JPPIPA 11(9) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

STEM Integration in Karate Sport as Physics Learning Media: Development, Validation, and Analysis of Student Learning Outcomes on Impulse and Momentum Materials

RA Sania Noviana[1], Ida Sriyanti[1*], Wahyu Indra Bayu[2], Nor Farahwahidah binti Abdul Rahman[3]

[1] Master of Physics Education, Faculty of Education, Universitas Sriwijaya, Palembang, South Sumatra, Indonesia
[2]Master of Physical and Health Education, Faculty of Education, Universitas Sriwijaya, Palembang, South Sumatra Indonesia
[3]Department of Science Education and Innovative Mathematics, Technology Malaysia University, Skudai, Johor, Malaysia.

Received: July 02, 2025
Revised: August 21, 2025
Accepted: September 25, 2025
Published: September 30, 2025

Corresponding Author:
Ida Sriyanti
ida_sriyanti@unsri.ac.id

DOI: 10.29303/jppipa.v11i9.11972

Abstract: Creative thinking skills are essential competencies in the 21st century, involving cognitive processes and divergent thinking to generate innovative solutions from various perspectives. This study aims to develop and implement a STEM-based learning approach integrated with physics, focusing on impulse and momentum, to improve students' creative thinking skills. Karate is utilized as a contextual medium to facilitate real-life application of physics concepts. The research applies the Research and Development (R&D) method using the 4D model: Define, Design, Develop, and Disseminate. Validation involved nine experts, consisting of lecturers and teachers, who provided feedback to refine the developed e-module. Content validity was assessed using the Content Validity Ratio (CVR) and Content Validity Index (CVI), both reaching 1.00 (100%) across all aspects such as content relevance, Problem-Based Learning (PBL) suitability, ability to assess creative thinking, and design feasibility. Product trials with 101 senior high school students demonstrated significant improvement in creative thinking skills, as shown by an N-Gain score of 0.72. These findings indicate that the developed STEM-based e-module is effective in enhancing students' understanding of physics through contextual and engaging learning.

Keywords: Creative thinking skills, E-module, Impulse, Momentum, Physics

Introduction

Facing the challenges of the globalisation era, mastery of 21st century skills is a must for students, one of which is creative thinking skills (Onsardia et al., 2019; Tang et al., 2020). These skills include complex mental processes that involve cognitive abilities and divergent thinking to generate innovative ideas that are able to solve problems from various points of view (Zubaidah et al., 2017). Through the development of creative thinking skills, students are trained to create new ideas, integrate various ideas, be open to various perspectives, and evaluate the effectiveness of these ideas (Putri et al., 2023). Unfortunately, the level of creative thinking skills among students is still relatively low. This condition is evident in physics and science subjects (Nugroho et al., 2023), especially in topics such as impulse and momentum. The low level of these skills is largely due to the use of learning strategies, models and methods that are not in accordance with the characteristics and real-life context of students (Wulandari et al. 2021; Sujatmika et al., 2022).

Physics learning is one of the important components in science education that aims to equip students with conceptual understanding, critical-creative thinking ability, and problem-solving skills. Physics, as a science that studies natural phenomena through mathematical principles and experiments, has a

How to Cite:
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

central role in shaping students' scientific mindset (Hake, 1998). However, despite its importance, physics is often perceived as a difficult and abstract subject by students, especially on topics that require mathematical understanding and visualisation, such as impulse and momentum (Aryantara et al., 2024; Heryani et al., 2023; Nazifah & Asrizal, 2022). The concepts of impulse and momentum, although fundamental in physics, are often not deeply understood by students due to the lack of real contexts that can connect the theory to everyday life. This is exacerbated by conventional learning methods, where the teacher is more dominant in delivering the material, while students tend to be passive (Marginson et al., 2013).

Conventional learning methods, often referred to as the 'chalk and talk' approach, tend to make students passive recipients of information. In this method, the teacher explains the material in a one-way manner, while students only listen and take notes. This approach is less effective in building deep conceptual understanding because students are not actively involved in the learning process (Osborne et al., 2003; Dani et al., 2021). As a result, students often just memorise formulas and concepts without understanding their meaning and application in real life. This is one of the causes of low student interest and motivation in learning physics (Prince, 2004).

One solution to overcome this challenge is through contextualised learning, which connects subject matter to real-world situations. Contextual learning is based on the theory of constructivism, which emphasises that knowledge is constructed by students through experience and interaction with their environment (Tyukavina et al., 2022). In contextualised learning, materials are taught in a context that is relevant to students' daily lives, thus making learning more meaningful and interesting (Mesci & Erdaş Kartal, 2021). For example, physics concepts such as impulse and momentum can be taught through real examples, such as car crashes, ball games, or sports movements. Conventional learning methods, often referred to as the 'chalk and talk' approach, tend to make students passive recipients of information. In this method, the teacher explains the material in a one-way manner, while students only listen and take notes. This approach is less effective in building deep conceptual understanding because students are not actively involved in the learning process (Osborne et al., 2003). As a result, students often just memorise formulas and concepts without understanding their meaning and application in real life. This is one of the causes of low student interest and motivation in learning physics (Hardiyansyah et al., 2019; Prince, 2004)

This research is important because the low level of students' creative thinking skills stems from the lack of contextual learning media relevant to their daily lives (Noviana, 2024; Yanti et al., 2023). By integrating the physics concepts of impulse and momentum into the context of karate, this study offers an innovative approach expected to enhance both conceptual understanding and creative thinking skills. Contextualised learning has been shown to be effective in improving students' interest and understanding. A study by Marlina et al. (2022) showed that students who learnt physics through a contextualised approach had better conceptual understanding compared to students who learnt through traditional methods. In addition, contextual learning can also increase students' learning motivation because the material taught becomes more relevant to their lives (Kartikasari, 2023; Yanti et al., 2023).

