



Validation of Problem-Based Learning Teaching Modules on Momentum and Impulse to Improve Students' Critical Thinking Skills

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ABSTRACT

Purpose of the study: This study aims to validate a Problem-Based Learning (PBL) teaching module on Momentum and Impulse material to improve the critical thinking skills of Grade XI students. The validation ensures the module's feasibility before implementation in the classroom.

Methodology: This research and development (R&D) study used the Four-D Model (Define, Design, Develop, Disseminate), limited to the development stage. Validation involved four experts who assessed the module using a validation questionnaire. Data were analyzed quantitatively based on content, construct, language, presentation, and assessment criteria.

Main Findings: The module received an average validity score of 89%, categorized as "Valid" without revision. The highest scores were in learning construct/model (92%) and assessment (91%). All aspects is content, language, presentation, and graphics were deemed suitable for classroom use, supporting the module's readiness for implementation.

Novelty/Originality of this study: This study offers a PBL-based teaching module specifically designed for the Merdeka Curriculum, integrating critical thinking indicators and Pancasila Student Profile values. It addresses the lack of contextual, structured physics teaching tools and provides a validated, practical resource for teachers to enhance students' critical thinking through real-world problems.

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1. INTRODUCTION

The era of the Fourth Industrial Revolution and Society 5.0 has transformed the world landscape, including the world of education. The 21st century requires students to not only master knowledge content (hard skills) but also develop 21st-century competencies, often referred to as the 4Cs: Critical Thinking, Creativity, Collaboration, and Communication [1]. Among the four, critical thinking skills are considered the main foundation [2]. These skills go beyond remembering and understanding, toward the ability to analyze, evaluate, and create [3].

Critical thinking means the ability to identify problems, analyze arguments, evaluate evidence, draw logical conclusions, and solve problems systematically [4], [5]. Critically thinking students do not simply accept information, but question, investigate, and reflect on it, which ultimately shapes their excellent science literacy skills [6]. However, the reality in the field often shows the opposite. Physics learning in many schools still tends to be teacher-centered, focusing on memorizing formulas and solving routine problems [7], [8]. The subject of

momentum and impulse, which has many applications in everyday life such as traffic accidents, sports, and airbag technology, is often taught in an abstract and mathematical way. This approach results in meaningless learning, making it difficult for students to relate the concepts to real-world contexts and ultimately preventing them from optimally developing their critical thinking skills [9], [10].

The reality on the ground shows that physics education, especially in Indonesia, still faces many challenges. The learning approach is often still teacher-centered, conventional, and oriented towards memorizing formulas and solving standard problems [11]. Lectures and drills still dominate, resulting in less meaningful learning [12], [13]. Although the effectiveness of PBL has been widely recognized in theory, its implementation in the classroom requires concrete and structured learning tools, one of which is teaching modules. Teaching modules serve as operational guidelines for teachers and students to carry out the PBL-based learning process systematically [14], [15]. However, the availability of physics teaching modules, particularly on the topics of Momentum and Impulse, which are specifically designed to improve critical thinking skills, is still very limited.

The concepts of momentum and impulse are concrete examples that are often taught in isolation from real-world contexts. In fact, these concepts are fundamental principles that can explain a variety of phenomena in everyday life, from the design of vehicle safety technology (seat belts and airbags) and strategies in sports (such as softball or boxing) to the analysis of traffic accidents [16], [17]. However, without the right approach, this material is reduced to a set of formulas ($p = m.v$ and $I = F.\Delta t$) and calculation problems. As a result, students find it difficult to establish a connection between abstract physics concepts and their relevant applications. This situation not only reduces students' interest in learning but also fails to train and measure their critical thinking skills [18].

In response to these challenges, the Indonesian government launched the Merdeka Curriculum, which emphasizes student-centered learning and strengthening the Pancasila Student Profile [19]. One of the key elements in the profile is "Critical Thinking." This curriculum gives teachers the flexibility to develop contextual and relevant teaching tools. Although the effectiveness of PBL has been supported by many studies in theory, its implementation in the classroom is often hampered by a lack of operational and structured learning tools [20]. Teachers need clear and practical guidance to implement complex models such as PBL without losing sight of their essence and purpose. Teaching modules serve as "comprehensive guides" containing objectives, activity steps, materials, worksheets, and assessment instruments [21]. However, the availability of physics teaching modules, especially for the topics of Momentum and Impulse, which are specifically designed based on PBL syntax and integrated with critical thinking skill indicators, is still very limited.

