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Research Article

Mapping Students' Misconceptions in Momentum and Impulse: A Systematic Literature Review of Conceptual Understanding and Instructional Interventions

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ABSTRACT

Purpose of the study: This study aims to identify and analyze students' misconceptions regarding momentum and impulse through a Systematic Literature Review (SLR), focusing on patterns of misconceptions, difficulties in conceptual understanding, and effective instructional interventions reported in previous studies.

Methodology: This study employed a PRISMA-based Systematic Literature Review design. Articles were collected from Scopus-indexed journals, SINTA-accredited journals, ERIC, Taylor & Francis, ResearchGate, and Google Scholar published between 2018 and 2025. The article selection process used purposive sampling based on predefined inclusion and exclusion criteria. From 1,032 identified articles, 8 eligible studies were selected for analysis. Data were collected through document analysis and analyzed using thematic analysis and narrative synthesis.

Main Findings: The findings indicate that students' conceptual understanding of momentum and impulse remains low, while misconceptions persist in force–time–impulse relationships, graphical interpretation, momentum conservation, and momentum–energy integration. Most misconceptions originate from an incomplete understanding of Newtonian mechanics and fragmented conceptual structures. Several instructional approaches, including multiple representations, knowledge integration, cognitive conflict, conceptual change text, and demonstration-based learning, were found effective in reducing misconceptions and improving conceptual understanding.

Novelty/Originality of this study: This study provides a focused synthesis of misconception patterns specifically in momentum and impulse topics and emphasizes the importance of conceptual integration-based instruction in reducing persistent misconceptions in physics learning.

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1. INTRODUCTION

Conceptual mastery is a fundamental aspect of physics learning because it serves as the basis for students to build meaningful scientific knowledge and forms the foundation for 21st-century skills [1]. These skills play a crucial role in reducing misconceptions [2], facilitating students' ability to connect various pieces of knowledge to find effective solutions [3], [4], and discovering alternative answers to problems they face [5]. With a strong understanding, students can align their intuitive understanding with the new concepts they are learning [6]. This becomes increasingly relevant in learning that is closely tied to everyday life, such as in the topics of momentum and impulse [7].

Impulse momentum is a key concept that students need to master, as it involves fundamental principles that are relevant to everyday life [8]. Furthermore, this topic is discussed in relation to force, velocity, mass, and their relationship to time [9]. It is also a fundamental topic in physics education. Consequently, many studies have chosen impulse momentum as their research topic.

However, evidence from the field still shows that students, including prospective physics teachers, often hold misconceptions about basic concepts [10], particularly regarding momentum and impulse. These misconceptions hinder prospective teachers' ability to apply concepts to new situations [9], solve problems, and explain physical phenomena scientifically [11]. This is caused by errors in thinking schemes [12], limitations in basic mathematical skills [13], and a tendency to emphasize solving numerical problems without being able to explain the conceptual reasons behind them [14]. These various findings need to be summarized in a systematic literature review to comprehensively map the patterns of causes of misconceptions regarding momentum and impulse. This condition indicates that misconceptions regarding momentum and impulse remain a serious problem in physics learning because students are still unable to integrate force, time, momentum, and impulse concepts consistently.

A systematic literature review discussing misconceptions in physics has been conducted by [15], while the development of diagnostic instruments to detect misconceptions; however, research focusing on the misconceptions of pre-service teachers regarding momentum and impulse remains scarce. Furthermore, previous studies tend to remain general across various physics topics or emphasize instrument development without deeply examining specific misconception patterns in a particular subject. Previous studies mainly focused on misconception diagnosis and remediation broadly in physics learning, while limited reviews specifically synthesized misconception patterns and conceptual integration difficulties in momentum and impulse concepts [17] [18]. In addition, previous studies rarely explain how fragmented conceptual structures contribute to students' failure in integrating force, impulse, momentum, and energy concepts [9]. Furthermore, limited studies have systematically synthesized instructional approaches that are effective in overcoming misconceptions specifically in momentum and impulse learning. Therefore, a more focused systematic literature review is needed to comprehensively identify misconception patterns and conceptual change strategies related to momentum and impulse concepts. In fact, each physics topic has distinct conceptual characteristics, allowing for the emergence of unique misconception patterns. On the other hand, there have been few studies that systematically integrate various empirical findings to identify trends, similarities, or differences in the causes of misconceptions, particularly in the context of prospective physics teachers. This gap indicates that a more focused and comprehensive study is needed to specifically uncover the forms of misconceptions and their underlying factors in the topics of momentum and impulse. Thus, this study aims to fill this gap through a more targeted and in-depth systematic literature review approach.