In this context, the STEM (Science, Technology, Engineering, Mathematics) approach offers an ideal framework for creating integrative and applicable learning. STEM not only integrates disciplines but also encourages students to think critically, solve problems and apply knowledge in a real context (Bybee, 2013; Nazhifah et al., 2023). The STEM approach emphasises project-based learning and problem-based learning, where students are encouraged to identify problems, design solutions and test these solutions through experiments or projects (Schweingruber, 2014). STEM approaches have been shown to be effective in improving student learning outcomes, especially in science and maths subjects. A study showed that students who learnt through the STEM approach had higher critical thinking skills and creativity compared to students who learnt through traditional methods. In addition, the STEM approach can also improve students' collaboration and communication skills, which are important skills in the 21st century (Ardi & Marlina, 2025; Syukri et al., 2021; Zubaidah, 2018).

Sport, as part of everyday life, can be an effective context for learning physics. Sports provide real-life examples of physics concepts that can be directly observed and measured. For example, movements in sports such as running, jumping or kicking can be used to explain physics concepts such as force, energy and momentum (Armandita et al., 2017). By utilising the context of sports, physics learning can be more interesting and easily understood by students. Karate, as one of the martial arts sports, provides concrete examples of physics concepts, particularly impulse and momentum. Movements in karate, such as punches and kicks, involve physics principles that can be explained mathematically and visually. For example, when a karateka performs a punch, the concepts of impulse (force acting in a short period of time) and momentum (the product of mass and velocity) can be directly explained (Martina & Hau, 2021). By utilising the context of karate, physics learning can be more interesting and easily understood by students. Karate was selected as the contextual medium because its punching and kicking movements directly involve the concepts of impulse and momentum, which can be measured and analyzed in real-time. Using karate makes the learning process more applicable, engaging, and relatable to students' real-life experiences, thereby helping to address their difficulties in understanding abstract concepts.

In addition, karate can also be used to explain other physics concepts, such as Newton's laws of motion, kinetic energy and potential energy. For example, the kicking motion in karate can be used to explain Newton's third law, the action-reaction law. When a karateka kicks, the foot exerts a force on the target (action), and the target exerts an equal but opposite force on the foot (reaction). By using real examples like this, students can more easily understand abstract physics concepts. However, the development of effective STEM-based learning media with the context of karate sport is still rare. In fact, innovative and interactive learning media can be a powerful tool to improve student engagement and learning outcomes (Ciptayani, 2021). STEM-based learning media not only presents material visually and interactively, but also involves students in an active learning process through experiments, simulations, and projects (Kosasih, 2021). STEM-based learning media can be in the form of teaching materials, videos, computer simulations, teaching aids, or interactive applications (Ratnasari et al., 2023). For example, STEM-based learning media for impulse and momentum material can be in the form of teaching materials on punching and kicking movements in karate, where students can change variables such as mass and speed to see the effect on impulse and momentum. By using media like this, students can more easily understand abstract physics concepts.

In addition, STEM-based learning media can also engage students in practical projects, such as designing and testing props that use the principles of physics. For example, students can design props that simulate punching movements in karate and test the effect of variables such as mass and speed on impulse and momentum(Lee, Hooshyar, Lin, Wang, & Huang, 2023). By doing projects like this, students not only understand physics concepts, but also develop critical thinking, creativity and collaboration skills (Sucilestari et al., 2023). The novelty of this research lies in its integration of STEM-based physics learning with the context of karate, which has rarely been explored as a learning medium. This approach not only delivers concepts theoretically but also provides an interactive learning experience through motion simulations and real-force analysis. Therefore, this study aims to develop STEM-based physics learning media with karate context, test its validation and effectiveness, and analyse its impact on students' learning outcomes on impulse and momentum (Martina & Hau, 2021). This learning media is designed to combine the concepts of science, technology, engineering, and mathematics with movements in karate, thus making physics learning more interesting and easily understood by students (Aninnas et al., 2023). The stages of developing this learning media include needs analysis, design, development, implementation, and evaluation. In the analysis stage, the needs of students and the curriculum were identified. At the design stage, a prototype of STEM-based learning media with karate context is designed. At the development stage, the learning media is made and tested on a limited basis. At the implementation stage, the learning media is used in classroom learning. In the evaluation stage, the effectiveness of learning media in improving student learning outcomes is analysed. Validation of learning media is done through expert assessment (media, material, and learning design) as well as limited trials to students. This validation aims to ensure that the learning media meets the standards of feasibility and effectiveness in learning. In addition, the impact of learning media on student learning outcomes was analysed through learning outcome tests (pretest and posttest) and student response questionnaires.

Method

This research uses the Research and Development (R&D) method. The development model applied was the 4D model which consists of define, design, develop, and disseminate stages (Creswell, 2019; Purnama, 2016) Figure 1.

The research sample consisted of 101 students of class XI of SMA Negeri 22 Palembang, who were selected through purposive sampling technique. The selection of this sample was based on the suitability with the research objectives, namely students who had participated in STEM learning using technology-based tools. The purposive sampling technique was chosen to ensure the relevance of the research results to the learning context studied, as well as to increase the reliability and validity of the data obtained (Creswell, 2019; Purnama, 2016).

The validation process involved nine experts, consisting of five lecturers and four teachers. The validation process involved nine experts, consisting of five lecturers (one expert in physics impulse concepts, one expert in physics momentum concepts, one media expert, one learning model expert, and one creative thinking expert) and four physics teachers. Validation was conducted by analysing comments and suggestions from the experts, which were then used as the basis for revising the developed e-modules. The validity measurement instrument used a question item validation sheet, which was analysed using the Content Validity Ratio (CVR) and Content Validity Index (CVI) approaches (Knebel atal., 2022; Prananto, 2022).