The development of such modules cannot be done carelessly. A teaching module that claims to improve critical thinking must undergo a rigorous validation process before being widely tested. Therefore, the development of a Problem-Based Learning teaching module for Momentum and Impulse material is an urgent need. However, the teaching module product that has been developed cannot be implemented immediately. Validation steps are needed to ensure that the resulting module is not only theoretically sound but also practical and suitable for use in the classroom. This validation covers aspects of content suitability, language, presentation, and graphics, and most importantly, its suitability with PBL syntax and its ability to stimulate critical thinking [22], [23].

Teaching modules serve as "comprehensive guides" containing objectives, activity steps, materials, worksheets, and assessment instruments [20], [24], [25]. However, the availability of physics teaching modules, especially for the topics of Momentum and Impulse, which are specifically designed based on PBL syntax and integrated with critical thinking skill indicators, is still very limited [26]. Based on the above description, this study entitled "Validation of Problem-Based Learning Teaching Modules on Momentum and Impulse Material to Improve Students' Critical Thinking Skills" was conducted. The validation of this teaching module is a crucial step before it is tested in the field, in order to ensure its quality as an innovative learning tool that can be relied upon to help teachers create relevant, contextual, and effective physics lessons that train students' critical thinking skills.

2. RESEARCH METHOD

This study employed a Research and Development (R&D) approach using the Four-D Model (Define, Design, Develop, and Disseminate) by Thiagarajan [27]. The development stages consist of four stages, namely define, design, develop, and disseminate [28]. However, this research was limited to the development stage, covering only the first three phases (Define, Design, and Develop). The Disseminate stage was not conducted due to constraints in time, cost, and the primary research objective, which focused on producing and validating a high-quality product prototype. The emphasis at this stage was to ensure the teaching module met feasibility standards in terms of content, pedagogy, and language before proceeding to broader implementation.

2.1. Research Design

The study followed the procedural steps of the Four-D Model:

1. Define: Conducting a front-end analysis to identify learning needs, curriculum requirements, and the characteristics of students and material.
2. Design: Creating the initial design or draft (Draft I) of the PBL-based teaching module.
3. Develop: Conducting expert validation to assess the module's feasibility and revising the product based on validator feedback to produce the final draft (Draft II).
4. Disseminate: This stage was not executed in this study, as the research scope was limited to product development and validation.

Reason for Limiting to the Development Stage: The decision to restrict the research to the development stage was based on methodological prudence. A rigorous validation process is a fundamental prerequisite before any educational intervention can be tested for its effectiveness in the classroom. This study prioritized establishing the content validity and construct validity of the module through expert judgment. Subsequent research phases, such as limited classroom trials (to measure practicality and preliminary effectiveness) and wider dissemination, require a separate, more extensive research design. Therefore, this study serves as a crucial foundational step, ensuring the developed module is theoretically and pedagogically sound for future experimental or quasi-experimental studies.

2.2. Research Subjects

The research was conducted at State Islamic Senior High School 2 Lahat during the even semester of the 2025/2026 academic year. The subjects of this validation study were four experts (validators) consisting of:

1. Two physics education lecturers from Sriwijaya University, who assessed the module's alignment with learning theory, PBL syntax, and critical thinking constructs.
2. Two experienced physics teachers from State Islamic Senior High School 2 Lahat, who assessed the module's practicality, suitability to the student context, and alignment with the operational implementation of the Merdeka Curriculum.

This composition ensured a balance between theoretical/academic and practical/classroom perspectives

2.3. Research Instrument

The primary instrument for data collection was a teaching module validation questionnaire. This questionnaire was developed based on:

1. The National Education Standards Agency (BSNP) guidelines for textbook assessment, covering aspects of content feasibility, presentation feasibility, language feasibility, and graphic feasibility.
2. PBL syntax according to Arends (2012), to evaluate the appropriateness of the learning model construct.
3. Indicators of critical thinking skills adapted from Facione (1990), such as interpretation, analysis, evaluation, and inference, to assess the integration of these skills in learning activities and assessments.
4. Guidelines for Merdeka Curriculum teaching modules, particularly concerning the integration of the Pancasila Student Profile (P3).

