Validity and Reliability Analysis of a Problem-Based Learning Model with a Multimodal Approach

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Abstract - *This research aims to develop and evaluate the validity and reliability of Problem-Based Learning (PBL) based learning materials with a multimodal approach to improve critical thinking skills and digital literacy of junior high school students on the topic of Work, Energy, and Simple Machines. The developed devices include Learning Objectives Flow (ATP), teaching modules, PBL–multimodal model designs, and instruments for measuring critical thinking and digital literacy. Validation was conducted by four expert validators using Aiken's V analysis, while reliability was tested with Percentage of Agreement (PA). The research results show that all instruments are in the valid category, with validity values: ATP = 0.82; teaching module = 0.82; PBL-multimodal model = 0.85; critical thinking instrument = 0.84; and digital literacy instrument = 0.84. The reliability of all instruments is also high, namely: ATP = 0.87; teaching module = 0.93; PBL-multimodalal model = 0.91; critical thinking instrument = 0.95; and digital literacy instrument = 0.93. These findings confirm that the developed instrument is content-valid, presentation-valid, construction-valid, and language-valid, and that it is consistent across validators. The validator provided suggestions for improvement, such as variations in creative activities in the ATP, improvements to the teaching modules, multimodal integration in the learning model, condensing critical thinking essay questions, and modifying digital literacy questions into multiple-choice format. Thus, this PBL–multimodal device is proven to be valid and reliable, and has the potential to support 21st-century skills, particularly critical thinking and digital literacy.*

Keywords*: Validity; Problem-Based Learning; Multimodal; Critical Thinking; Digital Literacy.*

INTRODUCTION

The rapid advancement of information and communication technology has transformed the educational landscape (Wiryany et al., 2022), creating both opportunities and challenges in designing learning experiences that can sustain students' motivation and engagement (Darmayasa et al., 2025). The need for adaptive and contextual learning media has become increasingly urgent to remain relevant to the demands of the 21st century and the diverse characteristics of learners (Gani et al., 2025; Azizah et al., 2025). At the junior high school level, science learning still faces problempedagogis related to unengaging teaching materials, a lack of cultural context, and misalignment with technological developments, which ultimately fail to support deep conceptual understanding (Angelina, 2021). Technology-based multimodal approaches offer a solution through diverse and interactive representations of information, which have been proven to enrich learning experiences and enhance critical thinking skills (Setyaningsih et al., 2023; Zendrato et al., 2022).

The demands of the 21st century emphasize critical thinking, problem-solving, and digital literacy skills (Cynthia & Sihotang, 2023). However, the achievements of Indonesian students remain relatively low, as reflected in the results of PISA 2022, which placed Indonesia in the low category for science, reading, and mathematics literacy (OECD, 2023). National surveys also confirm the low level of digital literacy among junior high school students (Gunawan et al., 2025). These conditions underscore the urgent need to transform science learning through strategies that promote higher-order thinking skills and the intelligent use of technology.

The multimodal components in this study were designed to follow each syntax of PBL so that every stage is supported by appropriate forms of representation. At the problem orientation stage, students receive stimuli in the form of introductory texts and supporting visuals to help them understand the context of the problem. The task organization stage is complemented by short audio-visual materials explaining the workflow and role distribution. Furthermore, the individual and group investigation stages utilize a combination of videos, interactive simulations, and digital worksheets to encourage deeper conceptual exploration. At the stage of developing and presenting results, students make use of visual and audio-visual media to design products or presentations. Finally, at the analysis and evaluation stage, teachers and students use reflective texts and conceptual summary visuals to reinforce understanding and assess the learning process that has taken place.