Content Validity Ratio (CVR):

$$\mathrm{CVR} = n - \frac{\frac{n_e}{2}}{\frac{n}{2}} \quad (1)$$

Content Validity Index (CVI):

$$\mathrm{CVI} = \frac{\mathrm{CVR}}{\text{Number of sub-questions}} \quad (2)$$

Remark:
n_e : number of validators who agree
N : total validators

Table 1. Minimum CVR Standards ((Knebel, da Costa, dos Santos, de Sousa, & Silva, 2022)

Validators	Minimum CVR value
5	0.99
6	0.99
7	0.99
8	0.75
9	0.78
10	0.62

After the E-Module product was declared valid, electronic module dissemination was carried out, pre-test and post-test were developed to measure students' creative thinking skills. This instrument refers to four indicators of creative thinking skills, namely fluent thinking, flexibility, originality, and elaboration (Tam, 2023; Torrance, 1977). The validity of the instrument was tested using Person Reliability, with the results. This study used a quantitative descriptive approach to analyze the effect of E-Module X-based learning on students' creative thinking skills.

Table 2. Criteria CVR((Knebel, da Costa, dos Santos, de Sousa, & Silva, 2022)

Range	Interpretation validity
0.80 – 1.00	Very High
0.60 – 0.79	High
0.40 – 0.59	Moderate
0.20 – 0.39	Low
0.00 – 0.19	Very Low

The research process began with the implementation of a pre-test, where students took an initial test using a validated instrument before receiving the learning intervention. Furthermore, students were given treatment in the form of using E-Modul X in learning STEM-based impulse and momentum materials. Learning takes place in accordance with the intervention design until students complete all stages of learning using the STEM-based Teaching E-Module on impulse and momentum material in karate sports. After the intervention is completed, learners take a post-test with the same instrument as the pre-test to measure changes in their creative thinking skills as a result of the application of learning. pre-test and post-test will be calculated using the N-Gain Normality test. Then the improvement of learners' creative thinking skills is calculated based on the normalized N-gain score using SPSS version 27. The N-Gain criteria can be seen in Table 3.

Table 3. Category *N-Gain* (Doyan et al., 2020)

Category	Low	Moderate	High
Score	$g \leq 0.3$	$0.3 < g \leq 0.7$	$0.7 < g \leq 1$

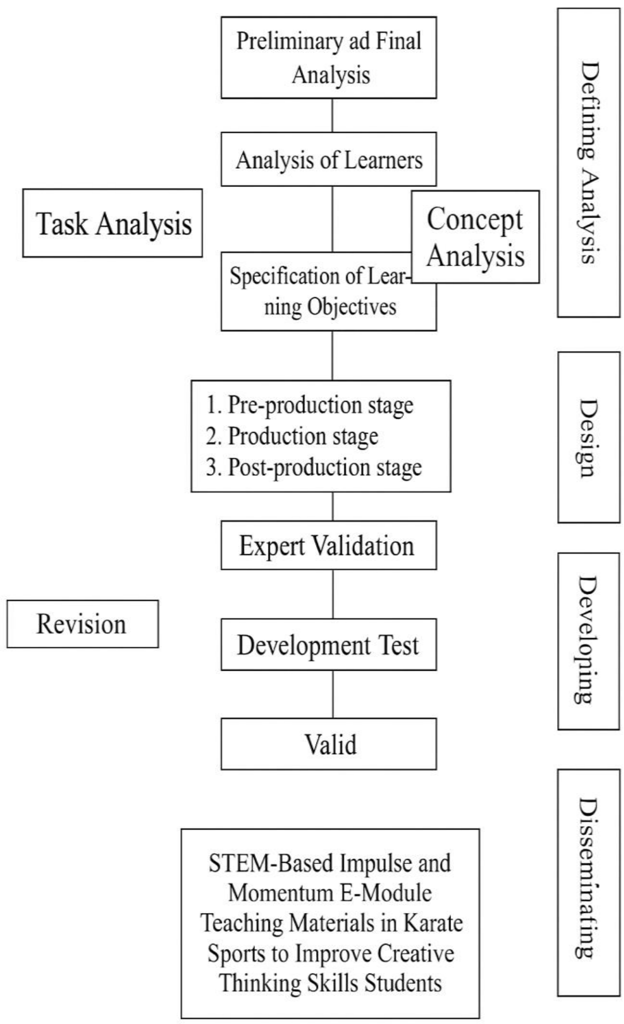


Figure 1. 4D Development Model Chart

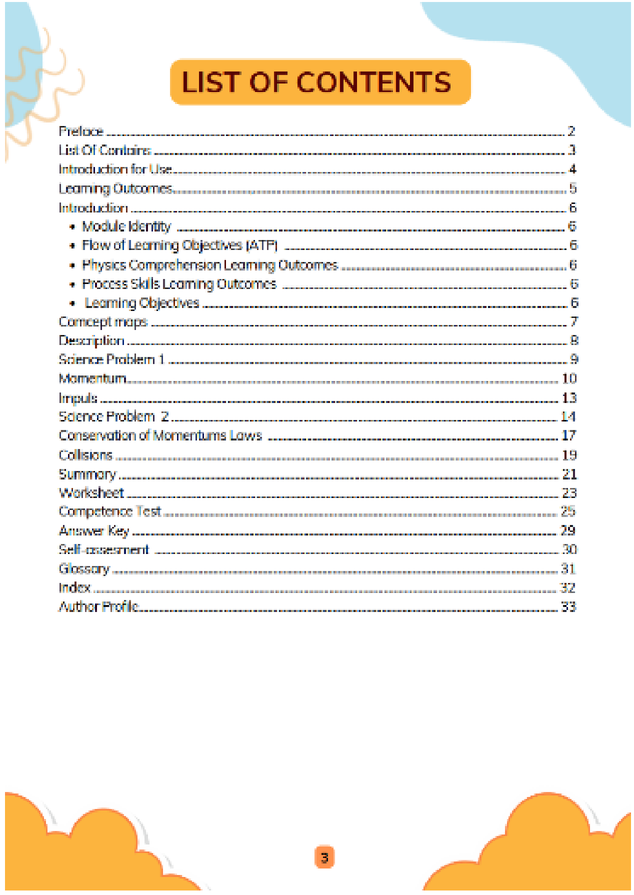
Result and Discussion

Development Stage

The development stage in this research consists of several sub-stages, namely the pre-production stage, the production stage, the post-production stage, and the validity test. In the pre-production stage, researchers first determined relevant learning materials, namely the physics concepts of impulse and momentum contextualized in karate sports. This stage is then followed by the preparation of an outline of the content of the contextual-based electronic module as a guideline in designing and developing learning products. The choice of contextual approach is based on the characteristics of students who more easily understand abstract concepts if associated with real experiences, such as physical activities in sports (Rusman, 2011).