The questionnaire used a Likert scale with four scoring alternatives: 4 (Very Good), 3 (Good), 2 (Fair), and 1 (Poor). The instrument's content validity was established through expert judgment during its development phase, ensuring the items accurately represented the aspects to be measured (content, construct, language, presentation, and assessment).

2.4. Data Collection Technique

Data were collected through non-test techniques, specifically:

1. Document Analysis: Studying curriculum documents, textbooks, and relevant literature during the Define stage.
2. Interview: Conducting unstructured interviews with physics teachers at State Islamic Senior High School 2 Lahat to identify needs and constraints in the field.
3. Questionnaire: Distributing the validation questionnaire to the four validators after they had thoroughly reviewed the teaching module draft. Validators provided scores and qualitative suggestions for improvement.

2.5. Data Analysis Technique

The quantitative data from the validation questionnaire were analyzed using descriptive statistical analysis to determine the validity score percentage for each aspect and the overall module. The analysis followed these steps:

1. Calculate the total score given by all validators for each aspect/item.

2. Calculate the maximum possible score for each aspect/item (number of validators × maximum scale score (4)).
3. Calculate the percentage of validity for each aspect using the formula:

$$\text{Validity Percentage} = \frac{\text{Total Score Obtained}}{\text{Maximum Possible Score}} \times 100\% \quad \dots(1)$$

4. Convert the percentage score into a validity category based on the criteria in Table 1.
5. The module is declared valid and ready for use if the average validation score from all aspects reaches a minimum of 76% (Valid category). Qualitative feedback from validators was used as a basis for minor improvements, although major revisions were not required if the score was in the "Valid" category.

Table 1. Product validity level criteria and revisions

Percentage (%)	Criteria	Description
76-100	Valid	No Revision Needed
56-75	Valid Enough	No Revision Needed
40-55	Less Valid	Revision
0-39	InValid	Revision

The data obtained was analyzed quantitatively using predetermined validity criteria, whereby a percentage of 76-100% was categorized as "Valid" without the need for revision.

2.6. Research Procedure

The research procedure followed the Four-D model stages, executed as follows:

1. Define:
 - a. Conducted a front-end analysis through interviews and observation of learning at State Islamic Senior High School 2 Lahat.
 - b. Analyzed the Core Competencies (CP) and Learning Objective Flow (ATP) for Phase F, Momentum and Impulse material.
 - c. Formulated learning objectives and determined the integration of critical thinking indicators and P3 values.
2. Design:
 - a. Selected the PBL model as the learning approach.
 - b. Designed the module format according to Merdeka Curriculum guidelines (general information, core components, appendices).
 - c. Developed the initial product (Draft I), including learning scenarios, student worksheets, and assessment instruments.
 - d. Designed the module's visual appearance using Microsoft Word and Canva.
3. Develop:
 - a. Conducted an expert validation test by submitting Draft I and the validation questionnaire to the four validators.
 - b. Collected and analyzed validation data quantitatively and qualitatively.
 - c. Revised the module based on validator suggestions to produce the final draft (Draft II), which was declared valid and ready for implementation.

3. RESULTS AND DISCUSSION

3.1. Definition stage

This definition stage was carried out to identify obstacles encountered during physics lessons at State Islamic Senior High School 2 Lahat through interviews and questionnaires distributed to physics teachers. This definition stage consisted of five stages. The results of these stages were used as guidelines for developing teaching modules on momentum and impulse based on problem-based learning (PBL).

The results of the interview questionnaire with physics teachers at State Islamic Senior High School 2 Lahat show that the curriculum implemented in Grade XI (Phase F) is the Merdeka Curriculum. However, the implementation of the Merdeka Curriculum in Phase F has not been optimal because teachers do not yet have complete teaching tools that are suitable for learning needs. The main obstacles faced by teachers in implementing the Merdeka Curriculum are limited teaching materials, such as learning modules, and understanding of new components in the curriculum, such as Learning Outcomes (CP), Learning Objective Flow

(ATP), Learning Objectives (TP), and Pancasila Student Profile (P3). These components are important for teachers to master in developing teaching modules.