Problem-Based Learning is a relevant approach because it requires analysis, evaluation, and the resolution of contextual problems (Zainuri et al., 2024). The effectiveness of PBL increases when it is combined with appropriate learning media (Azizah et al., 2022). The integration of a multimodal approach adds value through the presentation of content in multiple formats, such as text, visuals, audio, video, and simulations, which enrich information representation and learning interactions (Firmansyah & Suchaina, 2023). However, despite its strong potential, studies that specifically combine PBL and multimodality in the context of junior high school science remain very limited and have not yet produced strong empirical evidence, particularly in international publications. Most existing studies only measure learning outcomes or general critical thinking skills without instruments specifically designed to assess the contribution of multimodality within the PBL framework.

These limitations are also reinforced by international studies. Research shows that multimodal assessment still faces issues of validity, reliability, and rubric consistency in higher education practice (Midgette, 2025). The development of multimodal instruments is also still at an early stage, as seen in game-based assessments that have not been widely used to evaluate pedagogical models such as PBL at the junior high school level (Liu et al., 2025). Other comprehensive reviews emphasize that multimodal research in education rarely targets the K–12 population and pays limited attention to the development of methodologically sound instruments (Guerrero-Sosa et al., 2025). Even in the K–8 context, the application of multimodal learning analytics remains limited and has not yet led to the development of mature evaluative instruments (Caskurlu et al., 2025). Earlier multimodal assessment frameworks have also highlighted the challenges of implementation in schools and indicated that valid and reliable instrument adaptations for practical PBL multimodal contexts are not yet available (Ross et al., 2021). These findings confirm that the research gap in this area is real, significant, and still unresolved.

Based on this gap, the present study is directed at validating and testing the reliability of instruments used to assess the effectiveness of multimodal PBL, rather than directly testing the implementation of the model itself. This focus is aligned with the early stages of development according to

Borg and Gall, which emphasize the importance of instrument validation prior to field testing (Husnayayin et al., 2024; Zainuri et al., 2025). Valid and reliable instruments are crucial for accurately measuring complex constructs such as critical thinking and digital literacy (Khairunnisa et al., 2024; Qothrunnada et al., 2023).

The results of this study are expected to produce a strong, well-tested, and ready-to-use evaluation instrument, while also strengthening the scientific contribution to the development of innovative learning models. With a solid instrumental foundation, further research on the effectiveness of multimodal PBL in junior high school science learning can be conducted more accurately and with greater impact.

RESEARCH METHODS

This quantitative research aims to test the validity and reliability of a Problem-Based Learning (PBL) science learning module with a multimodal approach. The validated instruments include ATP, Teaching Modules, and LKPD, with questionnaires as the measurement tool (Widiana et al., 2023). This approach was chosen to ensure the device meets academic and technical standards as an applicable learning medium (Wibowo, 2023).

The research subjects consisted of four expert validators selected based on different areas of expertise, including subject-matter experts, media experts, learning experts, and language experts. In addition, the method for selecting the expert validators was explained transparently. The validators were chosen using purposive sampling with clear criteria: having expertise in science education, minimum experience in educational research, and competence in instrument development or multimodal evaluation. This approach ensured that the validation process was conducted by parties who were truly relevant and competent.

The assessment focused on content, presentation, and language using a validity questionnaire based on BSNP guidelines. The aspects evaluated included content suitability, material completeness, language clarity, presentation quality, and the effectiveness of multimodal integration, using a 1–5 Likert scale.

The research procedure began with the development of a module draft that integrated the topics of Work, Energy, and Simple Machines with text, visuals, audio, and video. The draft was distributed to validators, while feedback was collected thru online questionnaires. Validation analysis was performed using Aiken's V coefficient, with a value ≥ 0.75 considered valid (Aiken, 1985, in Arafani et al., 2025). Thus, the learning device is declared suitable after passing the expert validation stage.

$$V = \frac{\sum S}{[n\,(c-1)]} \qquad (1)$$

Description:
V : Item validity agreement index
$\sum S$: Total score
S : $r - l_0$
l_0 : The lowest validity score
c : Highest validity score
r : The figure provided by the appraiser after analysis
n : number of validators

The validity presentation data obtained were then matched against validity criteria as stated in (Utaminingsih et al., 2024; Amanah et al., 2025). The data were then interpreted based on validity (feasibility) criteria using Aiken's V table. The validity criteria can be seen in the following table.

