Phenomenon , 2025, Vol. 15 (No. 2), pp. 305-327
Phenomenon : Jurnal Pendidikan MIPA
phenomenon@walisongo.ac.id

Development of An Ethnophysics-Based Flipbook E-Module Using Lato-Lato to Improve Students' Conceptual Understanding of Momentum and Impulse

Qodriya Ramadhani[1], Linda Lia[2], Wacharaporn, Khaokhajorn[3], Nanang Winarno[4], Lukman Hakim[5]

[1,2]Pendidikan Fisika Universitas PGRI Palembang, Palembang, Indonesia
[3]Department of Science Education, Sakon Nakhon Rajabhat University, Thailand
[4]Science Education Department, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Indonesia, Indonesia,
[5]Pendidikan IPA Universitas PGRI Palembang, Indonesia

Abstract

This study aimed to develop and evaluate an ethnophysics-based digital flipbook e-module integrating the traditional lato-lato game and Problem-Based Learning (PBL) to enhance high school students' conceptual understanding of momentum and impulse. The study employed the 4D development model, comprising the Define, Design, Develop, and Disseminate stages. Three expert validators assessed the e-module's validity in terms of content, media, and language, while its practicality was evaluated through individual testing (n = 3) and small-group testing (n = 10). Changes in conceptual understanding were examined using a one-group pretest–posttest design involving 35 students and a 25-item conceptual understanding test (Cronbach's alpha = 0.70). Expert validation yielded an overall mean score of 3.88 on a four-point scale, while the individual and small-group practicality tests produced scores of 66% and 78%, respectively. The mean test score increased from 53.8 to 83.1, with a normalized gain (N-gain) of 0.64, indicating a moderate improvement. A paired-samples t-test revealed a statistically significant within-group difference, $t(34) = -21.67$, $p < 0.001$, with a standardized mean change of Cohen's $d_z \approx 3.67$. These findings support the validity and practicality of the developed e-module and indicate improved students' conceptual understanding scores during implementation. Integrating culturally familiar collision phenomena, PBL activities, and digital learning support offers a contextualized approach to teaching momentum and impulse. However, the absence of a comparison group limits causal interpretations of the observed improvement.

Keywords: ethnophysics; e-module; momentum, impulse; conceptual understanding.

Pengembangan E-Modul Flipbook Berbasis Etnofisika Menggunakan Permainan Lato-Lato untuk Meningkatkan Pemahaman Konsep Momentum dan Impuls Siswa

Abstrak

Penelitian ini bertujuan untuk mengembangkan dan mengevaluasi e-modul *flipbook* digital berbasis etnofisika yang mengintegrasikan permainan tradisional lato-lato dan *Problem-Based Learning* (PBL) untuk

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

meningkatkan pemahaman konsep momentum dan impuls siswa SMA. Penelitian menggunakan model pengembangan 4D yang meliputi tahap *Define, Design, Develop,* dan *Disseminate*. Tiga validator ahli menilai validitas e-modul berdasarkan aspek isi, media, dan bahasa, sedangkan kepraktisan dievaluasi melalui uji perorangan (n = 3) dan uji kelompok kecil (n = 10). Perubahan pemahaman konsep diukur menggunakan desain *one-group pretest–posttest* yang melibatkan 35 siswa dengan instrumen tes pemahaman konsep sebanyak 25 butir (Cronbach's alpha = 0,70). Hasil validasi ahli menunjukkan skor rata-rata keseluruhan sebesar 3,88 dari skala maksimum 4,00, sedangkan hasil uji kepraktisan masing-masing mencapai 66% dan 78%. Rata-rata skor tes meningkat dari 53,8 menjadi 83,1, dengan nilai *normalized gain* (N-gain) sebesar 0,64 yang termasuk kategori sedang. Uji t berpasangan menunjukkan perbedaan yang signifikan secara statistik dalam kelompok, $t(34) = -21{,}67$, $p < 0{,}001$, dengan perubahan rata-rata terstandarisasi dalam kelompok sebesar Cohen's $d_z \approx 3{,}67$. Temuan ini mendukung validitas dan kepraktisan e-modul yang dikembangkan serta menunjukkan peningkatan skor pemahaman konsep siswa selama implementasi. Integrasi fenomena tumbukan yang dikenal dalam konteks budaya, aktivitas PBL, dan dukungan pembelajaran digital menawarkan pendekatan kontekstual untuk pembelajaran momentum dan impuls. Namun, tidak adanya kelompok pembanding membatasi interpretasi kausal terhadap peningkatan yang diamati.

Kata kunci: etnofisika; e-modul; momentum, impuls; pemahaman konsep.

INTRODUCTION

Physics learning aims to develop students' conceptual understanding and ability to explain natural phenomena through scientific principles and mathematical representations. However, momentum and impulse remain challenging concepts for senior high school students, particularly in distinguishing momentum from impulse and interpreting their relationships during collisions (Akhsan et al., 2023; Zidni et al., 2024) . Students also tend to associate momentum primarily with velocity while overlooking the contributions of mass and direction (Arisanti et al., 2024). These difficulties indicate the need for learning experiences that connect abstract concepts with observable physical phenomena rather than emphasizing mathematical procedures alone.

Preliminary needs analysis conducted through an interview with a physics teacher at a private senior high school in Palembang, South Sumatra, Indonesia revealed limitations in instructional resources despite the implementation of the Merdeka Curriculum. Physics instruction primarily relied on printed textbooks and teacher-guided problem-solving procedures, while electronic modules had not previously been used as instructional materials. Previous research has demonstrated the potential of

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

digital physics modules integrating local wisdom to produce valid and practical instructional resources and support students' creative thinking skills (Pratiwi et al., 2025) .

Furthermore, Xu et al. (2023) highlighted persistent difficulties in students' understanding of momentum, particularly in integrating net force, interaction time, and changes in momentum, emphasizing the importance of instruction that promotes conceptual connections rather than isolated procedural knowledge. Similarly, Wiyani (2022) reported that multiple-representation-based instruction improved students' problem-solving skills in momentum and impulse compared with conventional learning. These findings reinforce the need for instructional resources that connect scientific concepts with meaningful learning experiences and support conceptual mastery in physics (Doyan et al., 2024) . Accordingly, the development of a contextual digital e-module integrating culturally familiar phenomena was considered relevant to addressing the instructional needs identified at the research site.