The developed electronic module contains various important components to support a structured and meaningful learning process. These components include: cover page, foreword, table of contents, description of the electronic module, instructions for use, learning outcomes, learning objectives, flow of learning objectives, concept map, introduction section, and main subject matter focusing on impulse and momentum material. In addition, the module is also equipped with a creative thinking box feature to stimulate students' creative thinking skills, practice questions, evaluation and competency tests accompanied by answer keys and self-assessment, bibliography, glossary, index, and author profile. The preparation of this structure refers to the module development guidelines by Kepmendikbudristek (2024) as well as instructional design principles according to Dick & O.Carey (2015), which emphasize the importance of integration between learning objectives, materials, and evaluation.

The structure and components compiled in this electronic module also refer to the opinion of Rahmadani et al. (2019), which states that learning modules ideally include instructions for use, targeted competencies, supporting information, practice questions, work instructions, evaluation, and feedback on evaluation results. To optimize display and interactivity, the module was developed using the Heyzine platform-a website that allows the integration of multimedia elements such as text, images, videos, and interactive links to support STEM-based digital learning STEM (Sung et al., 2016). The completed product marks the end of the production stage and continues into the post-production stage, where validity testing is conducted by experts. This process aims to assess the suitability of the content, design, and effectiveness of the learning instrument before it is disseminated. The validity test is conducted to ensure that the learning product has met the eligibility criteria of content, design, and learning objectives. The structure or table of contents of the electronic module can be seen in Figure 2.


LIST OF CONTENTS

Preface 2
List Of Contains 3
Introduction for Use 4
Learning Outcomes 5
Introduction 6
- Module Identity 6
- Flow of Learning Objectives (ATP) 6
- Physics Comprehension Learning Outcomes 6
- Process Skills Learning Outcomes 6
- Learning Objectives 6

Concept maps 7
Description 8
Science Problem 1 9
Momentum 10
Impuls 13
Science Problem 2 14
Conservation of Momentums Lows 17
Collisions 19
Summary 21
Worksheet 23
Competence Test 25
Answer Key 29
Self-assessment 30
Glossary 31
Index 32
Author Profile 33

3

Figure 2. Table of contents in the electronic module

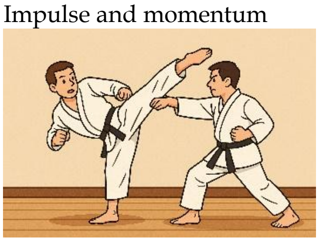
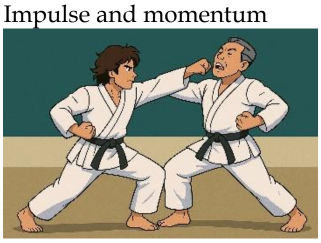
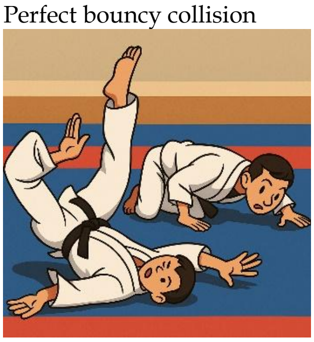
This study used several data collection instruments, namely expert validation sheets, practicality questionnaires, and pre-test and post-test instruments. The validity of the instrument was validated through a series of feasibility tests, in which it obtained a score of 1.00 (very high), the feasibility of Problem-Based Learning (PBL) based on (very high), the feasibility in measuring creative thinking skills of 1.00 (very high), and the feasibility of the design consisted of 1 (very high). The results of the product validity analysis Table 4.

Table 4. Validity Analysis Results

Aspect	S-CVI/Ave	S-CVI/UA
Content feasibility	1	1
feasibility based on problem-based learning (PBL)	1	1
Feasibility in measuring creative thinking skills	1	1
Design feasibility	1	1
Average (%)	100	100

Based on the validity analysis presented in Table 4, all assessment aspects including content feasibility, the implementation of Problem-Based Learning (PBL), feasibility in measuring creative thinking skills, and the design of the e-module achieved S-CVI/Ave and S-CVI/UA scores of 1 with an average of 100%. According to the content validity index criteria, an S-CVI value of ≥ 0.90 is categorized as highly valid, indicating that the learning product meets high-quality standards and does not require major revisions. Based on the validity analysis presented in Table 2, all assessment aspects including content feasibility, the implementation of Problem-Based Learning (PBL), feasibility in measuring creative thinking skills, and the design of the e-module achieved S-CVI/Ave and S-CVI/UA scores of 1 with an average of 100%. According to the content validity index criteria, an S-CVI value of ≥ 0.90 is categorized as highly valid, indicating that the learning product meets high-quality standards and does not require major revisions. This perfect score demonstrates full agreement among the experts (expert judgment) regarding the relevance and feasibility of the evaluated components. Therefore, this PBL-based e-module can be directly implemented in the subsequent stage, and any refinements made are minor in nature, such as terminology harmonization and consistency in language usage.

