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Validation of Physics Module on Energy: Integrating Palembang Local Wisdom and PhET Simulation

Nurkholisa Fajriah, Hamdi Akhsan*, Kistiono
Magister of Physics Education, Faculty of Teacher Training and Education, Sriwijaya University, Indonesia
*Corresponding Author: hamdiakhsan@fkip.unsri.ac.id

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Abstract: Rendahnya literasi sains di kalangan siswa Indonesia, khususnya dalam konsep fisika abstrak seperti energi potensial dan energi kinetik, menuntut pengembangan bahan ajar yang inovatif dan relevan secara budaya. Penelitian ini bertujuan mengembangkan dan memvalidasi modul ajar fisika yang mengintegrasikan kearifan lokal Palembang, Problem-Based Learning (PBL), dan simulasi PhET. Penelitian menggunakan pendekatan Research and Development (R&D) berbasis model 4-D (Define, Design, Develop), yang dihentikan pada tahap pengembangan. Validasi dilakukan oleh tiga ahli (materi fisika, pedagogi, dan media pembelajaran) serta diuji coba melalui uji one-to-one (n=2) dan uji kelompok kecil (n=4). Data dianalisis secara kuantitatif menggunakan koefisien validitas isi Aiken's V. Hasil menunjukkan bahwa modul memperoleh nilai rata-rata Aiken's V sebesar 0,87, yang dikategorikan sebagai "Sangat Valid", dengan skor tertinggi pada aspek relevansi kearifan lokal Palembang (V = 0,93) dan penerapan PBL (V = 0,88). Tanggapan siswa menunjukkan bahwa 92–95% menyatakan modul mudah dipahami, relevan dengan konteks lokal, dan membantu memvisualisasikan konsep energi melalui simulasi PhET. Dengan demikian, modul ini dinyatakan layak digunakan sebagai bahan ajar dalam pembelajaran fisika yang selaras dengan prinsip Kurikulum Merdeka.

Keywords: Aiken's V, Energi Potensial dan Kinetik, Kearifan lokal Palembang, Modul ajar fisika, Problem Based Learning, Simulasi PhET

INTRODUCTION

In the context of 21st-century demands, scientific literacy has become a key competency that enables students to understand natural phenomena, make evidence-based decisions, and solve everyday life problems (OECD, 2018). However, reality shows that Indonesian students' scientific literacy remains low, as reflected in the 2018 Programme for International Student Assessment (PISA) results, which placed Indonesia 70th out of 78 participating countries with an average score of 396, far below the OECD average of 489 (Aina & Hariyono, 2023). This low scientific literacy not only affects students' mastery of scientific concepts but also hinders the development of critical thinking skills, a core competency in Indonesia's Merdeka Curriculum and essential 21st-century skills (Arifah et al., 2021).

Research indicates that science education in Indonesia is still predominantly teacher-centered, relying heavily on memorization and lecture-based instruction (Dwi et al., 2024; Fuadi et al., 2020). As a result, students are less actively engaged in knowledge construction and struggle to connect abstract concepts such as potential and kinetic energy with real-life contexts. This challenge is further exacerbated by the scarcity of instructional materials that are contextual and culturally relevant to students' lived experiences (Wahyuni & Lia, 2020). To address this issue, ethnoscientific approaches and local wisdom-based learning have emerged as promising pedagogical solutions. (Wahyuni & Lia, 2020) demonstrated that developing physics comic books grounded in Palembang's local wisdom effectively enhances students' interest and conceptual understanding. This approach aligns well with Problem-Based Learning (PBL), which has been proven to improve scientific literacy and critical thinking skills (Ety Kurniati, 2023).

Therefore, developing a teaching module that integrates Palembang's local wisdom, PBL, and PhET simulations represents a strategic step forward. PhET simulations have been shown to help students visualize abstract energy concepts through dynamic and interactive representations (Aina & Hariyono, 2023). The integration of these three elements not only addresses the

challenges of low scientific literacy and underdeveloped critical thinking but also aligns with the Merdeka Curriculum's emphasis on contextual, engaging, and culturally rooted learning.