The preliminary needs analysis, based on an interview with a physics teacher, indicated that although Project-Based Learning (PjBL) had been implemented, the reported instructional activities did not consistently provide opportunities for students to connect physics concepts with everyday phenomena. This finding suggests a need to strengthen the contextual and investigative components of classroom instruction rather than indicating an inherent limitation of PjBL. Sujanem & Putu Suwindra (2023) showed that interactive physics e-modules integrated with Problem-Based Learning (PBL) have potential to support students' critical thinking skills. Accordingly, the developed e-module incorporated structured problem-solving activities to facilitate conceptual exploration and help students relate observable phenomena to formal physics concepts.

Contextual learning provides opportunities to connect abstract physics concepts with observable phenomena, particularly through activities involving forces, motion, and collisions (Zhakypova & Sydykova, 2021). Ethnophysics extends this approach by integrating scientific concepts embedded in cultural practices and familiar activities. Previous studies have highlighted the potential of culturally relevant learning contexts to support student engagement and meaningful physics learning (Misbah et al., 2024; Tongco, 2025) . Integrating local knowledge into physics teaching materials has also

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

been explored to support conceptual understanding and analytical thinking (Kariani et al., 2025; Sartika et al., 2025) .

The traditional Indonesian game lato-lato provides a culturally familiar context for examining momentum, impulse, and collision phenomena. Its repeated collisions allow students to observe changes in velocity, momentum transfer, and relationships between interaction time and force (Arisanti et al., 2024; Zidni et al., 2024) . The traditional Indonesian game lato-lato provides a culturally familiar context for examining momentum, impulse, and collision phenomena. Its repeated collisions allow students to observe changes in velocity, momentum transfer, and relationships between interaction time and force (Arisanti et al., 2024; Zidni et al., 2024) .

However, meaningful conceptual learning requires these phenomena to be organized into systematic activities that guide students from observation toward scientific explanations. Problem Based Learning (PBL) offers a structured approach to contextual investigations through five stages: problem orientation, learning organization, guided investigation, presentation of results, and evaluation of problem-solving processes. Within the lato-lato context, these stages guide students in identifying collision-related problems, investigating relevant physical quantities, developing conceptual explanations, and evaluating their solutions. Integrating PBL into ethnophysics-based instructional materials therefore provides a systematic connection between culturally familiar phenomena and scientific problem-solving activities.

Digital flipbook-based e-modules can facilitate this integration through visual representations, animations, formative assessments, and organized learning activities. Previous studies have explored multimedia and inquiry-based learning resources for teaching momentum and impulse (Panggabean, 2022; Susilawati et al., 2022), as well as electronic physics materials supporting conceptual learning (Ndoa et al., 2023) . Research on digital resources, diagnostic assessments, and interactive instructional activities further emphasizes the importance of supporting students' learning difficulties (Baihaqi et al., 2021; Permana et al., 2023; Pribadi & Supahar, 2023; Suryanto et al., 2022) . Kvisoft Flipbook Maker has been applied in the development of physics e-modules, including instructional materials on temperature and heat (Adhhan & Tanjung, 2022) . In the present study, the digital flipbook format was used to organize lato-lato phenomena and structured PBL activities within a single instructional resource.

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

Previous studies have examined lato-lato as a contextual resource for physics learning (Akhsan et al., 2023; Arisanti et al., 2024; Zidni et al., 2024) , while ethnophysics-based electronic modules have been developed to support students' critical thinking skills (Lestari & Apsari, 2022) . Other investigations have explored digital physics learning materials and PBL to support conceptual learning, problem-solving, and critical thinking (Kariani et al., 2025; Kinasih et al., 2023; Ndoa et al., 2023; Sartika et al., 2025; Sujanem & Putu Suwindra, 2023) . Nevertheless, these studies provide limited evidence regarding the systematic integration of lato-lato collision phenomena across all five PBL stages within a digital flipbook, accompanied by evaluations of product validity, practicality, and students' conceptual understanding of momentum and impulse. Addressing this specific gap, the present study integrates culturally familiar collision phenomena with structured problem-solving activities in a digital learning resource. This integration represents a context-specific form of ethno-digital scaffolding, in which cultural phenomena and organized digital instructional support facilitate the transition from everyday observations to formal physics explanations.

Therefore, this study aimed to develop and evaluate an ethnophysics-based digital flipbook e-module integrating lato-lato phenomena and the five stages of PBL for teaching momentum and impulse. Specifically, the study examined the e-module's content, media, and language validity; its practicality through individual and small-group trials; and preliminary changes in students' conceptual understanding following implementation. Using the 4D development model, the study provides initial empirical evidence regarding the feasibility and potential educational value of culturally contextualized digital physics learning resources.

RESEARCH METHODS

Research Design

This research employed a research and development (R&D) design based on the 4D model comprising Define, Design, Develop, and Disseminate. The model guided the development of an ethnophysics-based digital flipbook e-module using the traditional lato-lato game for momentum and impulse instruction. Product evaluation included expert validation, individual and small-group practicality trials, and a limited classroom assessment of students' conceptual understanding using a one-group pretest–posttest

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

design.

Expert assessment established the product's content and presentation suitability, practicality trials assessed students' experience using the e-module, and paired testing measured changes in conceptual understanding during classroom implementation.

Development Procedure

Development followed the four main stages of the 4D model, that are define, design, develop, and Disseminate. The Define stage involved analysis of the senior high school physics curriculum, a review of literature concerning misconceptions about momentum and impulse, and an initial interview with a physics teacher. These activities examined the learning context and the need for materials that connect mathematical representations with observable collisions. The resulting needs analysis informed the learning objectives, content, and selection of the lato-lato game as a contextual phenomenon.

During Design, the repeated motion and collisions of the lato-lato balls were mapped onto momentum, impulse, conservation of momentum, and collisions. The learning activities were sequenced according to five Problem-Based Learning stages: problem orientation, organization for learning, guided investigation, presentation of findings, and analysis and evaluation of problem solving. Visual explanations, prompts, and formative activities were planned to connect physical observations with formal physics representations.