Table 5. Application of Physics Concepts of Impulse and Momentum in Karate Techniques

Physics concepts in karate technique	Description of physics concepts of impulse and momentum in karate technique
Impulse and momentum  **Figure 3.** Ura mawashi geri technique (source: personal documentation)	The ura mawashi geri technique in karate is an inside-out spinning kick directed at the opponent's head or body. From a physics point of view, this technique involves the concepts of momentum and impulse. Momentum is generated from the mass of the foot and the speed of its swing, while impulse occurs when the foot makes contact with the target in a short period of time, resulting in a large force. The faster the kick and the shorter the contact time, the greater the impulsive force transferred to the opponent. The effectiveness of the kick is greatly influenced by speed, swing angle, and proper hip rotation (Halliday, Resnick, and Walker 2014).
Impulse and momentum  **Figure 4.** Age tsuki technique (upward punch) (Source: Personal Documentation)	In karate techniques such as age tsuki (upward punch), the physics concepts of impulse and momentum are crucial in understanding the effectiveness of strikes. Momentum is the result of mass times velocity ($p = mv$), and in karate, a practitioner tries to maximize the momentum of a punch by combining body strength, hip rotation, and hand movement in synchronization. When the punch hits the target, a sudden change in momentum occurs in a very short period of time. This is where the concept of impulse comes into play: impulse is force times time ($I = F\Delta t$), which is equivalent to a change in momentum (Serway & John W. Jewett, 2018). By shortening the time of impact (Δt), for example with a sharp and fast strike, the force exerted on the opponent becomes greater. This explains why fast, focused punches such as age tsuki can produce significant impact despite being performed with a relatively small body mass. This technique reflects the application of the principle of conservation of momentum and the relationship between impulse and force in the mechanical system of the human body.
Perfect bouncy collision  **Figure 5.** Karateka undergoes perfect bouncing ($e = 1$) upon collision (source: personal documentation)	In physics, a perfect collision occurs when two objects collide with no loss of kinetic energy, with a coefficient of restitution of $e = 1$. In the context of karate, this situation can occur when two karateka collide with each other in training or competition-for example, when their arms collide with each other at opposite speeds and directions. In a perfect collision, the kinetic energy before and after impact remains the same, and both objects bounce back without permanent deformation. Although the human body is not an ideal rigid body, certain body parts such as bones and joints can approach perfect bouncy behavior under certain conditions, especially when contact is fast and elastic. This understanding is important in designing defense and attack techniques to minimize injuries and control impact forces.(Halliday, Resnick, & Walker, 2014).

The validation results presented in that all comments and suggestions from the seven validators were fully accepted and implemented. The revisions covered various aspects, including: restructuring paragraphs for better readability with the addition of supporting media such as images or videos; adjusting the measurement units in questions and removing extreme values in answer options; limiting the number of questions to 10–15 items to avoid learner fatigue; aligning physics concepts with the context of karate; adding up-to-date references (within the last 5 years); improving learning objectives based on the ABCD method; incorporating momentum and impulse content more comprehensively; refining the STEM content and adding core competency indicators; enhancing concept maps, LKPD components, and author profiles; adding visual engagement through videos of karate training or matches; and correcting all typographical errors thoroughly. With these revisions, the e-module is declared highly valid and feasible for implementation, with no major revisions required. This perfect score demonstrates full agreement among the experts (expert judgment) regarding the relevance and feasibility of the evaluated components. Therefore, this PBL-based e-module can be directly implemented in the subsequent stage, and any refinements made are minor in nature, such as terminology harmonization and consistency in language usage.

The validation results presented in that all comments and suggestions from the seven validators were fully accepted and implemented. The revisions covered various aspects, including: restructuring paragraphs for better readability with the addition of supporting media such as images or videos; adjusting the measurement units in questions and removing extreme values in answer options; limiting the number of questions to 10–15 items to avoid learner fatigue; aligning physics concepts with the context of karate; adding up-to-date references (within the last 5 years); improving learning objectives based on the ABCD method; incorporating momentum and impulse content more comprehensively; refining the STEM content and adding core competency indicators; enhancing concept maps, LKPD components, and author profiles; adding visual engagement through videos of karate training or matches; and correcting all typographical errors thoroughly. With these revisions, the e-module is declared highly valid and feasible for implementation, with no major revisions required.

The Dissemination Stage

The dissemination stage is carried out after the learning device product is developed and validated. At this stage, the product is disseminated to relevant parties, such as teachers and learners, to be used in a wider learning context Tabel 5.

Based on the results of pretest and posttest data analysis through the N-Gain test on the use of STEM-based e-modules in physics learning with the context of karate sports on impulse and momentum material, the average N-Gain is 0.72, which is in the medium to high category according to Hake's classification (1998). These results indicate that the e-modules developed are quite effective in improving student learning outcomes.

Table 6. N-Gain Analysis

Aspect	Pretest	Postest	N-gain	Category
Fluent thinking	29.85	92.05	0.89	High
Flexibility	30.58	89.52	0.85	High
Original	33.09	72.33	0.59	Medium
Elaboration	36.26	77.69	0.65	Medium
Average	32.45	82.90	0.72	

The fluent thinking aspect obtained an N-Gain value of 0.89, which is included in the high category. This shows that students have increased their ability to generate many ideas or solutions in a short time, especially when asked to explain the concept of impulse and momentum in the context of karate movements. According to Guilford (2018), fluent thinking is the ability to express various relevant responses to a stimulus, which is very important in creative learning. The use of a STEM approach that integrates real contexts, such as karate movements, allows students to think faster and more flexibly because they are directly involved cognitively and physically (Bybee, 2013).

The flexibility aspect shows an N-Gain value of 0.85, also in the high category. This increase indicates that students are able to switch from one approach to another in solving problems or understanding concepts, for example by explaining collisions from various perspectives: as momentum, as force, or in the framework of Newton's laws. Sternberg & Lubart (1995) stated that flexibility in thinking is a characteristic of learning that encourages creative problem solving, and project-based approaches such as STEM e-modules are very effective in fostering this skill. The originality aspect has an N-Gain value of 0.59, which is in the moderate category. This shows that students' ability to generate new or unique ideas is starting to increase, although not yet optimal. In abstract physics learning, the integration of real contexts such as karate provides different stimuli so that students begin to develop personal interpretations of concepts such as impulse or impact force. This is in line with Torrance's theory (1977) which emphasizes that the originality of ideas is triggered by a stimulating and contextually relevant learning environment.