Based on the results of the observation questionnaire, it was revealed that the availability of Physics teaching modules for Phase F is still very limited. The teaching modules owned by teachers are generally still simple and only contain learning objectives, learning activities, and basic assessments. One of the materials identified as requiring the development of teaching modules is Momentum and Impulse. Based on the results of the observation questionnaire analysis, 100% of teachers agreed and supported the development of a complete version of the teaching module for this material to support the implementation of the Merdeka Curriculum.

3.2. Design Stage

The design stage was carried out to create a Momentum and Impulse teaching module based on Problem Based Learning (PBL) using the following three stages.

a. Media Selection.

This stage is carried out to ensure that the media used are in accordance with the characteristics and learning needs of the Momentum and Impulse material. The selection of media in the development of PBL-based teaching modules is adjusted to the results of the analysis in the define stage, where the teaching modules developed must be in accordance with the Learning Outcomes (CP) and Learning Objective Flow (ATP), use clear and systematic language, be operational in nature, and be equipped with attractive visual elements. The teaching module, which includes diagrams, illustrations, and links to instructional videos, is expected to help students understand the abstract concepts in the Momentum and Impulse material.

b. Format Selection.

The teaching module format is adjusted to the teaching module development guidelines in the Merdeka Curriculum. Aspects considered in the development of teaching modules include content/material suitability, linguistic suitability, presentation suitability, and graphic suitability. The module format is designed to contain essential components, including general information, core components, and appendices, which are arranged systematically.

c. Initial Design.

At this stage, an initial product was created in the form of a Momentum and Impulse teaching module based on Problem Based Learning (PBL). The teaching module was designed based on the results of data analysis in the define stage using Microsoft Word and the Canva application for cover design. The typography used for the content is the Cambria font with a size of 12 pt, while the cover uses the League Spartan and Polybin fonts with sizes varying from 12-40 pt. The teaching module is designed with a dominant blue color scheme that represents the character of physics, and is printed in A4 paper format for ease of use in learning.

The teaching module content is designed in accordance with the Problem Based Learning syntax, which is divided into five learning phases. Each phase is equipped with a learning scenario that integrates critical thinking skill indicators, including problem identification, data analysis, solution evaluation, and decision making. The Momentum and Impulse material is presented through a contextual approach with examples of applications in everyday life, such as traffic accident analysis, airbag technology, and principles in sports.

The teaching module also integrates the values of the Pancasila Student Profile through collaborative learning activities and problem-solving tasks that emphasize critical reasoning and group cooperation.