During Develop, the e-module was assembled in digital flipbook format with lato-lato collision representations, conceptual explanations, PBL activities, and formative exercises. The development emphasized scientific accuracy, contextual relevance, and the clarity of visual and written explanations.

The e-module was then reviewed by expert validators for the accuracy of physics concepts, suitability for high school learners, and quality of its media presentation. Their feedback informed refinements to conceptual clarity, visual presentation, and usability before classroom implementation.

Dissemination was limited to implementation and feedback collection at the partner school. Students used the e-module to examine the relationship between momentum change, impulse, and forces through lato-lato collisions. This limited dissemination was intended to document product use and preliminary learning outcomes,

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

not to establish broad generalizability.

Participants

Participants were purposively selected from a private senior high school in Palembang, South Sumatra, Indonesia, based on curriculum relevance and institutional accessibility. Practicality testing involved three students in the one-to-one trial and ten in the small-group trial. A separate limited classroom implementation involved 35 students who completed both pretest and posttest assessments. Purposive sampling and the single-school context limit the generalizability of the results (Etikan, 2016; Handley et al., 2018).

Research Instruments

Data were collected using expert validation sheets, a student practicality questionnaire, and a 25-item multiple-choice conceptual understanding test. The test covered five items at understanding (C2), eight at applying (C3), seven at analyzing (C4), and five at evaluating (C5) levels. Expert judgment established the content relevance and clarity of the 25 test items; the test had a Cronbach's alpha coefficient of 0.70. Item difficulty was categorized as easy (eight), moderate (ten), and difficult (seven); discrimination was categorized as adequate (eleven), good (eleven), and very good (three).

Three validators assessed six content criteria, five media criteria, and language suitability on a four-point scale. Content criteria addressed curriculum alignment, learning objectives, conceptual coverage, clarity of explanations, cultural relevance, and competency support. A ten-item practicality questionnaire using a five-point scale examined interpretability (two items), ease of use (four), attractiveness (two), and time efficiency (two).

Content validity of the conceptual understanding test was evaluated through expert judgment by the same three validators who assessed the e-module: two university lecturers and one high school physics teacher. Four aspects were considered: alignment of each item with the intended indicator, accuracy of the answer key according to physics principles, clarity of the question context to avoid multiple interpretations, and unambiguous language. The product and the test were assessed separately according to their respective evaluation criteria, while employing the same experts helped maintain conceptual alignment between instructional content and assessment items.

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

Data Analysis

Data analysis combined descriptive summaries of expert ratings, practicality percentages, and students' pretest–posttest outcomes with inferential testing. Normalized gain (N-gain) was used to describe changes relative to the available score range, classified as low ($g < 0.30$), moderate ($0.30 \leq g < 0.70$), or high ($g \geq 0.70$) according to Hake (1998) (1998). The interpretation of normalized gain follows established approaches for analyzing conceptual learning gains (Bao, 2006)

$$N - gain = \frac{(Posttest\ score - Pretest\ score)}{(Maximum\ score - Pretest\ score)}$$

Differences between students' pretest and posttest scores were analyzed using a paired-samples t-test. The assumption of normality concerned the distribution of the paired differences. Cohen's d_z was calculated as the mean paired difference divided by the standard deviation of those differences.

RESULTS AND DISCUSSION

RESULTS

Needs analysis indicated the need for learning resources that help students connect mathematical representations of momentum and impulse with observable events. The teacher interview indicated continued reliance on printed books and procedural exercises, while electronic modules had not been used as instructional materials. Lato-lato collisions were consequently selected as a familiar physical context through which changes in motion, momentum, impulse, and interaction forces could be explored.

The design stage produced an e-module structure integrating lato-lato collision phenomena with five stages of Problem-Based Learning (PBL). The sequence moved from problem orientation and identification of relevant physical quantities through guided investigation, presentation of conceptual explanations, and evaluation of solutions. Illustrations, guiding questions, and formative tasks were arranged to connect the observed game phenomena with the formal concepts of momentum and impulse.

Needs analysis indicated the need for learning resources that help students connect mathematical representations of momentum and impulse with observable events. The teacher interview indicated continued reliance on printed books and procedural exercises, while electronic modules had not been used as instructional materials. Lato-lato collisions were consequently selected as a familiar physical context through which

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

changes in motion, momentum, impulse, and interaction forces could be explored.

The design stage produced an e-module structure integrating lato-lato collision phenomena with five stages of Problem-Based Learning (PBL). The sequence moved from problem orientation and identification of relevant physical quantities through guided investigation, presentation of conceptual explanations, and evaluation of solutions. Illustrations, guiding questions, and formative tasks were arranged to connect the observed game phenomena with the formal concepts of momentum and impulse.

The development stage resulted in an ethnophysics-based digital flipbook e-module designed for teaching momentum and impulse concepts. The initial sections of the e-module include a cover, learning instructions, and learning objectives that introduce the learning resource and provide guidance for its use. The visual presentation of these components is shown in Figure 1.



Figure 1. Main components of the developed ethnophysics-based digital flipbook e-module: (a) cover, (b) learning instructions, and (c) learning objectives.

Figure 1 illustrates the main instructional components of the developed ethnophysics-based digital flipbook e-module, including the cover, learning instructions, and learning objectives. The learning instructions provide guidance for students in navigating and using the e-module, while the learning objectives clarify the competencies expected to be achieved. The organization of these components reflects a systematic instructional design intended to facilitate independent learning and support students' understanding of momentum and impulse concepts. Thus, the figure demonstrates how the e-module was structured to provide clear learning guidance and align its instructional content with the intended learning outcomes.