Table 1. Validity Category

Value Range	Validation Level
V ≥ 0, 75	Valid
V ≤ 0,75	Invalid

(Utaminingsih et al., 2024)

The results of the validity analysis are used to determine which aspects of the learning model need to be improved based on feedback from the validators (Zainuri et al., 2025). Next, a reliability test was conducted to determine the consistency of the assessment between validators. Reliability in this study was calculated using the Percentage of Agreement (PA) method, which emphasizes the level of agreement among raters regarding the validated aspects. Percentage of Agreement (PA), which is the percentage of value agreement between the first, second, and third validators, is used in the Borich method to determine the reliability of the learning device validation results (Borich, 2016).

$$PA = \left(1 - \frac{A-B}{A+B}\right) \times 100\ \% \qquad (2)$$

Description:
PA : *Percentage of Agreement*
A : Highest Scores
B : Lowest Scores

The validation of learning materials is considered reliable when the reliability value is ≥ 0.75 or 75% (Makhrus et al., 2020). Thus, if the results reach or exceed this threshold, the developed learning model can be declared to have strong reliability.

In this study, data processing and analysis were conducted using Microsoft Excel to calculate Aiken's V index and the Percentage of Agreement (PA).

RESULTS AND DISCUSSION

This section presents the results of the validity and reliability tests for the Problem-Based Learning (PBL) with multimodal approach, including the ATP, teaching modules, learning model design, and critical thinking and digital literacy instruments. The device is designed to support junior high school science learning on the topics of Work, Energy, and Simple Machines with the integration of text, visuals, audio, and video. Validation was conducted by seven experts who assessed the content, presentation, language, and suitability of the device with the goals of 21st-century skills development.

Results

This section presents the results of the validity and reliability tests for the learning materials that have been developed. Expert evaluations covered content suitability, presentation, and language, as well as their alignment with the goals of critical thinking development and digital literacy. The validity and reliability results not only indicated the instrument's suitability but also served as the basis for revisions to meet academic and practical standards.

Validity

The validity test using Aiken's V coefficient shows that the instrument has a high level of suitability with the learning indicators, making it suitable for use as a supporting tool in the implementation of the multimodal Problem-Based Learning (PBL) model. According to Arikunto (2010), validity is a measure of the accuracy of an instrument in assessing the aspects that should be measured, so the higher the value of Aiken's V, the better its accuracy and relevance to the learning objectives (Septyaningrum & Lestari, 2023). Details of the validation results can be seen in Table 2 below.

Table 2. ATP Validity

Aspect	V	Category
Content validation	0.83	Valid
Presentation validation	0.81	Valid
Language validation	0.81	Valid
Average	**0.82**	**Valid**

Overall, the ATP validation results show that it is a valid category, making this instrument suitable for use as a reference in developing learning materials.

Next, to ensure the teaching materials'suitability more comprehensively, a validation test was also conducted on the teaching module. The results of the validators' assessment of the teaching module can be seen in Table 3 below.

Table 3. Teaching Module Validation

Aspect	V	Category
Content validation	0.82	Valid
Presentation validation	0.86	Valid
Language validation	0.79	Valid
Average	**0.82**	**Valid**

The results of the validation of the teaching module indicate that all three assessed aspects (content, presentation, and language) obtained consistently valid average scores. These findings confirm that the developed teaching module has met the feasibility standards as one of the main instruments in learning implementation. Therefore, the module is expected to be regarded as a relevant and effective means of supporting the achievement of learning objectives.