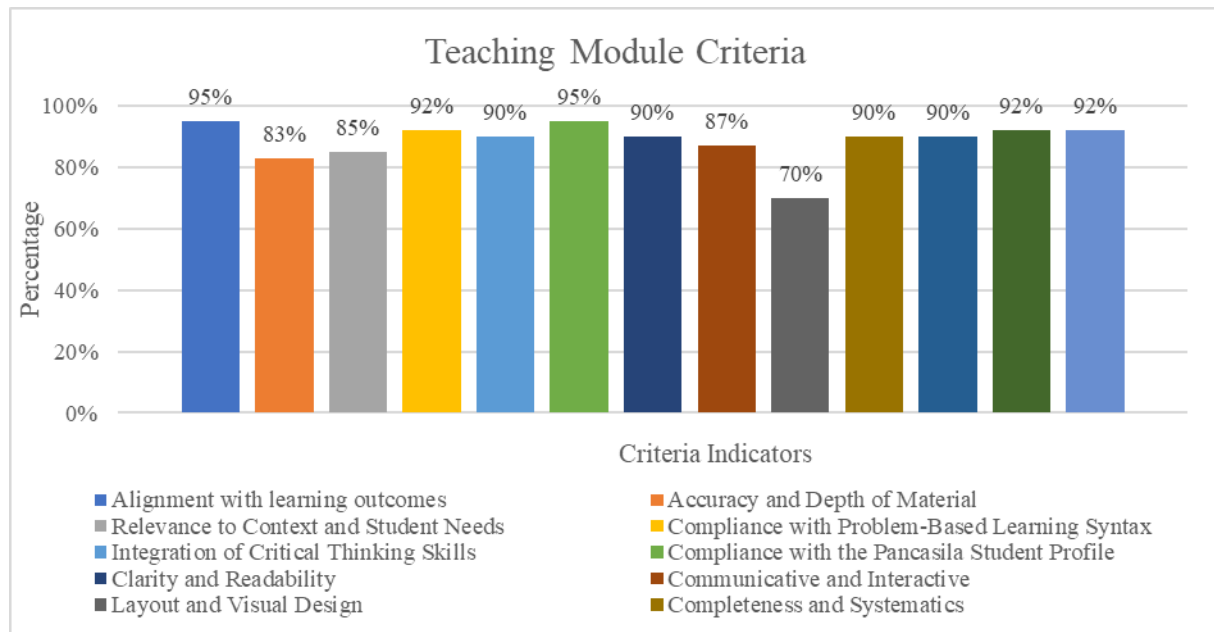


Figure 1. Result Teaching Module Criteria

Based on the design stage of the Momentum and Impulse teaching module based on Problem Based Learning (PBL), data analysis focused on ten criteria for module feasibility. Data obtained from literature studies and needs analysis showed that in terms of suitability with learning outcomes, all module components were designed to strictly refer to CP Phase F for Momentum and Impulse material. In terms of relevance to the student context, the module integrates real-life examples that are familiar to State Islamic Senior High School 2 Lahat students to increase the relevance of the material. The aspect of critical thinking skills integration is realized through the provision of complex problem scenarios that require students not only to memorize formulas but also to analyze cause-and-effect relationships. Data on clarity and readability show that the language used is tailored to the cognitive level of grade XI, avoiding excessive technical terms. In terms of layout and visual design, the module is designed with clear infographic principles, using consistent colors, fonts, and spacing to improve readability.

For strength and depth of material, the scope is designed to cover everything from basic concepts and mathematical formulations to applications in modern technology and physics phenomena. Compatibility with PBL syntax is evident in the organization of modules into five phases, while the integration of the Pancasila Student Profile is implemented through collaborative activities and reflection on ethical values. Communicative and interactive aspects are supported by a variety of activities, including group discussions and simulations. Finally, data on completeness and systematics confirm that all components of the complete version of the Merdeka Curriculum teaching modules have been fulfilled.

3.3. Development Stage: Product Validation Results

The teaching module products were tested by conducting validity tests. This test was conducted to assess and evaluate the suitability of the teaching module, which was assessed by two lecturers and five physics teachers. The teaching module was assessed in terms of content/material suitability, learning construct/model, language, presentation, and assessment. The results of the validation data analysis can be seen in Table 2.

Table 2. Results of the Teaching Module Validity Test Assessment

No.	Aspect	Validity Score	Category	Description
1.	Content/Material Suitability	88%	Valid	No Revision Needed
2.	Learning Model/Construct	92%	Valid	No Revision Needed
3.	Linguistics	89%	Valid	No Revision Needed
4.	Presentation	80%	Valid	No Revision Needed
5.	Assessment	91%	Valid	No Revision Needed
Average		89%	Valid	

Based on Table 2, the results of the validation test of the Momentum and Impulse teaching module based on Problem Based Learning obtained the following quantitative data. The module obtained an average

validity score of 89%, which is classified as Valid. Analysis by aspect shows variations in achievement, with the learning construct/model aspect achieving the highest score of 92%, followed by the assessment aspect (91%), language (89%), content/material suitability (88%), and presentation (80%). All validated aspects were categorized as Valid without requiring revision, despite differences in percentages for each aspect. This data indicates that the module has met the minimum feasibility standards and is ready to be implemented in learning.