In addition to its instructional structure, the developed e-module incorporates the traditional lato-lato game as a contextual learning resource to introduce momentum,

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

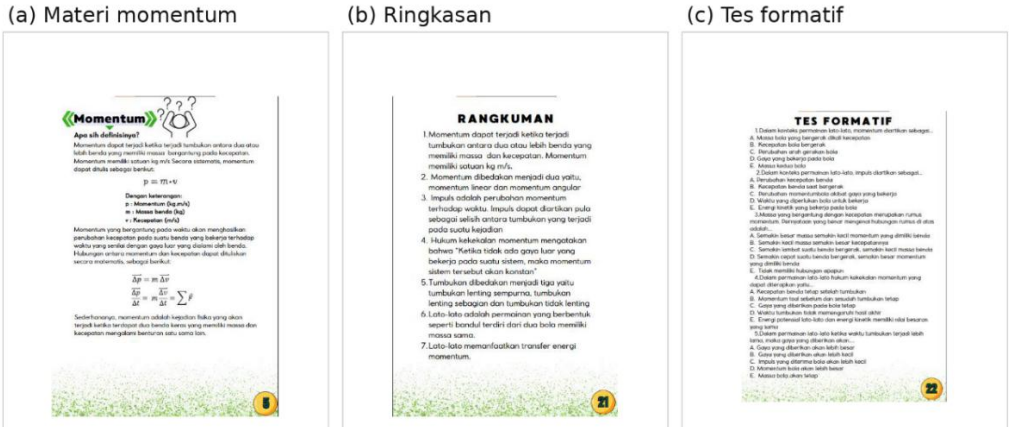
impulse, and collision concepts. This integration is presented through an introductory explanation of the game and guiding questions designed to activate students' prior knowledge and encourage their curiosity about the physical phenomena involved. The presentation of these ethnophysics-based learning components is illustrated in Figure 2.



Figure 2. Integration of the lato-lato game into the developed ethnophysics-based digital flipbook e-module: (a) contextual problem presentation and (b) introduction to the lato-lato game.

Figure 2 illustrates the integration of the lato-lato game as a contextual learning resource in the developed e-module. Figure 2(a) presents guiding questions that encourage students to recall their experiences with the game and observe the repeated collisions between the two balls. This activity is intended to stimulate curiosity and introduce a contextual problem related to momentum and impulse. Meanwhile, Figure 2(b) introduces the lato-lato game as a familiar cultural context for physics learning. Together, these components provide an initial foundation for connecting everyday experiences with scientific concepts and support the problem-orientation stage of Problem-Based Learning (PBL).

Following the presentation of contextual problems through the lato-lato game, the developed e-module provides learning materials, concept summaries, and formative assessments to support students' understanding of momentum and impulse. These components are designed to facilitate conceptual learning, reinforce essential physics principles, and provide opportunities for students to evaluate their understanding. Examples of these components are presented in Figure 3.



Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

Figure 3. Learning content and assessment components of the developed ethnophysics-based digital flipbook e-module: (a) momentum learning materials, (b) concept summary, and (c) formative assessment.

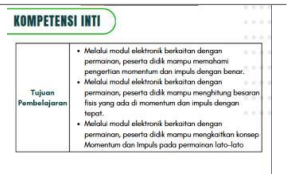
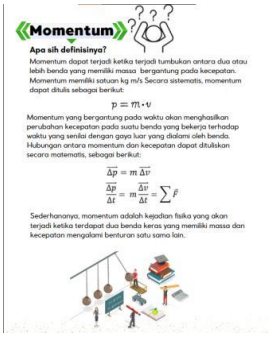
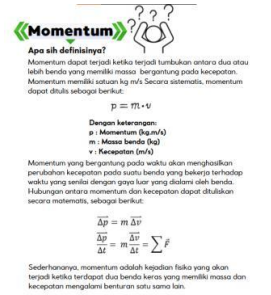
Figure 3 illustrates the organization of learning materials and assessment components within the developed e-module. Figure 3(a) presents the momentum learning materials, which introduce relevant physics concepts and mathematical representations to support students' conceptual understanding. Figure 3(b) provides a summary of essential concepts, allowing students to review and consolidate the information presented in the learning materials. Meanwhile, Figure 3(c) displays formative assessment questions designed to evaluate students' understanding of momentum and impulse concepts. The integration of these components reflects a structured learning sequence that combines conceptual explanation, knowledge reinforcement, and assessment. This organization is intended to support independent learning and provide opportunities for students to monitor their conceptual understanding.

Based on the feedback obtained during the expert review process, several revisions were made to improve the developed e-module. These revisions focused on the visual design, organization of learning objectives, removal of unnecessary decorative elements, and improvement of text readability. The experts' comments and the corresponding changes to the e-module before and after revision are presented in Table 1.

Table 1 Expert Feedback and Revisions to the Developed E-Module

No.	Before Revision	Expert Feedback	After Revision
1		The cover design was overly crowded and unsuitable for senior high school students.	

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

No.	Before Revision	Expert Feedback	After Revision
2		The section contained excessive information.	
3		The decorative element at the bottom was unnecessary.	
4		The text size was too small.	

As shown in Table 4, the revisions to the developed e-module addressed four aspects of instructional presentation and visual design. The cover was redesigned to provide a simpler appearance appropriate for senior high school students, while the learning objectives were reorganized to improve clarity. Unnecessary decorative elements were removed, and the presentation of the angular momentum material was adjusted to improve text readability. The comparison between the initial and revised versions demonstrates how expert feedback was incorporated into the product refinement process. These revisions were intended to improve the visual clarity, readability, and instructional suitability of the e-module.

The expert validation results further provide an assessment of the developed e-module's quality. Validation by two university lecturers and one high school physics

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

teacher yielded mean scores of 3.89 for content, 3.87 for media, and 3.89 for language. The overall mean score was 3.88 out of 4.00, indicating that the e-module met the highly valid category according to the study's established criteria. These findings suggest that the developed e-module demonstrated a high level of suitability across the evaluated aspects. However, the validation scores reflect expert judgments of product quality rather than direct evidence of improvements in students' conceptual understanding.

Practicality Results

The one-to-one evaluation involving three students yielded a practicality score of 66%, while the small-group evaluation involving ten students yielded 78%. Both scores met the study's criteria for practical use. The questionnaire assessed comprehensibility, ease of use, attractiveness, and time efficiency. Feedback from these trials informed refinements to navigation, visual clarity, and accessibility.

Results of the Disseminate Stage and Conceptual Understanding

The e-module was disseminated through limited classroom implementation at one school. The evaluation of students' conceptual understanding revealed an increase in mean scores from 53.8 on the pretest to 83.1 on the posttest, representing an average improvement of approximately 29.3 points. The normalized gain (N-gain) was 0.64, indicating a moderate level of conceptual improvement based on Hake (1998) classification. As presented in Figure 2, the higher posttest score indicates improved student performance following the implementation of the ethnophysics-based flipbook e-module. These findings provide descriptive evidence of positive changes in students' conceptual understanding of momentum and impulse during the learning intervention.