METHODS

This study employed a Research and Development (R&D) approach using the 4-D development model (Define, Design, Develop, Disseminate), modified to conclude at the Develop stage (Thiagarajan et al., 1974). This method was selected to align with the primary objective of the research: to produce a teaching module that is valid, contextual, and suitable for classroom use. The R&D method is highly appropriate because it enables the researcher not only to design the product but also to systematically evaluate its feasibility through expert validation and limited trials, essential steps before widespread implementation (Basri, 2022). In this context, the iterative development of a module integrating Palembang local wisdom, Problem-Based Learning (PBL), and PhET simulations ensures the validity of content, cultural relevance, and pedagogical appropriateness, making the 4-D model the most suitable choice.

The research was conducted from August to October 2025 at SMAN 22 Palembang, South Sumatra. The location was selected based on the school's readiness to implement the Merdeka Curriculum and the support provided by the school principal and physics teachers in the module development process. The population of this study consisted of Grade X students of SMAN 22 Palembang and experts in physics education. The sample was selected using purposive sampling and included:
Three expert validators:

- A physics content expert (an experienced physics teacher),
- A pedagogy/PBL expert (a certified Teacher Leader and vice principal for quality management),
- An instructional media expert (a teacher holding a master's degree in informatics education);

Six Grade X students for limited trials, comprising:

- Two students in the one-to-one trial (with average and low academic ability),
- Four students in the small-group trial (with heterogeneous academic abilities).

The research began with a needs analysis (Define), conducted through literature review, interviews with physics teachers, and preliminary classroom observations to identify students' difficulties in understanding potential and kinetic energy concepts. This analysis revealed that students experience significant misconceptions and low motivation due to abstract instruction disconnected from their local context (Dwi et al., 2024; Maison et al., 2020). Based on these findings, the researcher proceeded to the design and development phase (Design–Develop). The module was structured in accordance with the Merdeka Curriculum framework (Badan Standar, Kurikulum et al., 2025) and includes the following components: (1) general information, (2) core components (learning objectives, triggering questions, PBL activities, PhET simulations, student worksheets/LKPD, assessment, remedial tasks, and enrichment activities), and (3) appendices. Local Palembang contexts, such as the Ampera Bridge, Musi River, and falling coconut phenomena were integrated into learning activities, in line with the principles of ethnoscience (Munandar et al., 2022; Wahyuni & Lia, 2020).

Once the module was developed, it underwent product validation by three expert validators (a physics content expert, a PBL/pedagogy expert, and an instructional media expert) and limited trials with students through one-to-one validation (n = 2) and a small-group trial (n = 4). The expert validation instrument consisted of a Likert-scale questionnaire (1–5), adapted from ethnoscience-based module validation instruments (Wahyuni & Lia, 2020) and the Merdeka Curriculum module validation guidelines (Warliani et al., 2023). To quantitatively analyze the module's feasibility, the researcher used the average score formula as follows:

$$X = \frac{\sum Xi}{n} \qquad (1)$$

With,
X = average score,
Xi = score from each validator,
n = number of validator

Afterward, the data were analyzed using Aiken's V formula to objectively measure content validity. The formula used is (Utami et al., 2024):

$$V = \frac{S - n.lo}{n(c - lo)} \quad (2)$$

with,
S = the sum of the scores from all validators for one item,
n = number of validator
l_o = lower score (1),
c = higher score (5).
The resulting V value ranges from 0 to 1, referring to the criteria (Utami et al., 2024):

- V ≥ 0,80 shows high content validity,
- V between 0,70 and 0,79 shows moderate content validity,
- V < 0,70 indicate poor content validity, requiring revision or removal of the item.

Qualitative data from the one-to-one interviews and open-ended responses from the small-group trials were analyzed thematically to revise aspects related to language clarity, layout, LKPD (student worksheet) instructions, PhET accessibility, and contextual relevance. The validation results served as the basis for refining the module before it is implemented in a classroom-scale effectiveness trial.

FINDINGS AND DISCUSSION

Expert Validation

The developed teaching module underwent validation by three expert validators: a physics content expert (a physics teacher at SMAN 22 Palembang), a pedagogy/learning expert (a vice principal for quality management and a certified teacher leader), and an instructional media expert (a teacher holding a master's degree in informatics education). The validation was conducted using a Likert-scale instrument ranging from 1 to 5.

Graph 1. Expert Validation Results

Graph 1 confirms that the Relevance of Local Wisdom aspect achieved the highest score (4.9), followed by Content Validity (4.8) and PBL Implementation (4.7), while Graphic Design scored the lowest (4.3), although it still falls within the "Valid" category. These results indicate that the module meets the standards of academic and pedagogical appropriateness. The calculated Aiken's V values for each aspect of the module are presented in Table 1.

