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Development of STEM-Based Physics E-Teaching Materials in the Context of South Sumatra Local Wisdom for High School Students

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Abstract: This study aims to validate physics teaching materials in the form of STEM-based e-modules in the context of local wisdom of South Sumatra. This type of development research uses the Rowntree development model which consists of 3 stages, namely the planning, preparation, and evaluation stages. This research uses tessmer formative evaluation. Then, the research instrument used was a validation sheet with data collection techniques using a Likert scale and a Guttman scale. The validation data was analyzed by determining the average of each assessment. The results showed that STEM-based physics teaching materials in the context of South Sumatra's local wisdom were in the valid and very valid categories, with results for product 1 e-modules for content aspects of 81%, media design 74% and language 76%. Product 2 e-LKPD for content aspects 73%, media design 77% and language 74%. Product 3 e-modules for material aspects 93.5%, design and language 93.25% as well as learning design 88.75%. Thus, it can be concluded that STEM-based physics teaching materials in the context of local wisdom of South Sumatra are valid, the three products have met the standards and criteria that have been set.

Keywords: Local wisdom; Physics; South Sumatra; STEM; Teaching material

Introduction

Physics is the most fundamental science and cannot be separated from everyday life. In the learning process, students are required to be able to build knowledge within themselves with their active role during the teaching and learning process (Latifah et al., 2020). The digital revolution has given birth to a new paradigm in education oriented towards new educational styles, academic programs and educational services, in line with the demands of the 21st century driven by the ever-increasing pace of technological development. Therefore, teachers need to anticipate learning processes that support students to understand and adapt to the knowledge and skills needed in this era (Lao et al., 2021; Maritsa et al., 2021).

The 21st century brings rapid changes. The development of science and technology (IPTEK) resulted in several paradigm shifts in the learning process characterized by changes in curriculum, media and technology. Good learning media interpret abstract concepts to make them easy to understand. One of the demands of 21st century learning is the integration of technology as a learning medium to develop students' learning skills (Novitra et al., 2021).

The 21st century requires learners to be more active in acquiring new knowledge, and STEM-based learning has a positive relationship with the learning needs of this

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era (Kan & Murat, 2020; Zainil et al., 2023). STEM helps learners organize and integrate various knowledge in one project, by combining four main areas: Science, Technology, Engineering and Mathematics. However, the STEM approach still has limitations, such as not always being applicable in all situations and potentially limiting the scope of content taught (Thao et al., 2024; Wiyono et al., 2024b). Learning with the STEM approach requires students to interact and create investigations to gain knowledge. Learning with the STEM approach is a solution to increase innovation in physics learning that is in line with the current development era (Diana & Turmudi, 2021).

The application of physics concepts in everyday life is often found and widely encountered. One of them is the phenomenon and local wisdom in a place. Local wisdom is a form of knowledge, belief, understanding or insight as well as customs or ethics that guide human behavior in the life of ecological communities (Hikmawati et al., 2022; Trisnowati et al., 2023). Local wisdom, such as culture and traditions inherent to a region, has great potential to become a concrete context for STEM learning. In South Sumatra, there is a diversity of nature, culture and traditions that reflect the principles of physics that can be integrated into learning (Melinia et al., 2024). Unfortunately, this potential has not been widely utilized in the development of physics teaching materials, especially in digital format or e-teaching materials.

Local wisdom can be associated with the process of physics learning, especially in the development of teaching materials in the form of e-modules and e-LKPD. Physics teaching materials based on local wisdom have an influence on the learning process of students so that the level of response from students will be known (Hidayanto et al., 2016). Physics learning is still considered difficult for students. Learners have difficulty in explaining the connection between material and natural phenomena. Learners assume that scientific phenomena have nothing to do with physics, because physics is identical to various formulas and experiments are only carried out in the laboratory. In addition, the lack of linking material with everyday life makes students lack understanding of the concepts in physics material. One way to overcome students' difficulties in understanding physics concepts so that they are easy to understand is through the development of contextual-based physics teaching materials (Asyhari et al., 2024; Oktaviani et al., 2017).