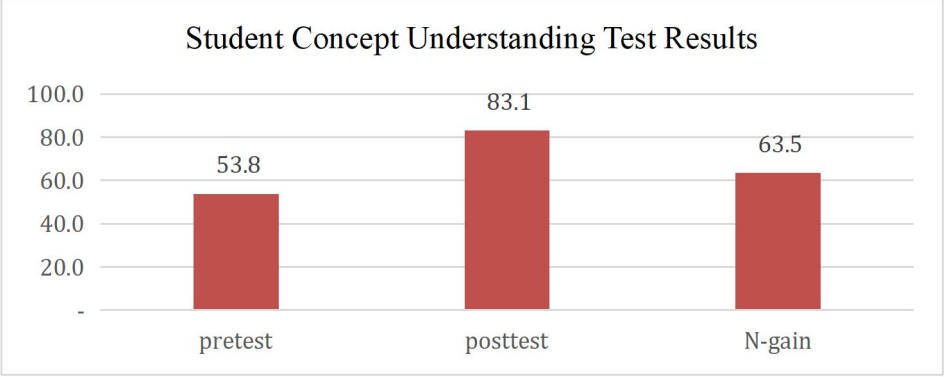


Figure 2. Comparison of mean pretest and posttest scores and normalized gain in conceptual understanding of momentum and impulse.

Figure 3 presents students' conceptual understanding across four cognitive levels:

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

understanding (C2), applying (C3), analyzing (C4), and evaluating (C5). These levels represent different cognitive demands in learning momentum and impulse, ranging from interpreting fundamental concepts to applying physical principles, analyzing collision-related phenomena, and evaluating conceptual explanations. The pretest and posttest profiles provide a descriptive overview of students' performance across these cognitive domains. The distribution complements the overall test results by illustrating the cognitive dimensions assessed during the implementation of the e-module.

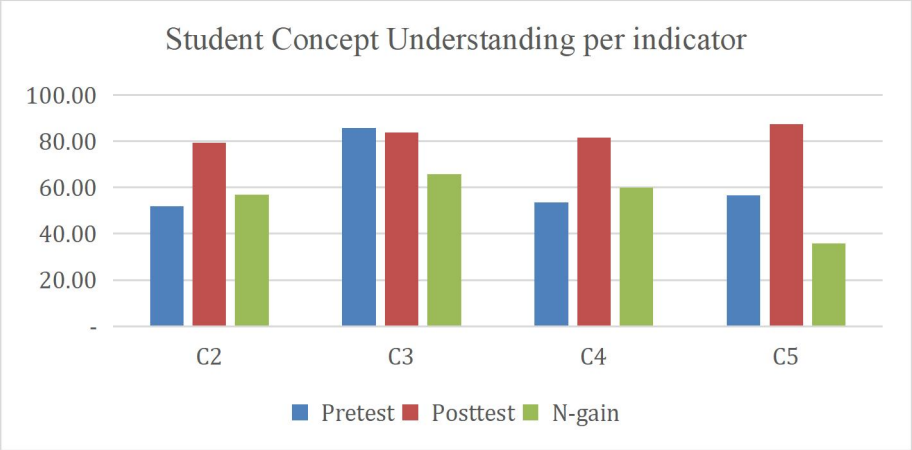


Figure 3. Students' conceptual understanding across cognitive levels.

The paired-samples t-test revealed a statistically significant difference between pretest and posttest scores, $t(34) = -21.67$, $p < 0.001$. The mean paired difference, calculated as pretest minus posttest, was −29.25 points (SD = 7.98), with a 95% confidence interval ranging from −32.00 to −26.51. The negative mean difference indicates that posttest scores were higher than pretest scores. Cohen's d_z of approximately 3.67 indicates a large standardized within-group change in students' conceptual understanding. These results provide inferential evidence of a significant difference in students' conceptual understanding scores before and after the implementation of the e-module.

Table 1. Paired-samples t-test results

Comparison	**Mean Difference**	**SD**	**SE**	**95% CI**	**t**	**df**	**p**
Pretest–Posttest	-29.25	7.98	1.34	[-32.00, -26.51]	-21.67	34	<.001

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

DISCUSSION

Product Validity and Conceptual Accuracy

The expert validation results demonstrated high levels of content, media, and language validity, with an overall mean score of 3.88 out of 4.00. The content validity score of 3.89 indicates favorable expert judgments regarding the alignment of instructional materials with learning objectives and the scientific accuracy of momentum and impulse concepts. These findings are consistent with Noviana et al. (2025) reported the development and expert validation of STEM-integrated physics learning media using karate movements as a contextual representation of momentum and impulse. Similarly, Yusra et al. (2023) emphasized the importance of instructional content and learning design in developing an e-module for momentum and impulse, while Ndoa et al. (2023) demonstrated the relevance of systematic digital instructional material development for teaching the same concepts. Unlike these studies, the present research integrated lato-lato collision phenomena with five stages of Problem-Based Learning (PBL), establishing a structured relationship between culturally familiar physical events and conceptual investigations. The validation findings therefore support the instructional suitability of the developed product, particularly in terms of conceptual accuracy and alignment between scientific content and contextual learning activities.

The media and language validation scores of 3.87 and 3.89, respectively, further indicate positive expert evaluations of the e-module's digital presentation and instructional clarity. The integration of visual representations, explanatory materials, guiding questions, and formative activities provides an organized learning environment for exploring momentum and impulse. Marnita et al. (2024) examined digital module development using the TPACK framework, highlighting the importance of integrating technological and pedagogical considerations into instructional materials. Nasbey et al. (2024) similarly developed a digital physics module incorporating the Dilemma-STEAM learning model, whereas Panggabean (2022) investigated the feasibility and practicality of multimedia representations for momentum and impulse learning. The present study differs in its integration of a traditional collision-based game with sequential PBL activities within a flipbook e-module. The favorable media and language evaluations indicate that this instructional configuration met the established expert assessment criteria, although the contribution of individual multimedia features

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

to student learning was not examined separately.