After the module is declared valid, the next stage is the validation of the PBL model with a multimodal approach, which includes the quality of syntax, development rationale, reaction principles, social system, support system, as well as instructional and accompanying impacts. The results of the assessment are presented in Table 4 below.

Table 4. Validation of the Learning Model

Aspect	V	Category
Rasional development validation	0.88	Valid
Validation of syntax clarity and multimodal integration	0.81	Valid
Validate the principle of reaction	0.88	Valid
Social system validation	0.88	Valid
System support validation	0.88	Valid
Instructional impact validation	0.81	Valid
Validation of accompanying impact	0.81	Valid
Average	**0.85**	**Valid**

The validation results show that the multimodal PBL learning model achieved valid scores across all components, confirming its syntactic clarity, sound rationale, and attention to reaction principles, social systems, and instructional support. Suggestions from validators were technical and did not affect feasibility, so the model is ready for trial implementation. Following this, validation also covered the critical thinking assessment instruments, which are essential to ensure reliable measurement of students' targeted abilities. The results are shown in Table 5.

Table 5. Validation of Critical Thinking Instruments

Aspect	V	Category
Content Validation	0.90	Valid
Contruction validation	0.81	Valid
Language Validation	0.81	Valid
Average	**0.84**	**Valid**

Next, validation was also conducted on the digital literacy instrument designed using indicators according to Japelidi.. The results of the digital literacy instrument validation are shown in the following table.

Table 6. Validation of digital literacy instruments

Aspect	V	Category
Content Validation	0.88	Valid
Contruction validation	0.84	Valid
Language Validation	0.81	Valid
Average	**0.84**	**Valid**

Overall, the results of the digital literacy instrument validation show that all assessment aspects have met the valid criteria with good averages. Thus, all the developed tools, from the ATP, learning modules, multimodal-based PBL learning models, critical thinking instruments, to digital literacy instruments, can be declared suitable for use. The results of this validation are an important basis before reliability analysis is conducted to ensure consistency between assessments (Guo et al., 2024; Wörner et al., 2022).

Reliability

Besides validity, this study examined reliability to confirm consistent assessments across validators. Reliability reflects the instrument's stability, ensuring that content, presentation, and language remain trustworthy when evaluated by different parties. The reliability results for all instruments ATP, teaching modules, learning models, critical thinking, and digital literacy are summarized in Table 7.

Table 7. Reliability Table

Aspect	R	Category
ATP	0.87	Reliable
Module	0.93	Reliable
Learning Model	0.91	Reliable
Critical Thinking	0.95	Reliable
Digital Literacy	0.93	Reliable

Based on Table 7, the reliability test results show excellent consistency with the average value falling into the high category. This finding strengthens previous validity results, confirming that the developed instrument is not only appropriate in content and presentation but also consistent in its assessments. This consistency is an important foundation for the device to be used repeatedly in various learning contexts without reducing the accuracy of the results. Thus, the resulting instrument can be trusted and is suitable for use as the main support for implementing the multimodal-based PBL model in junior high school science learning. Furthermore, the high reliability value also indicates agreement among validators, ensuring the quality of the device is scientifically accountable and providing a guaranty of reliability in educational practice.