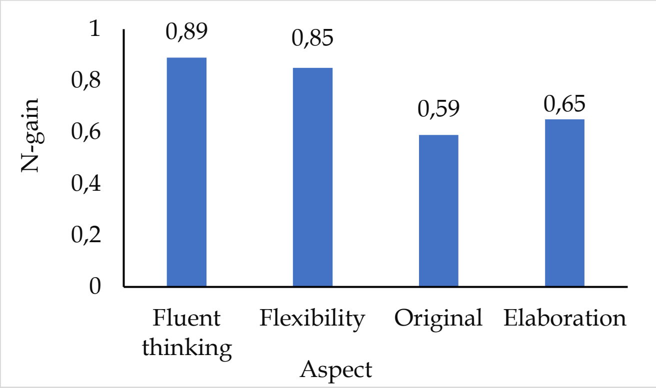


Figure 6. Graph of Analysis of Students' Creative Thinking Skills

The elaboration aspect received an N-Gain value of 0.65, also in the moderate category. This value indicates an increase in students' ability to develop or detail ideas in more depth, for example in explaining how rotating movements in karate can produce large changes in momentum. According to Treffinger et al. (2002), elaboration is an important indicator in creative thinking because it shows the depth of understanding of concepts. With the help of interactive e-modules that present visualizations and concrete examples, students can expand their understanding of the material.

Conclusion

This study successfully developed and described a Science, Technology, Engineering, and Mathematics (STEM) learning model integrated with physics learning to improve students' creative thinking skills in the concept of impulse and momentum. The results of the analysis showed that the integration of STEM with the context of karate sports as a medium for learning physics contributed positively to students' conceptual understanding and encouraged the development of creative thinking aspects, such as fluent thinking, flexibility, originality, and elaboration. The model underwent rigorous expert validation, achieving perfect scores (S-CVI/Ave = 1.00, S-CVI/UA = 1.00, CVR = 1.00), indicating excellent relevance, clarity, and feasibility. The N-Gain test data showed a significant increase in student learning outcomes, with an average N-Gain value of 0.72 (high category). The highest increase was in the aspects of fluent thinking (0.89) and flexibility (0.85), which showed that students were able to think fluently and adaptively in understanding physics concepts contextually. The aspects of originality (0.59) and elaboration (0.65) also showed positive developments that reflected the growth of students' abilities in expressing new ideas and expanding explanations of physical phenomena. Thus, it can be concluded that the implementation of STEM-based learning that utilizes karate as a contextual medium has proven effective in enhancing creativity, while making physics learning more meaningful, applicable, and connected to real life. These findings support the importance of an interdisciplinary and contextual approach in teaching complex physics concepts. Beyond karate, this model holds promising potential for adaptation in other sports or kinetic-based activities, such as taekwondo, basketball, or athletics, to contextualize physics learning and further stimulate students' creativity and problem-solving skills

Acknowledgments
The author would like to thank all Prof. Dr. Ida Sriyanti, M.Si as supervisor I and Dr. Wahyu Indra Bayu, M.Pd as supervisor II, lecture and validators who very instrumental in providing direction and guidance in this research.

Author Contributions
Author 1 (Researcher), Author 2 (Supervisor I), Author 3 (Supervisor II)

Funding
Own costs.

Conflicts of Interest
No conflicts of interest

References

Aninnas, A., Subali, B., & Widiyatmoko, A. (2023). Pengembangan E-Modul Zat Aditif dan Adiktif Berbasis Etnosains untuk Meningkatkan Kreativitas Ilmiah Siswa SMP. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 998–1007. https://doi.org/10.29303/jppipa.v9ispecialissue.4307

Ardi, S., & Marlina, I. (2025). Analysis Development E-Worksheet Based PBL-STEM Approach with a Assisted by Nanofiber Membrane Media on Renewable Energy Materials to Improve Students' Creative Thinking Abilities. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 466–473. https://doi.org/10.29303/jppipa.v11i2.8397

Armandita, P., Wijayanto, E., Rofiatus, L., Anisma Susanti, Rumiana, & Samanta. (2017). Analisis Kemampuan Berpikir Kreatif Pembelajaran Fisika Di Kelas XI MIA 3 SMA Negeri 11 Kota Jambi. *Jurnal Penelitian Ilmu Pendidikan*, *10*(2), 129. https://doi.org/10.21831/jpipfip.v10i2.17906

Aryantara, E., Kurniawan, W. R., Setiawan, I., & Adi, S. (2024). Model Latihan Tendangan Mawashi Geri Menggunakan Media Gawang Untuk Siswa Ekstrakurikuler Karate di SMP Kabupaten Demak. *Indonesian Journal for Physical Education and Sport*, *5*(1), 287–296. Retrieved from