Practicality and Implementation Conditions

The practicality evaluation yielded scores of 66% in the one-to-one trial and 78% in the small-group trial, indicating that the e-module met the predetermined criteria for practical use in both settings. These findings demonstrate the importance of considering students' experiences when evaluating digital instructional products. Panggabean (2022) examined the practicality of multimedia-based momentum and impulse learning resources, while Nasbey et al. (2024) investigated the development of digital physics materials designed for contemporary learning environments. Marnita et al. (2024) also explored digital instructional modules integrating technological and pedagogical components. In comparison, the present study assessed practicality during successive formative trials of an ethnophysics-based flipbook incorporating PBL activities. The two practicality scores provide complementary evidence of product usability across different trial conditions rather than establishing a causal improvement in practicality between the evaluations.

The practicality findings also highlight the relationship between instructional organization and students' ability to engage with digital learning resources. Feedback concerning navigation, visual clarity, and accessibility informed refinements to the e-module before classroom implementation. Nasbey et al. (2024) provide a relevant example of digital instructional material development in physics education, while Bhale & Dongre (2025) emphasize accessibility and equitable participation as important considerations in electronic learning environments. Kim et al. (2018) further demonstrate the educational relevance of structured computer-based scaffolding within problem-based learning. These perspectives are particularly applicable to the developed e-module because students are required to progress through interconnected activities involving problem identification, investigation, explanation, and evaluation. The practicality results therefore support the usability of the instructional sequence under the tested conditions, while its broader applicability depends on the characteristics of learners and available technological resources.

Changes in Students' Conceptual Understanding

The implementation results demonstrated an increase in students' mean conceptual understanding scores from 53.8 on the pretest to 83.1 on the posttest, corresponding to a

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

paired mean increase of 29.25 points. The normalized gain of 0.64 indicates a moderate improvement, while the paired-samples t-test demonstrated a statistically significant difference between the two measurements, $t(34) = -21.67$, $p < 0.001$. These findings are relevant to Xu et al. (2023), who identified difficulties in students' integration of force, time, and momentum change and investigated conceptual framework-based instruction to strengthen knowledge integration. Zidni et al. (2024) highlighted the potential of lato-lato as a contextual resource for learning collision and momentum concepts, whereas Ndoa et al. (2023) developed electronic physics learning materials addressing momentum and impulse. The present research extends these instructional directions by incorporating lato-lato phenomena into a digital learning sequence organized through five PBL stages. The observed improvement in test scores provides empirical evidence of changes in conceptual understanding during implementation, although the one-group design does not establish that these changes resulted exclusively from the e-module.

The normalized gain and standardized mean difference provide complementary information about the magnitude of the observed learning outcomes. The N-gain of 0.64 represents a moderate improvement relative to the available score range, consistent with the classification proposed by Hake (1998). Bao (2006) demonstrated the importance of distinguishing alternative approaches to calculating average normalized gains, while Burkholder et al. (2020) examined methodological considerations in the quantitative analysis of concept inventory data. In the present study, Cohen's d_z of approximately 3.67 indicates a large standardized within-group change relative to the variability of paired score differences. The moderate N-gain and large standardized change are not contradictory because the measures use different denominators and characterize distinct aspects of students' performance. Together, the results describe a substantial within-group difference between pretest and posttest scores without providing an independent estimate of the causal effect of the intervention.

Integration of Ethnophysics and Problem-Based Learning

The integration of the lato-lato game into the e-module provides a culturally familiar context for examining the physical relationships among velocity, momentum, impulse, and collision forces. Akhsan et al. (2023) examined the physical phenomena associated with lato-lato and their relevance to physics teaching, while Arisanti et al. (2024) analyzed ethnophysics concepts represented by traditional lato-lato and Newton's

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

pendulum. Zidni et al. (2024) further discussed the instructional potential of lato-lato for representing collision and momentum concepts. These studies establish the relevance of lato-lato as a cultural and physical phenomenon for science education. The present research extends this contextual foundation by organizing lato-lato collision phenomena into sequential learning activities rather than treating the game solely as an example or demonstration. Through this integration, observable collision events become the starting point for identifying physical quantities, investigating conceptual relationships, and constructing explanations based on scientific principles.

The use of five PBL stages provides an instructional structure for connecting culturally familiar phenomena with scientific problem solving. Sujanem & Putu Suwindra (2023) investigated interactive physics e-modules integrated with blended PBL to enhance students' critical thinking skills, while Kinasih et al. (2023) examined PBL supported by a three-dimensional digital module in relation to physics problem-solving skills. Kim et al. (2018) demonstrated the educational value of computer-based scaffolding within PBL environments through a meta-analytic investigation. Although these studies focused on different learning outcomes and instructional configurations, they support the pedagogical relevance of combining structured problem solving with digital instructional assistance. In the present study, the five PBL stages organize students' engagement with lato-lato phenomena, beginning with problem orientation and proceeding through investigation, presentation of explanations, and evaluation. This organization establishes a direct relationship between the cultural context, the learning process, and the conceptual objectives of momentum and impulse instruction.

Instructional Contribution and Research Limitations

The integration of cultural phenomena, digital representations, guiding questions, formative activities, and sequential PBL tasks constitutes a context-sensitive form of ethno-digital scaffolding. (Belland et al., 2017) demonstrated the relevance of computer-based scaffolding for supporting cognitive outcomes in STEM education, while Kim et al. (2018) specifically examined its effectiveness within problem-based learning environments. Xu et al. (2023) further highlighted the importance of instructional frameworks that promote connected conceptual knowledge in momentum learning. Building on these perspectives, the developed e-module combines culturally familiar collision phenomena with organized digital support to connect everyday

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

observations with formal physics explanations. Its contribution lies in the instructional integration of ethnophysics, digital learning resources, and PBL rather than in establishing a newly validated theoretical model. The findings provide initial evidence of the feasibility of this instructional configuration and its association with improved conceptual understanding scores during classroom implementation.