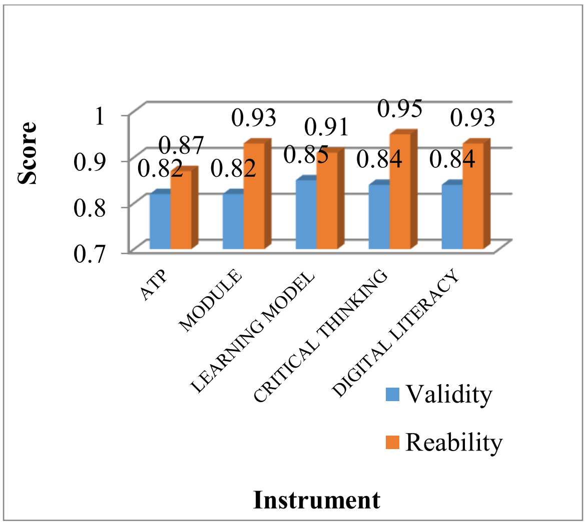

Figure 1. Validity and reliability results graph

Discussion

The results of this study confirm that all developed learning materials namely the Learning Objectives Flow (ATP), teaching modules, multimodal PBL learning model, critical thinking instruments, and digital literacy instruments met validity and reliability standards. Using Aiken's V, validity scores ranged from 0.79 to 0.90, while Percentage of Agreement (PA) values were between 87% and 95%.

For the Learning Objectives Flow (ATP), the validity average was 0.82 with reliability at 89%, showing alignment with learning achievement indicators. Validators, however, suggested refinements such as adding creative activities during the observation stage (e.g., demonstrations, presenting phenomena, or storytelling) to spark curiosity and encourage student-led questioning. They also emphasized the need for consistent ABCD-format objectives and complete identification of ATP within the school unit. These inputs strengthen the ATP as a guiding document for multimodal PBL learning. Similar findings by Setyaningsih et al. (2023) highlight that detailed goal-setting combined with creative student engagement fosters motivation and independent learning.

The teaching module achieved validity of 0.82 and reliability of 93%, placing it in the highly suitable category. While the module already followed PBL syntax, validators recommended improvements, such as including school identity, aligning lesson steps with multimodal PBL, and correcting typographical errors. They also advised making activities more interactive through illustrations, proportional images, and concise captions. Equations should be sequenced systematically for clarity. Such refinements ensure that the module becomes more engaging, accurate, and accessible for students. This aligns with Gunawan et al. (2015) and Mayer (2022), who argue that systematic multimodal designs enhance understanding of abstract concepts in science, particularly when combined with contextual and interactive presentation (Khairunnisa et al., 2024).

Validation of the multimodal PBL model yielded very strong results, with an average of 0.85 and reliability of 91%. Rational development, reaction principles, social systems, and support systems all scored highly, while syntax clarity and multimodal integration were valid but noted as improvable. Suggestions included intensifying multimodal integration (e.g., digital collaboration or application-based tools), ensuring teachers avoid directly answering problems but instead prompting student discussion, and specifying student activities more clearly alongside teacher roles. These suggestions reinforce constructivist principles where teachers act as facilitators rather than information providers (Hmelo-Silver, 2004). With these improvements, the multimodal PBL model is expected to be increasingly well-positioned as an effective pedagogical framework for fostering 21st-century skills. The effectiveness of PBL-based digital learning materials has also been empirically supported. Zainuri et al. (2025) reported that students taught using PBL e-modules showed significantly higher science process skills compared to those taught using conventional methods.

The critical thinking instrument recorded validity of 0.84 with reliability at 95%, confirming its strong quality. Still, validators advised sharper adjustments: each question should include clear illustrations, language must be simplified for SMP-level comprehension, and prompts like “explain” should be revised to “state your argument” to encourage reasoning. The number of essay questions was condensed to six, corresponding to the six critical thinking indicators, thus improving focus. These refinements are consistent with Azizah et al. (2022), who argue that argument-based assessment better evaluates reasoning quality compared to descriptive recall.

The digital literacy instrument also received an average validity of 0.84 and a reliability of 93%, indicating high suitability. The validator provided feedback to make the questions more open-ended, allowing students to demonstrate critical thinking skills in a digital context. Additionally, the answer options should be expanded to five (a–e) to reduce the chance of guessing, and the question format should be changed from single multiple-choice to multiple-choice. This change is highly relevant because digital literacy often involves more than one correct answer, such as in evaluating source credibility or selecting data protection strategies, as demonstrated by Lestari et al. (2022). Thus, the instrument becomes more representative for assessing students' digital literacy skills in dealing with information complexity. This recommendation aligns with Qothrunnada & Rokhmat (2024) and Putri Juliani & Erita

(2023), who stated that question formats with more than one correct answer can improve the accuracy of measuring digital literacy in science learning.