One way that can be used to help students is by developing teaching materials. Teaching materials that can help students and teachers in the physics learning process such as e-modules and e-LKPD. Some previous studies have shown the effectiveness of local wisdom integration in learning. For example, the development of local wisdom-based physics teaching materials for class X students at SMAN 4 Maros showed high validity and reliability, as well as positive responses from students (Ramli et al., 2024). Addition, the development of local content teaching materials (Aksara Ulu Besemah) in Pagaralam, South Sumatra, succeeded in preserving local wisdom and improving student understanding (Handayani, 2019), Development of STEM-A (Science, Technology, Engineering, Mathematic, and Animation) based on local wisdom in physics learning was also proven to improve student concept understanding (Utami et al., 2017).

This research offers an innovative approach in the development of physics teaching materials. Not only does it focus on strengthening physics concepts through the STEM approach, it also integrates local cultural elements to create a contextualized and relevant learning experience for students (Sumarni & Kadarwati, 2020). This distinguishes this research from previous studies that tend to separate physics teaching from the local cultural context.

Based on the above problems, the researchers wanted to develop electronic-based teaching materials, namely e-modules and e-LKPD. Then validate STEM-based physics teaching materials in the context of valid South Sumatra local wisdom so that later it can be an alternative teaching material for students and teachers, especially in independent learning. The integration of local wisdom in teaching materials can help students understand physics concepts more easily because it is associated with their daily experiences and environment.

Method

The type of research conducted is Research and Development (R&D) development. The method used in the development of e-Modules and e-LKPD is the Rowntree development model which consists of three stages, namely planning, development, and evaluation.

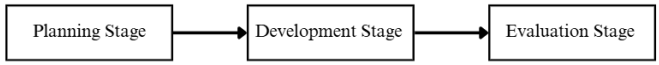

Figure 1. Rowntree's development research procedure

The first stage is planning stage begins with analyzing the needs of students related to the teaching materials to be developed. The analysis process was carried out by distributing questionnaires in the form of Google Forms to several high schools in Palembang, as well as in one of the schools in Muara Enim Regency. Respondents who filled out the questionnaire were

grade XI students. Then at the second stage is development stage begins with compiling an outline of the contents of physics e-teaching materials to determine the material in accordance with the learning topic. This e-teaching material includes the main material, the sub-material presented, and its relation to the context of local wisdom, STEM-based, and 21st century skills indicators. Then the existing local wisdom context is associated with the material to the questions in the e-teaching materials developed at the last stage, the evaluation stage is carried out on the teaching materials that have been developed.

This research uses Tessmer's formative evaluation. Where formative evaluation is an evaluation process using a gradual product trial to determine the advantages and disadvantages of the product being implemented or developed. The instrument used is a validation sheet with a Likert scale and a Guttman scale.

The instrument in this development is a validation sheet, which aims to determine the validity of teaching materials. The grid of validation sheet instruments consists of content, language and media design aspects. Data analysis techniques to measure the level of validity based on the Guttman scale and Likert scale. The level of validity according to the Guttman scale obtained from the validation sheet, according to Akbar (2017) in Meliana et al. (2022) the formula used is as follows.

$$NP_{r_1} = \frac{TS_{-e}}{TS_{-max}} \times 100\% \quad (1)$$

$$NP_{r_2} = \frac{TS_{-e}}{TS_{-max}} \times 100\% \quad (2)$$

$$NP_{r_3} = \frac{TS_{-e}}{TS_{-max}} \times 100\% \quad (3)$$

After obtaining the validation results from each validator, calculate the combined validation of the analysis results in the formula according to Akbar (2017) in Meliana et al. (2022) namely:

$$V = \frac{NP_{r_1} + NP_{r_2} + NP_{r_3}}{3} = \cdots \% \quad (4)$$

Information:
V = Validation (combined)
NP_{r_1} = 1st validator's process score
NP_{r_2} = 2nd validator's process score
NP_{r_3} = 3rd validator process score
TS_{-e} =Total empirical score (score obtained from validators)
TS_{-max} = Expected maximum total score

Based on a Likert scale for validation of e-teaching materials using a Likert scale is carried out on aspects of media, material, and language, which are assessed by validators of the e-modules that have been developed. This data analysis technique is used to measure the level of validity based on the Likert scale obtained from the validation sheet. According to Wiyono (2015), the formula used is as follows:

$$HVA\ (\%) = \frac{\text{Total validation score } (\Sigma R)}{\text{Total maximum scorel } (V)} \times 100\% \quad (5)$$

After obtaining the results of the combined validation analysis of the Guttman scale and Likert scale, then to see the level of validity of the developed teaching materials, it is determined by adjusting to the validity criteria presented in Table 1 below.