The interpretation of these findings is bounded by the research design and implementation context. The study involved purposively selected participants from a single school and employed a one-group pretest–posttest design without a comparison group. Etikan (2016) discusses the methodological characteristics of purposive sampling, while Handley et al. (2018) emphasize the importance of research design in interpreting intervention outcomes. Burkholder et al. (2020) further demonstrate the relevance of appropriate quantitative methods when evaluating changes in conceptual learning. Accordingly, the observed differences between pretest and posttest scores cannot be attributed exclusively to the developed e-module because other influences, including repeated testing and concurrent learning experiences, were not controlled experimentally. Furthermore, the contributions of the cultural context, PBL sequence, and digital instructional components were not evaluated independently. These limitations define the scope of the present findings and provide a methodological basis for subsequent investigations involving comparison groups, more diverse participants, and delayed assessments of conceptual understanding.

CONCLUSION

This study developed an ethnophysics-based digital flipbook e-module integrating lato-lato collisions into five stages of Problem-Based Learning for momentum and impulse instruction. Expert validation indicated high product validity (overall mean 3.88/4.00), while the one-to-one and small-group trials yielded practicality scores of 66% and 78%, respectively. Among 35 students, mean conceptual understanding scores increased from 53.8 on the pretest to 83.1 on the posttest, with a moderate N-gain of 0.64 and a statistically significant paired difference, $t(34) = -21.67$, $p < 0.001$. The findings support the e-module's suitability for the studied context and demonstrate improved conceptual understanding scores following implementation. Further controlled investigations are needed to establish causal effects and evaluate the design in other educational settings.

Universitas PGRI Palembang
©2025 Universitas Islam Negeri Walisongo
Email: lukmanhakim1976@gmail.com
ISSN: 2088-7868, e-ISSN 2502–5708

DECLARATIONS

Phenomenon: Jurnal Pendidikan MIPA was selected as the target journal because this study aligns with its scope of advancing science education through innovative learning materials. All authors have read and approved the manuscript for submission to this journal. **Availability of Data and Materials:** The research data are not publicly available due to participant confidentiality. Anonymized data may be provided upon reasonable request, subject to institutional approval. **Competing Interests:** The authors declare that they have no competing interests. **Funding:** This research was financially supported by the authors without external funding.

REFERENCES

Adhhan, M. F., & Tanjung, R. (2022). Pengembangan E-Modul Menggunakan Aplikasi Kvisoft Flipbook Maker Pada Materi Suhu dan Kalor Kelas XI SMA. JURNAL IKATAN ALUMNI FISIKA, 8(2), 11. https://doi.org/10.24114/jiaf.v8i2.34089

Akhsan, H., Putra, G. S., & Ariska, M. (2023). Newtonian Yoyo (Lato-Lato) Phenomenon in Indonesia: An Innovative Resource for IGCSE Physics Teaching and Learning? https://doi.org/10.21009/1

Arisanti, A., Nurlailiyah, A., Lestari, N. A., Misbah, Deta, U. A., & Prahani, B. K. (2024). Ethnophysics concepts analysis: Traditional vs. modern game in lato-lato and Newton's pendulum. Journal of Physics: Conference Series, 2900(1), 012028. https://doi.org/10.1088/1742-6596/2900/1/012028

Baihaqi, H. K., Jumadi, J., Mardiani, A., & Religia, R. (2021). Analyzing student inquiry in online and offline classes during the Covid-19 pandemic through momentum and impulse worksheets. Momentum: Physics Education Journal, 161–174. https://doi.org/10.21067/mpej.v5i2.5567

Bao, L. (2006). Theoretical comparisons of average normalized gain calculations. American Journal of Physics, 74(10), 917–922. https://doi.org/10.1119/1.2213632

Belland, B. R., Walker, A. E., Kim, N. J., & Lefler, M. (2017). Synthesizing Results From Empirical Research on Computer-Based Scaffolding in STEM Education. Review of Educational Research, 87(2), 309–344. https://doi.org/10.3102/0034654316670999

Bhale, T. Y., & Dongre, A. P. (2025). Ethical Considerations in E-Learning: Ensuring Equity, Privacy and Integrity. International Journal of Latest Technology in Engineering, Management & Applied Science, 14(8), 950–956.

Burkholder, E., Walsh, C., & Holmes, N. G. (2020). Examination of quantitative methods for analyzing data from concept inventories. Physical Review Physics Education Research, 16(1), 010141. https://doi.org/10.1103/PhysRevPhysEducRes.16.010141

Doyan, A., Susilawati, S., Annam, S., Muliyadi, L., Megahati, R. R. P., Hutabarat, R. A., Ikhsan, M., & Ardianti, N. R. (2024). The Trends Research of Conceptual Mastery in Students' Physics Learning (2015-2024): A Systematic Review. Jurnal Penelitian Pendidikan IPA, 10(6), 323–332. https://doi.org/10.29303/jppipa.v10i6.7827

Etikan, I. (2016). Comparison of Convenience Sampling and Purposive Sampling. American Journal of Theoretical and Applied Statistics, 5(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74.

Handley, M. A., Lyles, C. R., McCulloch, C., & Cattamanchi, A. (2018). Selecting and Improving Quasi-Experimental Designs in Effectiveness and Implementation Research. Annual Review of Public Health, 39(1), 5–25. https://doi.org/10.1146/annurev-publhealth-040617-014128

Kariani, K., Sukroyanti, B. A., & Habiburrahman, L. (2025). Development of Physics Ethnoscience-Based Teaching Materials to Enhance Student's Analytical Thinking Skills. Jurnal Pendidikan Fisika Dan Teknologi, 11(1a), 131–139. https://doi.org/10.29303/jpft.v11i1a.9541

Kim, N. J., Belland, B. R., & Walker, A. E. (2018). Effectiveness of Computer-Based Scaffolding in the Context of Problem-Based Learning for Stem Education: Bayesian Meta-analysis. Educational Psychology Review, 30(2), 397–429. https://doi.org/10.1007/s10648-017-9419-1

Kinasih, R. A., Prahani, B. K., Wibowo, F. C., & Costu, B. (2023). Profile of students' Physics Problem Solving Skills and Implementation PBL Model Assisted by 3D Digital Module to Improve Problem Solving Skills. Jurnal Penelitian & Pengembangan Pendidikan Fisika, 9(2), 245–256. https://doi.org/10.21009/1.09207

Lestari, N., & Apsari, N. (2022). e-Modul Ethnophysics for Critical Thinking Skills in the Covid-19 Pandemic. Jurnal Penelitian & Pengembangan Pendidikan Fisika, 8(2), 193–206. https://doi.org/10.21009/1.08202