Table 1. Expert Validation Results Based on Aiken's V Values

Validation Aspect	Average Score	Aiken's V Score	Category
Content Eligibility	4,8	0,90	Highly Valid
Implementation of PBL	4,7	0,88	Highly Valid
Relevance of Local Wisdom	4,9	0,93	Highly Valid
Graphic design	4,3	0,78	Valid
Assessment Quality	4,6	0,85	Highly Valid
Overall Average	4,7	0,87	Highly Valid

An Aiken's V value of ≥ 0.80 in four out of five aspects confirms that the module is highly valid according to the Aiken's V criteria (Utami et al., 2024). The validators provided minor suggestions for improvement, particularly regarding illustration layout, font size consistency, and a textual error where "Profil Pelajar Pancasila" was corrected to "Dimensi Profil Lulusan." These revisions were implemented prior to student trials.

One-to-One Validation

Following revisions based on expert feedback, the module was individually tested (one-to-one) with two Grade X students, one with average and one with low academic ability. This trial aimed to identify clarity of instructions, ease of access, and potential points of confusion in using the module. A semi-structured interview was used as the instrument, focusing on five dimensions: (1) ease of understanding the context, (2) clarity of LKPD (student worksheet) instructions, (3) accessibility of the PhET simulation, (4) relevance of the Palembang local context, and (5) quality of graphic design. Each statement was rated on a 1–4 scale (Strongly Disagree to Strongly Agree) and then converted into Aiken's V values.

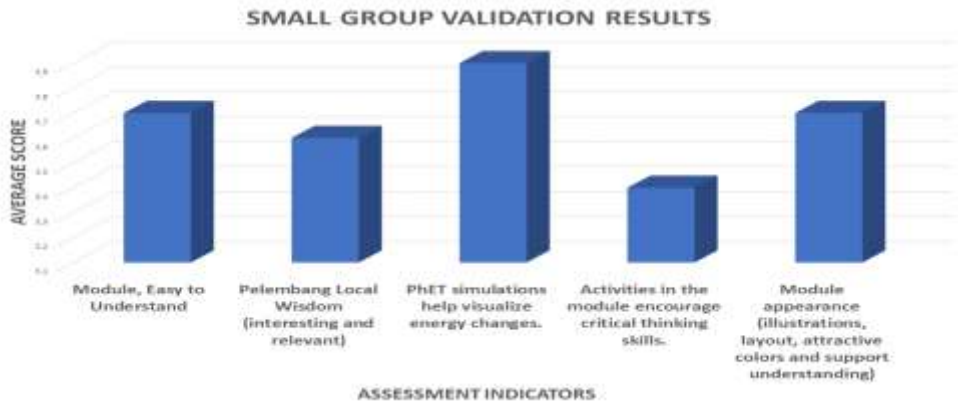
Table 2. One-to-One Validation Results Based on Aiken's V Values

Assessment Indicators	Student 1	Student 2	Average	Aiken's V	Category
Ease of Understanding Concepts	4	4	4	1	Highly Valid
Clarity of LKPD Instructions	4	3	3.5	0,83	Highly Valid
PhET Simulation Accessibility	4	3	3.5	0,83	Highly Valid
Relevance of Palembang Local Wisdom	4	4	4	1	Highly Valid
Graphic Display Quality	4	3	3.5	0,83	Highly Valid
Overall Average			4,6	0,89	Highly Valid

The results show that the Palembang context and module design received highly positive responses (score of 4), while LKPD instructions and PhET accessibility received a score of 3.5, as students were initially confused about how to access the simulation and calculate energy in the LKPD. This finding aligns with the study by (Aina & Hariyono, 2023), which states that students require explicit technical guidance when using digital simulations. Based on these results, the researcher added step-by-step instructions for accessing PhET and simplified the language used in the LKPD. The overall average Aiken's V value of 0.87 places the module in the "Highly Valid" category in terms of practicality.

Small-Group Validation

The small-group trial was conducted with four students of heterogeneous academic abilities to evaluate the module's readability, engagement, and contextual relevance in a collaborative learning setting. The instrument consisted of a questionnaire with five Likert-scale statements (ranging from 1 to 4). The scores were converted into percentages and Aiken's V values.