Discussion

3.4. Discussion

The validation results demonstrate that the developed PBL teaching module for Momentum and Impulse has met high feasibility standards from both theoretical and practical perspectives. Based on the analysis of the data above, it can be discussed that the design of this teaching module is a response to the challenges of implementing the Merdeka Curriculum at State Islamic Senior High School 2 Lahat, particularly in relation to the limitations of contextual and problem-based teaching tools. The Problem-Based Learning (PBL) approach adopted in this module is considered strategic for the Momentum and Impulse material, because the abstract nature of the material can be concretized through the solving of everyday problems [29]–[31]. This is in line with curriculum requirements that emphasize competency development through meaningful learning experiences [32], [33]. Visual design and layout that take into account the psychological aspects of learning are expected to reduce cognitive load and increase students' interest in learning [34], [35]. Integrating the values of the Pancasila Student Profile through group activities and reflection not only fulfills curriculum requirements, but also shapes the character of students who are able to think critically and work together [36], [37]. However, the main challenge in this design is to strike a balance between adequate depth of material and limited classroom learning time. The availability of comprehensive and systematic modules is expected to be a solution for teachers in implementing differentiated learning, as well as a guide for independent learning for students [38]. This is in line with the demands of the Merdeka Curriculum, which emphasizes problem-based learning and focuses on students [39]. The PBL approach is considered highly strategic for momentum and impulse material, which has tended to be taught in an abstract and mathematical manner. Through this module, it is hoped that students will be able to relate the concepts to real-world phenomena [22], [29].

Further validation is needed to ensure that all the criteria that have been designed can be effectively implemented in the field and are truly capable of improving students' conceptual understanding and critical thinking skills [40], [41]. The results of the validation of the Momentum and Impulse teaching module show very satisfactory results. The high score in the learning construct/model aspect (92%) proves that the integration of the Problem-Based Learning model in the module has been implemented comprehensively and in accordance with the correct syntax. The achievement in the assessment aspect (91%) reflects the quality of the evaluation instruments that are able to measure student competence comprehensively. The language score of 89% indicates that the module uses communicative language that is appropriate for the comprehension level of grade XI students. The content/material suitability aspect, which scored 88%, confirms the accuracy of the material and its suitability for the learning outcomes. Although the presentation aspect received a relatively lower score (80%), it is still in the valid category without the need for revision, indicating that the organization of the material and visual design are adequate, although there is still room for improvement. Overall, these validation results prove that the developed teaching module has met the academic and pedagogical eligibility standards for use in the Physics learning process at State Islamic Senior High School 2 Lahat.

The discussion's primary contribution lies in demonstrating that a rigorously validated, theory-informed teaching module can serve as a key lever for educational change. It provides a practical and validated solution to the dual challenge of implementing the Merdeka Curriculum while fostering 21st-century skills [42]–[44]. For researchers, this study offers a replicable framework for developing and validating teaching materials that integrate pedagogical models, skill frameworks, and national curriculum values [45], [46]. For practitioners, it delivers a ready-to-use tool that demystifies the implementation of PBL and critical thinking assessment, thereby empowering teachers to move beyond conventional, lecture-based methods. Future research should focus on empirical testing of this module's effectiveness in enhancing students' critical thinking skills and conceptual understanding in classroom settings [47]–[50].

Overall, this module is not just a collection of teaching materials. It is a validated, structured guide that helps teachers implement PBL effectively while systematically training critical thinking skills and instilling Pancasila values. The module is ready for the next stage of testing, namely limited implementation in the classroom to measure its practicality and preliminary effectiveness in improving students' critical thinking skills.

4. CONCLUSION

Based on the entire research and development process, it can be concluded that the Problem-Based Learning teaching module on Momentum and Impulse for Grade XI Phase F at State Islamic Senior High School 2 Lahat has been successfully developed and is deemed suitable for use. This module, which is integrated with

critical thinking skills and the values of the Pancasila Student Profile, has undergone a rigorous validation process by experts, with very satisfactory results. Overall, the module obtained an average validity score of 89%, which is classified as Valid without the need for revision, with the highest achievement in the aspects of learning construct/model (92%) and assessment (91%). These findings prove that the teaching module developed not only meets academic and pedagogical standards but is also capable of addressing the challenges of implementing the Merdeka Curriculum, particularly in providing teaching tools that are contextual, innovative, and oriented towards the development of 21st-century competencies. Thus, this module is ready to be implemented in the physics learning process to improve students' critical thinking skills and can be used as a reference for teachers in carrying out meaningful and relevant learning in line with the demands of the times.

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