From a methodological perspective, the use of Aiken's V and PA adhered to psychometric standards. Instruments are deemed valid at V ≥ 0.75 (Aiken, 1985, cited in Arafani, Mahrus, & Zulkifli, 2025) and reliable at PA ≥ 75% (Borich, 2016; Makhrus et al., 2020). Since all devices exceeded these thresholds, the instruments are both substantively valid and consistent in inter-rater assessment.

The comparative analysis presented in Figure 1 reinforces these findings. Across all instruments, validity scores ranged from 0.82 to 0.85, while reliability values were slightly higher, between 0.89 and 0.95. This pattern demonstrates not only validity in measuring the intended aspects but also stability across different evaluators. For example, ATP scored validity at 0.82 with reliability at 0.89, while the teaching module and learning model scored 0.82–0.85 for validity and 0.91–0.93 for reliability. The critical thinking and digital literacy instruments achieved validity at 0.84 and reliability above 0.90, confirming their robustness. This consistency suggests that the instruments can be applied across classrooms with minimal interpretation bias. As Wörner et al. (2022) argue, high agreement among validators is a sign of instrument reliability across evaluators.

From an evaluation theory standpoint, this balance reflects the principles highlighted by Aiken (1985), Borich (2016), and Kubiszyn & Borich (2024), who stress that effective instruments must combine strong validity with stable reliability. Validity ensures accurate measurement of competencies, while reliability guarantees consistency across contexts. Since all instruments scored above 0.80 (validity) and 0.87 (reliability), they surpass both national and international benchmarks for educational measurement tools.

Limitations of this study include the relatively limited number of validators involved in the validation process. Although the experts represented different areas of expertise (content, media, learning, and language), a larger number of validators would strengthen the generalizability and robustness of the validity results. A limited number of validators may influence the stability of the Aiken's V and Percentage of Agreement (PA) values. Furthermore, there is a potential risk of subjectivity or bias in expert judgment, as validation relies on human perception and professional experience. Even though structured validation instruments were used, personal perspectives and academic backgrounds of the validators could still influence the assessment results.

Further research is strongly recommended to proceed to the field testing stage through limited trials and large-scale classroom implementation as a response to the demands of 21st-century learning that emphasizes critical thinking skills, digital literacy, and collaboration in problem-solving (OECD, 2023; Gunawan et al., 2025). Experimental or quasi-experimental designs can be used to measure the effectiveness of multimodal PBL learning materials in improving students' critical thinking skills and digital literacy. Furthermore, involving more schools, teachers, and diverse student populations will increase the external validity of the findings, and comparisons between experimental and control groups are also recommended to provide stronger empirical evidence regarding the impact of the developed learning materials.

CONCLUSION

The research results showed that all instruments were in the valid category with an average Aiken's V value of 0.83 and high reliability with a PA value above 0.87. The comparison graph shows that reliability tends to be higher than validity, confirming the consistency of assessments between validators and the instrument's readiness for use in a learning context.

However, this study is still limited to the expert validation and reliability testing stages. The number of validators involved was relatively limited, and no classroom trials or field testing have been conducted to examine the effectiveness of the developed materials in real learning environments. Therefore, the findings of this study reflect the theoretical feasibility of the instruments rather than their empirical impact on students' critical thinking skills and digital literacy. In addition, potential subjectivity in expert judgment remains a possible source of bias. Therefore, future research is highly recommended to continue this development through limited trials and large-scale classroom implementation using experimental or quasi-experimental designs. Field testing is necessary to examine the effectiveness of the multimodal PBL learning materials in improving students' critical thinking and digital literacy across diverse school contexts. With further empirical testing, the developed learning materials are expected to make a significant contribution to science education and the implementation of 21st-century learning.

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