Graph 2. Small-Group Validation Results

The graph shows that the PhET simulation is effective in helping students understand energy transformation. This finding aligns with the study by (Aina & Hariyono, 2023), which states that PhET simulations can enhance students' conceptual understanding of physics and critical thinking skills through dynamic visualizations, real-time energy graphs, and engaging, safe virtual experiments. The relevance of Palembang local wisdom also

received highly positive responses; students reported that contexts such as the Ampera Bridge, Musi River, and the phenomenon of falling coconuts made the material more meaningful and closely connected to their daily lives. This is consistent with the principles of ethnoscience as described in (Wahyuni & Lia, 2020), which assert that integrating local wisdom into science instruction can increase students' interest, motivation, and conceptual understanding.

The aspects of module comprehensibility and visual design quality each scored 3.7, indicating that the language, layout, illustrations, and graphic design were appropriately tailored to the cognitive development level of high school students. This is in line with the Merdeka Curriculum module development principles, which emphasize accessibility, visual aesthetics, and clarity of instructions (Warliani et al., 2023). Meanwhile, the critical thinking aspect scored slightly lower than the other aspects. Nevertheless, overall, 92–95% of students indicated that they "agreed" or "strongly agreed" with the module's quality and relevance.

Table 3. Small-Group Validation Results Based on Aiken's V Values

No	Assessment Indicators	Average Score	Aiken's V	Category
1	Module, Easy to Understand	3,7	0,88	Highly Valid
2	Pelembang Local Wisdom (interesting and relevant)	3,6	0,85	Highly Valid
3	PhET simulations help visualize energy changes.	3,9	0,93	Highly Valid
4	Activities in the module encourage critical thinking skills.	3,4	0,78	Valid
5	Module appearance (illustrations, layout, attractive colors and support understanding)	3,7	0,88	Highly Valid
Overall Average		3,7	0,87	Highly Valid

The average Aiken's V value of 0.87 is categorized as "Highly Valid" according to the criteria established by (Utami et al., 2024). The highest score was achieved in the PhET simulation aspect for visualizing energy transformation (V = 0.93). The relevance of Palembang local wisdom (V = 0.85) and module comprehensibility (V = 0.88) also received highly positive responses, reinforcing the effectiveness of the ethnoscience approach in strengthening the connection between physics concepts and real-life contexts (Wahyuni & Lia, 2020). Although the aspect of activities designed to foster critical thinking scored slightly lower (V = 0.78), it still falls within the "Valid" category. Overall, the high consistency of Aiken's V values confirms that this module is highly practical, relevant, and ready for implementation in physics instruction aligned with the Merdeka Curriculum.

Discussion

Holistically, the Palembang local wisdom-based physics teaching module has met both content validity and practicality criteria. The Aiken's V values across all three validation stages, expert validation (0.87), one-to-one trial (0.89), and small-group trial (0.87) all exceed the 0.80 threshold, classifying them as "Highly Valid" (Utami et al., 2024). This demonstrates strong consistency between expert judgments and student perceptions as end-users of the module.

The integration of Palembang local wisdom, such as the Ampera Bridge, Musi River, and falling coconut phenomenon, not only enhances cultural relevance but also serves as an effective cognitive bridge for understanding abstract energy concepts, consistent with the findings of (Sae et al., 2021), who reported that locally grounded instructional materials significantly improve students' conceptual understanding. The Problem-Based Learning (PBL) approach encourages students to construct knowledge through authentic problems, and PBL models have been shown to enhance critical thinking skills (Arifah et al., 2021). Meanwhile, PhET simulations provide dynamic visual representations that help address misconceptions forming two complementary pillars that support the development of scientific literacy and critical thinking, as highlighted in the study by (Aina & Hariyono, 2023).

Thus, this module is not only academically valid but also practical, engaging, and fully aligned with the principles of the Merdeka Curriculum. Minor revisions based on validation feedback have refined the module, making it

ready for classroom-scale trials to measure its impact on student learning outcomes and scientific literacy.