https://shorturl.asia/624wY
Bybee, R. W. (2013). The Case for Education: STEM Challenges and Opportunities. In *NSTA (National Science Teachers Assocation) Press*. Arlington: NSTA (National Science Teachers Assocation) Press. Retrieved from www.nsta.org/permissions.
Ciptayani, P. P. (2021). *Profil Keterampilan Kolaborasi Siswa SMA Negeri 5 Denpasar* (p. 2021). p. 2021. Bali: Universitas Pendidikan Ganesha. Retrieved from http://repo.undiksha.ac.id/id/eprint/7654
Creswell, J. W. (2019). *Educational Research Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (4th ed.). Lincoln: John W. Creswell University of Nebraska.
Dani, R., Murniati, M., & Evendi, E. (2021). Application of the Guided Inquiry Model to Improve Student's Motivation and Creativity. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 642–650. https://doi.org/10.29303/jppipa.v7i4.783
Dick, W., Carey, L., & O.Carey, J. (2015). *The Systematic Design of Introduction* (7th ed.). Upper Saddle River: Pearson. Retrieved from https://efaidnbmnnnibpcajpcglclefindmkaj
Doyan, A., Susilawati, S., & Hardiyansyah, H. (2020). Development of Natural Science Learning Tools with Guided Inquiry Model Assisted by Real Media to Improve Students' Scientific Creativity and Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *7*(1), 15–20. https://doi.org/10.29303/jppipa.v7i1.485
Guilford, J. P. (2018). The Nature of Human Intelligence. *The Nature of Human Intelligence*, 1–335. https://doi.org/10.1017/9781316817049
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. https://doi.org/10.1119/1.18809
Halliday, D., Resnick, R., & Walker, J. (2014). Fundamentals of Physics Halliday & resnick 10ed. In *Wiley* (10Th ed.). The United States of America: Cleveland State University.
Hardiyansyah, A., Doyan, A., Jufri, A. W., Susilawati, S., & Jamaluddin, J. (2019). Analysis of Validation Development of Learning Media of Microscope Digital Portable Auto Design to Improve Student Creativity and Problem-Solving Ability. *Jurnal Penelitian Pendidikan IPA*, *5*(2), 228–232. https://doi.org/10.29303/jppipa.v5i2.273
Heryani, T. P., Suwarma, I. R., & Chandra, D. T. (2023). Development of STEM-Based Physics Module with Self-Regulated Learning to Train Students Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4245–4252. https://doi.org/10.29303/jppipa.v9i6.3578
Kartikasari, M., Ismet, I., & Sriyanti, I. (2023). Development of an E-Module Based on the 5E Learning Cycle to Improve the Creative Thinking Abilities of Junior High School Students. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 121–129. https://doi.org/10.29303/jppipa.v9ispecialissue.6528
Kepmendikbudristek. (2024). *Capaian Pembelajaran Pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah Pada Kurikulum Merdeka*. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.
Knebel, M. T. G., da Costa, B. G. G., dos Santos, P. C., de Sousa, A. C. F. C., & Silva, K. S. (2022). The conception, content validation, and test-retest reliability of the Questionnaire for Screen Time of Adolescents (QueST). *Jornal de Pediatria*, *98*(2), 175–182. https://doi.org/10.1016/j.jped.2021.05.004
Kosasih. (2021). *Pengembangan Bahan Ajar* (B. S. Fatmawati, Ed.). Jakarta: PT Bumi Aksara.
Lee, H. Y., Hooshyar, M., Lin, C. J., Wang, W. S., & Huang, Y. M. (2023). Image4Assess: Automatic learning processes recognition using image processing. *Proceedings of the ACM Symposium on Applied Computing*, (June 2024), 11–16. https://doi.org/10.1145/3555776.3577643
Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). STEM: Country comparisons. Report for the Australian Council of Learned Academies. In *Australian Council of Learned Academies (ACOLA)*, 2. Retrieved from http://www.voced.edu.au/content/ngv56992%5Cnwww.acola.org.au%0Ahttp://www.voced.edu.au/content/ngv56992
Marlina, L., Paramitha, G. P., & Sriyanti, I. (2022). Development of Electronic Modules Based on Critical Thinking Skills on Vibration, Waves, and Sound Materials for Junior High School Students. *Jurnal Pendidikan Sains Indonesia*, *10*(2), 342–354. https://doi.org/10.24815/jpsi.v10i2.23844
Martina, M. Y., & Hau, R. R. H. (2021). Identifikasi pemahaman konsep impuls dan momentum pada siswa kepeminatan fisika. *Jurnal Pendidikan Fisika Dan Sains*, *2*(2). Retrieved from https://jurnal.nusanipa.ac.id/index.php/intelligentes/article/view/198
Mesci, G., & Erdaş Kartal, E. (2021). STEM-Based NOS Teaching on 7th Grade Students' NOS Views. *MESCİ,Günkut ERDAŞ-KARTAL, Eda*, *16*(3), 272–298. https://doi.org/10.29329/epasr.2021.373.14
Nazhifah, N., Wiyono, K., & Ismet, I. (2023). Development of STEM-Based E-Learning on Renewable Energy Topic to Improve the Students

Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9575–9585. https://doi.org/10.29303/jppipa.v9i11.5206

Nazifah, N., & Asrizal, A. (2022). Development of STEM Integrated Physics E-Modules to Improve 21st Century Skills of Students. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2078–2084. https://doi.org/10.29303/jppipa.v8i4.1820

Noviana, R. A. S. (2024). *BERFIKIR KRITIS-KREATIF, MANDIRI: Kunci Sukses Peserta Didik di Era Global* (1st ed.). Palembang: Yayasan Pendidikan Lambang Budi Bakti Alumnika (YPLBBA).

Nugroho, P. S., Nasir, M., Syafi'i, M., & Erviyenni, E. (2023). Profile Perception of Student's Collaboration and Creative Thinking Skills in Physics. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 775–779. https://doi.org/10.29303/jppipa.v9i2.3055

Nurita, T., Yuliati, L., Mahdiannur, M. A., Ilhami, F. B., Fauziah, A. N. M., Hendratmoko, A. F., & Puspitarini, S. (2024). Increasing Pre-service Science Teacher Creativity Through STEM Problem-Solving. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 72–79. https://doi.org/10.29303/jppipa.v10i1.6335

Onsardia, Ranidiahb, F., & Bahrun, K. (2019). Human resource competencies in the era of globalization. *International Conference on Islamic Studies, 14th February 2019. Bengkulu Indonesia,* 213–223. Retrieved from https://osf.io/preprints/dsh97/

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049–1079. https://doi.org/10.1080/0950069032000032199

