven to improve concept retention and student engagement in the learning process (Fitriah & Sil yah., 2024). Quizzes designed by linking local elements, such as questions based on natural phenomena or local traditional customs, can strengthen knowledge transfer from local contexts to scienti c concepts. Thus, the improvement of teaching tools that emphasize ethnophysics aspects and insert interactive activities is a strategic step to improve the quality of physics learning that is relevant, interesting, and meaningful for students.

Learner Evaluation Stage

To answer students' responses, the following shows the data analysis process of the Instrument: Student Response Questionnaire to Virtual Simulation Media Integrated with Weirdness. Table 5 shows The Kaiser-Meyer-Olkin (KMO) statistic was recorded at 0.563, and the results of Bartlett's test were significant ($\chi 2 = 376.944$, df = 190, $p < 0.001$), suggesting that the dataset was appropriate for conducting factor analysis (Suprapto, 2019). The eigenvalues of the three proposed factors from Principal Component Analysis (PCA) were all greater than one (Figure 4 and Table 6).

Table 5. KMO Test

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.563
Bartlett's Test of Sphericity	Approx. Chi-Square	376.944
	Df	190
	Sig.	0.000

Table 6. Eigenvalue factors

Component (Factors)	Initian Eigenvalue		
	Total	%of Variance	Cumulative %
1	5.392	26.645	26.645
2	3.067	15.334	41.979
3	1.793	8.965	50.944
4	1.537	7.684	58.628
5	1.330	6.649	65.276
6	1.183	5.915	71.191

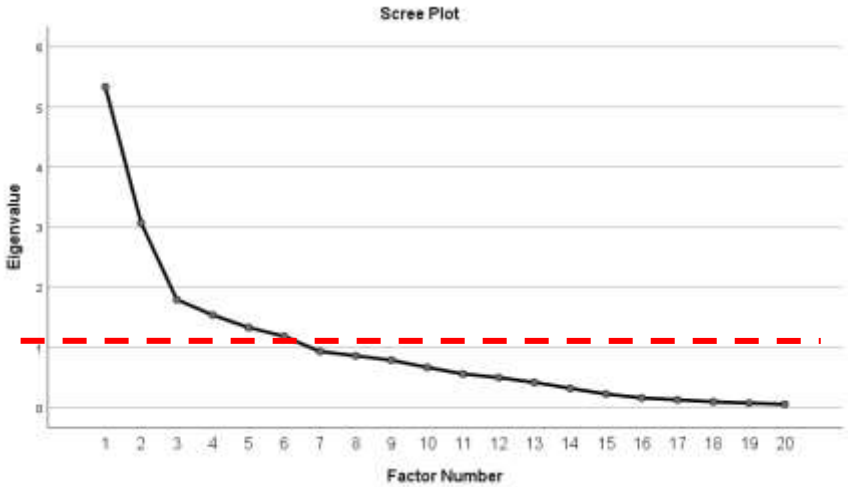

Figure 4. Eigenvalue diagram

The six factors accounted for 71.19% of the total variance. The Cronbach's alpha values of the six factors are 0.833, 0.728, 0.648, 0.79, 0.811, 0.813 as shown in Table 6.

Table 6. Loading factor

Item	Loading Factors					
	KDT α = 0.83 and VE (%)	KV α = 0.73 and VE (%)	AP α = 0,65 and VE (%)	FP α = 0,68 and VE (%)	KE α = 0.81 and VE (%)	DM α = 0.81 and VE (%)
C2	0.78	**13.97**				
A4	0.74					

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B1	0.66									
D1	0.61									
C1		0.93								
C5		0.56	**11.25**							
B2		0.48								
A1		0.47								
B4										
D3				0.65						
D5				0.58	**9.29**					
B3				0.54						
A2				0.45						
D4						0.63				
A5						0.62	**9.29**			
D2						0.59				
B5								0.93	**9.06**	
C4								0.65		
C3									0.83	**8.29**
A3									0.75	

The results of the EFA analysis show that the questionnaire totaling 20 items can be classi ed into 6 factors, namely KDT (Quality of attractiveness), KV (Clarity and Visibility), AP (Accessibility of Comprehension), FP (Comprehension Facility), KE (Ease of Evaluation) and DT (Attractiveness of Material). To analyze further, the factors consisting of these indicators are averaged to produce a diagram as in Figure 5.

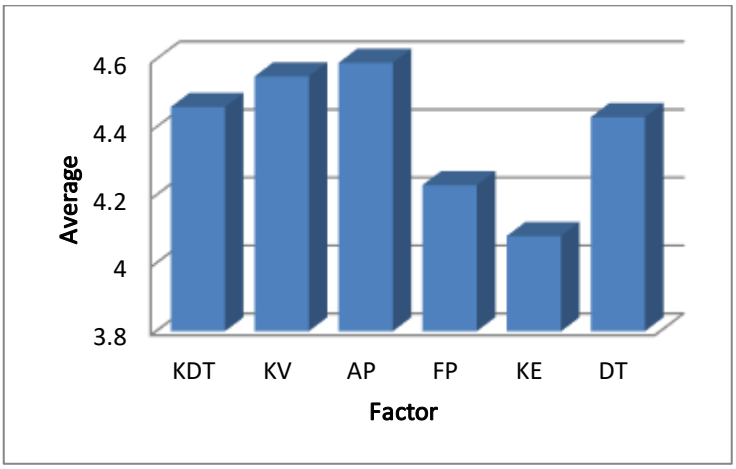

Figure 5. Diagram of each factor

Figure 5 shows that the AP factor is the highest, which means that the developed e-module can support science literacy understanding and further exploration. The diagram shows that the KE factor has the lowest average. This is because the e-module is enough to help students evaluate the results of the investigation. This is reinforced by Table 2 of the validation results that the content suitability value during the validation process has a low value. The suitability of e-module content to the needs of learners plays an important role in facilitating the process of evaluating learning outcomes (Meilasari et al., 2024). E-modules that are prepared with relevant, structured, and appropriate material for the ability level of learners allow them to more easily understand scientific concepts and apply them in the context of evaluation. The evaluation results and suggestions show that the suitability of the material in the learning media is still not sharp enough to direct students to the core concepts learned, so it is

recommended that further research emphasize the preparation of material that is focused, structured, and by the learning outcomes.

CONCLUSION

Fundamental Findings: The results showed that the developed ethnophysics e-module was rated highly valid based on the aspects of attractiveness, content suitability, presentation quality, and language use. Implications: Learners' responses indicate that this e-module is effective in supporting science literacy understanding and further exploration. Limitations: Some feedback from the validators indicated the need for improvement, especially in sharpening the ethnophysics material in the e-module and adding interactive activities for students. Future Research: The main weakness lies in the limited exploration of ethnophysics materials and animations in the e-module, so further development is needed to improve visualization and increase the effectiveness of ethnophysics-based physics learning.

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