CONCLUSION

This development research successfully produced a highly valid and practical physics teaching module for use in teaching potential and kinetic energy to Grade X students. The integration of Palembang local wisdom, Problem-Based Learning (PBL), and PhET simulations proved effective in making abstract concepts more contextual, engaging, and easier to understand. Expert validation and positive student responses confirm that the module meet the criteria of content validity, pedagogical appropriateness, cultural relevance, and readability. An Aiken's V value of ≥ 0.80 across all main aspects demonstrates strong consistency between expert academic judgment and end-user (student) perception. This module not only addresses the challenges of low scientific literacy and underdeveloped critical thinking among students, but also aligns with the spirit of the Merdeka Curriculum, which emphasizes differentiated, project-based, and locally rooted learning. Minor revisions have been implemented, making the module ready for classroom-scale trials to evaluate its impact on students' scientific literacy and conceptual understanding.

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REFERENCES

Aina, Q., & Hariyono, E. (2023). *Penerapan PhET Simulations Pada Pembelajaran Fisika untuk Meningkatkan Kemampuan Literasi Sains Peserta Didik SMA Kelas X*. https://doi.org/10.58706/jipp

Arifah, N., Kadir, F., & Nuroso, H. (2021). *Karst : Jurnal Pendidikan Fisika dan Terapannya Volume 4 | Nomor 1 | 14*.

Badan Standar, Kurikulum, dan A. P. (BSKAP), Kementerian Pendidikan, Kebudayaan, Riset, dan T., & Edisi Revisi Ke-3, J. 2025. (2025). *pembelajaran dan asesmen*. *04*(3), 9–47.

Basri, S. (2022). *Pengembangan Modul Fisika Berbasis Kearifan Lokal*. https://www.ejournal.jendelaedukasi.id/index.php/JJP

Dwi, O. :, Hikmah, L., Putri, A., & Setiaji, B. (2024). PT. Media Akademik Publisher IDENTIFIKASI KESULITAN PEMAHAMAN SISWA PADA MATERI USAHA DAN ENERGI. *Maret*, *2*(3), 3031–5220. https://doi.org/10.62281

Ety Kurniati, K. A. C. A. (2023). *Pengaruh Model Pembelajaran Problem Based Learning terhadap Literasi Sains Siswa SMA*. *3*(2), 248–252.

Fuadi, H., Robbia, A. Z., & Jufri, A. W. (2020). *Analisis faktor penyebab rendahnya kemampuan literasi sains peserta didik*. *5*, 108–116.

Maison, M., Lestari, N., & Widaningtyas, A. (2020). Identifikasi Miskonsepsi Siswa Pada Materi Usaha Dan Energi. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 32–39. https://doi.org/10.29303/jppipa.v6i1.314

Munandar, R., Ika Ristanti, C., Nurhidayati, N., Busyairi, A., & Rokhmat, J. (2022). Analisis Potensi Pembelajaran Fisika Berbasis Etnosains Untuk Meningkatkan Kecintaan Budaya Lokal Masyarakat Bima. *Jurnal Penelitian Dan Pembelajaran Fisika Indonesia*, *4*(1). https://doi.org/10.29303/jppfi.v4i1.169

OECD. (2018). *PISA 2018 Results (Volume I): What Students Know and Can Do: Vol. I*.

Sae, F. S., Husin, V. E. R., Mellu, R. N. K., Tinggi, S., & Pendidikan, I. (2021). *Mpfff*. *4*(1), 27–33.

Thiagarajan, S., Semmel, D., & Semmel, M. (1974). *90. Ref Thiagarajan Metode 4 D (buku)* (pp. 1–194).

Utami, L., Festiyed, Dian Purnama Ilahi, Arista Ratih, Elvi yenti, & Lazulva. (2024). ANALISIS INDEKS AIKEN UNTUK

MENGETAHUI VALIDITAS ISI INSTRUMEN SCINETIFIC HABBITS OF MIND. *Journal of Research and Education Chemistry*, *6*(1), 59. https://doi.org/10.25299/jrec.2024.vol6(1).17430

Wahyuni, A., & Lia, L. (2020). Pengembangan Komik Fisika Berbasis Kearifan Lokal Palembang Di Sekolah Menengah Atas. *Jurnal Penelitian Pembelajaran Fisika*, *11*(1), 37–46. https://doi.org/10.26877/jp2f.v11i1.4187

Warliani, R., Irvani, A. I., & Khoiril, A. (2023). *JIFP (Jurnal Ilmu Fisika dan Pembelajarannya) Analisis Modul Ajar Fisika berbasis Kearifan Lokal pada Platform Merdeka Mengajar Analysis of Local Wisdom-based Physics Modul Ajar on Merdeka Mengajar Platform*. http://jurnal.radenfatah.ac.id/index.php/jifp/index