Table 1. Criteria for validity

Criteria for validity (%)	Validation Level
80.01 – 100	Very valid
60.01 – 80.00	Valid
40.01 – 60.00	Less valid
20.01 – 40.00	Not valid
00.00 – 20.00	Very invalid

Result and Discussion

The result of this research is the validation of physics teaching materials in the form of STEM-based physics e-teaching materials in the context of South Sumatra's local wisdom. The development of teaching materials is an important focus in education to improve the effectiveness of learning. Based on a number of studies, there are several models and approaches used to ensure teaching materials are relevant and support meaningful learning (Hamnorriza & Erlinawati, 2015; Uyun et al., 2023). Digital teaching materials are increasingly popular, mainly because of their flexibility that allows for self-directed learning and distance learning. Digital teaching materials include e-modules, e-LKPD, learning videos, and web-based applications designed to facilitate access to learning for students. In this research, STEM-based physics teaching materials in the context of South Sumatra's local wisdom consist of STEM-based Particle Motion Dynamics E-modules and E-LKPD in the context of Palembang's local wisdom, as well as Dynamic Fluid E-modules in the context of Muara Enim's local wisdom.

In product 1, the validation sheet that has been filled in by the validator is analyzed to determine the validity criteria for the e-module developed. Data on the results of e-module validation are presented in Table 2.

The development of electronic learning modules (e-modules) is an effort to improve the quality and effectiveness of the learning process in the digital era. This study aims to analyze the results of e-module validation with a focus on three important aspects,

namely content, media design, and language. The validation data shows that the developed e-module obtained quite high scores on all three aspects. The results of the content aspect validation show a value of 81%, which means that the e-module content is in accordance with the learning objectives and the material presented (Pramana et al., 2020).

In other words, this e-module is able to convey essential concepts appropriately to students, according to the topic that has been determined. This also indicates that the information in the e-module can help students understand physics concepts more clearly and easily, especially in the STEM approach and local wisdom (Conradty et al., 2020; Dewi & Kuswanto, 2023; Sofyan et al., 2019).

Table 2. Results of E-module validation of each validator on content, design and language aspects using a Guttman scale

Aspects	Validator	Emp score	Max score	Overall validity percentage score	Criteria
Content	Validator 1	20	22	81	Very valid
	Validator 2	14	22		
	Validator 3	20	22		
Media Design	Validator 1	16	21	74	Valid
	Validator 2	14	21		
	Validator 3	17	21		
Language	Validator 1	7	10	76	Valid
	Validator 2	7	10		
	Validator 3	9	10		

In the media design aspect, the e-module scored 74%, indicating that the visualization, navigation, and overall appearance of the e-module have been well designed (Khairani et al., 2022). Furthermore, the language aspect received a score of 76%, indicating that the use of language in the e-module has been communicative and easily understood by students (Darwis et al., 2020; Khairani et al., 2022; Umbara, 2022).

This finding is in line with the results of previous studies which show that the development of e-modules with certain learning models, such as Learning Cycle 5E and Problem Based Learning, can produce products that are valid and practical for use in the learning process (Asma & Pariabti, 2024; Darwis et al., 2020; Fitri et al., 2024; Kahar et al., 2024; Pramana et al., 2020).

Although the overall validation results show that this e-module is good and valid, there is still room to improve the quality of the e-module. The development of innovative e-modules that meet the needs of students can be one of the strategies to improve the quality of learning in the future, especially those that link local wisdom and STEM (Aulyana & Fauzi, 2023; Fitonia et al., 2024; Mansour et al., 2024; Sari et al., 2020; Wiyono et al., 2024a).

Based on Table 3 product 2 in this study, the e-LKPD validation data shows a fairly good value in various aspects. In the content aspect, the validation value reached 73%. This indicates that the material in the e-LKPD is in accordance with the learning objectives and needs of students (Fitriyah & Madlazim, 2021). In addition, the media design aspect also received a high score of 77%. This shows that the visual appearance and interactivity of the e-LKPD have been well designed.