Marnita, Nurdin, D., Prihatin, E., & Marwan. (2024). Developing Digital Module Using the TPACK Framework to Enhance Students' Life Skill. Jurnal Penelitian Pendidikan IPA, 10(6), 2956–2970. https://doi.org/10.29303/jppipa.v10i6.7635

Misbah, Hamidah, I., Samsudin, A., Qamariah, & Abdul Rahman, N. F. (2024). Identification of Local Potential of South Kalimantan as a Source of Learning Fluid Physics. Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah, 9(2), 675–685. https://doi.org/10.24042/tadris.v9i2.27556

Nasbey, H., Sirait, R. A., Kurniawan, A. F., Samsudin, A., & Fadlan, A. (2024). Digital Physics Module for 21st Century Education on New and Renewable Energy Based on the Dilemma-STEAM Learning Model. Journal of Physics: Conference Series, 2866(1), 012117. https://doi.org/10.1088/1742-6596/2866/1/012117

Ndoa, Y. A. A., Anastasia, D. P., & Jumadi, J. (2023). Development of An Android-Based Physics E-Book with A Scientific Approach to Improve The Learning Outcomes of Class X High School Students on Impulse and Momentum Materials. Jurnal Pendidikan Fisika Indonesia, 18(2), 107–121. https://doi.org/10.15294/jpfi.v18i2.30824

Noviana, R. S., Sriyanti, I., Bayu, W. I., & Rahman, N. F. binti A. (2025). STEM Integration in Karate Sport as Physics Learning Media: Development, Validation, and Analysis of Student Learning Outcomes on Impulse and Momentum Materials. Jurnal Penelitian Pendidikan IPA, 11(9), 72–82. https://doi.org/10.29303/jppipa.v11i9.11972

Panggabean, D. D. (2022). The Feasibility and Practicality of Learning Multimedia

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

Based on Whiteboard Animation of Momentum and Impulse towards First Grade of Senior High School Student Learning Motivation. International Journal of Current Science Research and Review, 05(11). https://doi.org/10.47191/ijcsrr/V5-i11-19

Permana, H., Supriyati, Y., Muliyati, D., Sekartaji, A. A. D., Morales, M. P. E., & Ambarwulan, D. (2023). Development of a Two-Tier Diagnostic Test for The Analysis of Momentum and Impulse Learning Difficulties in Students. Jurnal Penelitian & Pengembangan Pendidikan Fisika, 9(2), 237–244. https://doi.org/10.21009/1.09206

Pratiwi, S. M. V., Wiyono, K., & Ismet, I. (2025). Integrating Palembang's Local Wisdom into a STEM-Based e-Module on Particle Dynamics to Foster Students' Creative Thinking Skills. Jurnal Pendidikan MIPA, 26(1), 476–498.

Pribadi, F. O., & Supahar. (2023). Development of self-diagnostic assessment media by scores based on desktop. Journal of Physics: Conference Series, 2582(1), 012045. https://doi.org/10.1088/1742-6596/2582/1/012045

Sartika, D., Andi Rosman, & Nur Intang. (2025). Enhancing Conceptual Understanding of Heat and Thermodynamics through Innovation of Local Wisdom-Differentiated Physics Learning Media. Jurnal Pendidikan Fisika, 13(2), 275–290. https://doi.org/10.26618/tcvhqv42

Sujanem, R., & Putu Suwindra, I. N. (2023). Problem-based Interactive Physics E-Module in Physics Learning Through Blended PBL to Enhance Students' Critical Thinking Skills. Jurnal Pendidikan IPA Indonesia, 12(1), 135–145. https://doi.org/10.15294/jpii.v12i1.39971

Suryanto, R. A., Dewi, P. S., & Rosana, D. (2022). Development of augmented reality integrated physics e-worksheet to improve students' problem-solving skills. Momentum: Physics Education Journal, 6(2), 150–161. https://doi.org/10.21067/mpej.v6i2.6624

Susilawati, S., Doyan, A., & Muliyadi, L. (2022). Effectiveness of Guided Inquiry Learning Tools to Improve Understanding Concepts of Students on Momentum and Impulse Materials. Jurnal Penelitian Pendidikan IPA, 8(3), 1548–1552. https://doi.org/10.29303/jppipa.v8i3.1919

Tongco, C. N. (2025). Design, Development, and Validation of Kalinangan at Isipang Lokal Sa Asignaturang Pisika Interactive Video Vignettes (Kislap IVVs) as Learning Guides in Physics. International Journal of Innovative Science and Research Technology, 453–495. https://doi.org/10.38124/ijisrt/25oct206

Wiyani, W. (2022). Efektivitas Pembelajaran Fisika Berbasis Multirepresentasi pada Materi Momentum dan Impuls untuk Meningkatkan Keterampilan Pemecahan Masalah. Unnes Physics Education Journal, 3(11), 63–69.

Xu, W., Jiang, Y., Yang, L., & Bao, L. (2023). Conceptual framework based instruction for promoting knowledge integration in learning momentum. Physical Review Physics Education Research, 19(2), 020124. https://doi.org/10.1103/PhysRevPhysEducRes.19.020124

Yusra, D. M., Citra, Y. D., & Rosnita, R. (2023). Explicit Instruction Based E-Module Development on Momentum and Impulsive Material. Integrated Science Education Journal, 4(1), 14–19. https://doi.org/10.37251/isej.v4i1.295

Zhakypova, Z., & Sydykova, C. (2021). The Importance Of Using Contextual Learning As An Effective Teaching Method. Alatoo Academic Studies, 21(3), 144–153. https://doi.org/10.17015/aas.2021.213.16

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708

Zidni, R., Mudzaki, M. K., & Setiaji, B. (2024). Traditional Game Lato-Lato: Physics Learning Media to Improve Students' Conceptual Mastery of Collision and Momentum Materials. Jurnal Materi Dan Pembelajaran Fisika, 14(2), 110. https://doi.org/10.20961/jmpf.v14i2.92310

Universitas PGRI Palembang
Email: lukmanhakim1976@gmail.com
©2025 Universitas Islam Negeri Walisongo
ISSN: 2088-7868, e-ISSN 2502–5708