Prananto, I. W., Rakhmawati, Y., & Pamungkas, T. (2022). Content Validity Ratio (CVR), Content Validity Index (CVI), and Confirmatory Factor Analysis (CFA) in Mathematics Learning Independence Instruments. *Kontinu: Jurnal Pe*, *6*(8), 14–20. https://doi.org/10.56304/s0040363622080021

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223–231. https://doi.org/10.1002/j.2168-9830.2004.tb00809.x

Purnama, S. (2016). Metode Penelitian Dan Pengembangan (Pengenalan Untuk Mengembangkan Produk Pembelajaran Bahasa Arab). *LITERASI (Jurnal Ilmu Pendidikan)*, *4*(1), 19. https://doi.org/10.21927/literasi.2013.4(1).19-32

Putri, A. S., Prasetyo, Z. K., Purwastuti, L. A., Prodjosantoso, A. K., & Putranta, H. (2023). Effectiveness of STEAM-based blended learning on students' critical and creative thinking skills. *International Journal of Evaluation and Research in Education*, *12*(1), 44–52. https://doi.org/10.11591/ijere.v12i1.22506

Rahmadani, D., Siagian, P., & Napitupulu, E. (2019). Pengembangan Perangkat Pembelajaran Berbasis Masalah Untuk Meningkatkan Kemandirian Belajar Siswa Sma Negeri 2 Binjai. *Paradikma Jurnal Pendidikan Matematika*, *12*(2), 1–5.

Ratnasari, R., Doyan, A., & Makhrus, M. (2023). Development of STEM Integrated Project-Based Learning Tools on Temperature and Heat Material to Improve Students' Generic Science Skills and Creativity: Feasibility Test. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 6992–6999. https://doi.org/10.29303/jppipa.v9i9.4178

Rusman. (2011). *MODEL-MODEL PEMBELAJARAN : Mengembangkan Profesional Guru*. Jakarta: Rajawali Pers.

Schweingruber, M. H. G. P. H. (2014). *STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research STEM Integration in K-12 Education Status, Prospects, and an Agenda for Research*. The National Academies Press. https://doi.org/https://doi.org/10.17226/18612

Serway, R. A., & John W. Jewett, J. (2018). *Physics for Scientists & Engineers & Modern Physics* (9th ed.). United States Of America: United States of America. Retrieved from https://digilib.unkhair.ac.id/706/1/Physics_for_Scientists_Engineers_Modern9_text_OK.pdf

Sternberg, R. J., & Lubart, T. I. (1995). *Defying the Crowd: Cultivating Creativity in a Culture of Conformity*. The Free Press.

Sucilestari, R., Ramdani, A., Sukarso, A., Susilawati, S., & Rokhmat, J. (2023). Project-Based Learning Supports Students' Creative Thinking in Science Education. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 1038–1044. https://doi.org/10.29303/jppipa.v9i11.5054

Sujatmika, S., Lestari, E. S., & Affandy, H. (2022). Systematic Literature Review on Creativity in the Field of Science Learning: Domain, Research Trends, and Their Analysis. *Edusains*, *14*(1), 34–49. https://doi.org/10.15408/es.v14i1.23526

Sung, Y. T., Chang, K. E., & Liu, T. C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers and Education*, *94*, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Syukri, M., Yanti, D. A., Mahzum, E., & Hamid, A. (2021). Development of a PjBL Model Learning Program Plan based on a STEM Approach to Improve Students' Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *7*(2), 269–274.

https://doi.org/10.29303/jppipa.v7i2.680

Tam, C. O. (2023). Integrating Creative Thinking Skills Pedagogies into a Higher Education Visual Arts Course. *International Journal of Art & Design Education*, *42*(1). https://doi.org/http://dx.doi.org/10.1111/jade.12452

Tang, T., Vezzani, V., & Eriksson, V. (2020). Developing critical thinking, collective creativity skills and problem solving through playful design jams. *Thinking Skills and Creativity*, *37*(January 2021). https://doi.org/10.1016/j.tsc.2020.100696

Torrance, E. P. (1977). Creativity in the classroom: What research says to the teacher. In *The Cambridge Handbook of Creativity*.

Treffinger, D. J., Young, G. C., Selby, E. C., & Shepardson, C. (2002). Assessing Creativity: A Guide for Educators. In *Journal of Education and Learning*. Retrieved from http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED505548%0Ahttp://dx.doi.org/10.1007/s41465-016-0002-3

Tyukavina, A., Potapov, P., Hansen, M. C., Pickens, A. H., Stehman, S. V., Turubanova, S., … Harris, N. (2022). Global Trends of Forest Loss Due to Fire From 2001 to 2019. *Frontiers in Remote Sensing*, *3*(March), 1–20. https://doi.org/10.3389/frsen.2022.825190

Wulandari, D., Hariyono, E., Suprapto, N., Hidaayatullaah, H. N., & Prahani, B. K. (2021). Profile of students' creative thinking skills on global warming material: Gender perspective in physics learning. *Journal of Physics: Conference Series*, *2110*(1), 0–7. https://doi.org/10.1088/1742-6596/2110/1/012028

Yanti, N., Rahmad, M., & Azhar. (2023). Application of PjBL (Project Based Learning) Based Physics Learning Model to Improve Collaboration Skills and Creative Thinking Ability of Students. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9973–9978. https://doi.org/10.29303/jppipa.v9i11.5275

Zubaidah, S. (2018). STEM : Apa , Mengapa , dan Bagaimana. *Prosiding Semnas Pend IPA Pascasarjana UM, 1*, 976-984. Retrieved from https://shorturl.asia/H6Jy5

Zubaidah, S., Fuad, N. M., Mahanal, S., & Suarsini, E. (2017). Improving creative thinking skills of students through Differentiated Science Inquiry integrated with mind map. *Journal of Turkish Science Education*, *14*(4), 77–91. https://doi.org/10.12973/tused.10214a