Table 3. Results of E-LKPD Validation for Each Validator on Content, Design and Language Aspects Using a Guttman Scale

Aspects	Validator	Emp score	Max score	Overall validity percentage score (%)	Criteria
Content	Validator 1	12	21	73	Valid
	Validator 2	16	21		
	Validator 3	18	21		
Media Design	Validator 1	16	21	77	Valid
	Validator 2	15	21		
	Validator 3	17	21		
Language	Validator 1	7	10	74	Valid
	Validator 2	7	10		

Aspects	Validator	Emp score	Max score	Overall validity percentage score (%)	Criteria
	Validator 3	9	10		

Furthermore, the language aspect of the e-LKPD obtained a validation score of 74%. This finding indicates that the use of language in e-LKPD has been communicative and in accordance with the level of understanding of students (Elyasmad et al., 2022; Feni et al., 2021; Fitriyah & Madlazim, 2021; Nisa et al., 2018). Thus, this e-LKPD can be said to have met the criteria of good quality in terms of content, media design, and language. Effective e-LKPD development does not only pay attention to content aspects, but also must consider media design and linguistic aspects.

The results of data validation in this study indicate that the e-LKPD developed is good enough, but there is still room for further improvement (Elyasmad et al., 2022). The results of previous studies have also shown the importance of paying attention to various aspects in the development of LKPD, as seen from the results of validation and field trials (Dewi et al., 2019; Hidayat et al., 2022). Based on Table 4, the results of validation on this third teaching material product get results for material aspects 93.5%, design and language 93.25% and learning design 88.75%.

Table 4. Results of E-module validation of each validator on content, design and language, learning design aspects using a Likert scale

Aspects	Score percentage (%)	Category
Content	93.5	Very valid
Design and language	93.25	Very valid
	95	Very valid
Learning Design	88.75	Very valid
Average HVA	92.63	Very valid

The validation results on the third teaching material product show a fairly high percentage of validity. For the material aspect, the teaching material product obtained a percentage of 93.5% which was included in the very valid category (Dinata & Darwanto, 2020). In the design and language aspects, teaching material products obtained a percentage of 93.25 and 95% which was also classified as very valid. Meanwhile, for the learning design aspect, teaching material products get a percentage of 88.75% which is in the valid category (Anita et al., 2020; Deda & Disnawati, 2019; Dinata & Darwanto, 2020; Liesandra & Nurafni, 2022).

This finding is in line with the results of previous research which shows that the process of developing electronic teaching materials based on Social and Emotional Learning obtained a very valid assessment from experts with a score of 87.36% (Anita et al., 2020). In addition, other studies have also revealed that the development of E-LKPD in learning mathematics flat geometry material based on ethnomathematics received media expert validation of 82.5% in the very valid category and material expert validation of 74.31% in the valid category (Anita et al., 2020; Liesandra & Nurafni, 2022; Sabrina & Rahardi, 2021). As for the results of research conducted by Nurhaisa et al. (2023), Rizki et al. (2021), and Suwandani & Lengkana (2024) successfully developed highly valid e-LKPD to train students' 21st century skills. Overall, the validation results on the teaching material products developed can be said to be very good with a high percentage of validity in the aspects of material, design and language, and learning design This is also in accordance with research conducted by Juniawan et al. (2024) and Sulaiman et al. (2023) who succeeded in making valid ETNO-STEM teaching materials.

Conclusion

The conclusion of the development of teaching materials in the form of e-modules and e-LKPD shows that the three products have been validated with good results, with the results for product 1 e-modules for content aspects 81%, media design 74% and language 76%. Product 2 e-LKPD for content aspects 73%, media design 77% and language 74%. Product 3 e-modules for material aspects 93.5%, design and language 93.25% as well as learning design 88.75%. although there is still room for further improvement. Overall, the development of these e-teaching materials emphasizes the importance of the integration of local wisdom and STEM in education, as well as the potential for their use to improve the quality of learning in the future.

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Author Contributions
K.W., I., and A.P.: devised the teaching material in context of south Sumatera local wisdom, review draft article; K.W. and I.: methodology; S.M.V.P., M.H.K., and R.P.A.: create validity instruments and analysis; S.M.V.P. and M.H.K.: writing original draft article, editing.

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Conflicts of Interest
The authors declare no conflicts of interest.

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