This article aims to provide a comprehensive overview Specifically, this study aims to identify dominant misconception patterns regarding momentum and impulse concepts and analyze instructional approaches that are effective in improving students' conceptual understanding based on previous empirical studies. The analysis of pre-service teachers' misconceptions regarding momentum and impulse. Through a systematic literature review, this study investigates the patterns and causes of these misconceptions by addressing two main questions: "What are the misconceptions held by pre-service teachers regarding momentum and impulse, and what are the causes of these misconceptions?" The results of this study are expected to serve as a reference and an important consideration for the development of future research in the field of physics education. The findings of this study are expected to contribute theoretically to the development of conceptual understanding research in physics education and practically to support educators in designing instructional strategies that effectively reduce misconceptions regarding momentum and impulse concepts.

2. RESEARCH METHOD

This study employed a *Systematic Literature Review* (SLR) design. This study used a qualitative review approach based on the PRISMA 2020 guidelines to systematically identify, evaluate, and synthesize previous studies related to students' misconceptions regarding momentum and impulse concepts. The SLR method was used to identify, evaluate, and summarize research findings related to pre-service physics teachers' misconceptions regarding momentum and impulse. The study was conducted by collecting journals indexed in Scopus and those with a minimum Sinta 3 ranking, using a systematic review selection protocol based on the PRISMA guidelines adapted from [3]. The article selection process employed purposive sampling, in which articles were selected based on predefined inclusion and exclusion criteria to ensure their relevance to the research objectives.

To ensure that this study is systematic, logical, and replicable, the SLR steps followed the PRISMA 2020 protocol as well as the SLR steps outlined by Kitchenham, which include: formulating research questions, developing a literature search strategy, determining inclusion and exclusion criteria, article selection process, quality appraisal, data extraction, and data analysis and synthesis. Through the PRISMA steps, articles were successfully collected from several databases, namely Google Scholar, ERIC, Scimago, ResearchGate, Taylor and Francis, Academia, and directly from Google search results. The search was limited to the period 2018–2025 (the last 7 years) using the keywords "misconceptions and impulse momentum." The researchers also used the keyword "conceptual understanding ability" because misconceptions are closely related to conceptual understanding ability. Data collection was conducted through document analysis of scientific articles obtained from several academic databases, including Scopus, ERIC, Taylor & Francis, ResearchGate, Google Scholar, and SINTA-accredited journals.

To improve the comprehensiveness of the search strategy, these keywords were combined with Boolean operators to make the search more systematic, such as: (“misconception” AND “momentum” AND “impulse”) OR (“conceptual understanding” AND “momentum impulse”) OR (“physics education” AND “misconception”). In addition, synonym variations such as “misunderstanding,” “alternative conception,” and “conceptual difficulties” were also used to broaden the scope of the article search. The article selection process is shown in Figure 1.

To answer the research questions, the researcher conducted a selection process involving inclusion and exclusion criteria to ensure that only truly relevant articles were used. The inclusion and exclusion criteria in this study were not only implied in the selection process but were also explicitly defined based on year of publication, article type, research subject, contextual material, and language used. The inclusion and exclusion criteria are presented in Table 1.

Table 1. Inclusion and Exclusion Criteria

Aspect	Inclusion Criteria	Exclusion Criteria
Year of publication	2018–2025	Outside the year range
Article type	Scientific journal (*peer-reviewed*)	Proceedings, thesis, opinion
Subject	Physics students/prospective teachers	In addition to students
Topic	Momentum and impulse	Other physics topics
Research focus	Misconceptions & conceptual understanding	Does not address misconceptions
Language	Indonesian & English	Other languages

The flowchart of the screening stages is presented in Table 1. From the initial search using various online databases, 1,032 articles were obtained, consisting of 605 from Scopus, 90 from Google Scholar, 135 from ERIC, 100 from ResearchGate, and 102 from Taylor and Francis. The screening procedure is visualized in the flowchart in Figure 1.

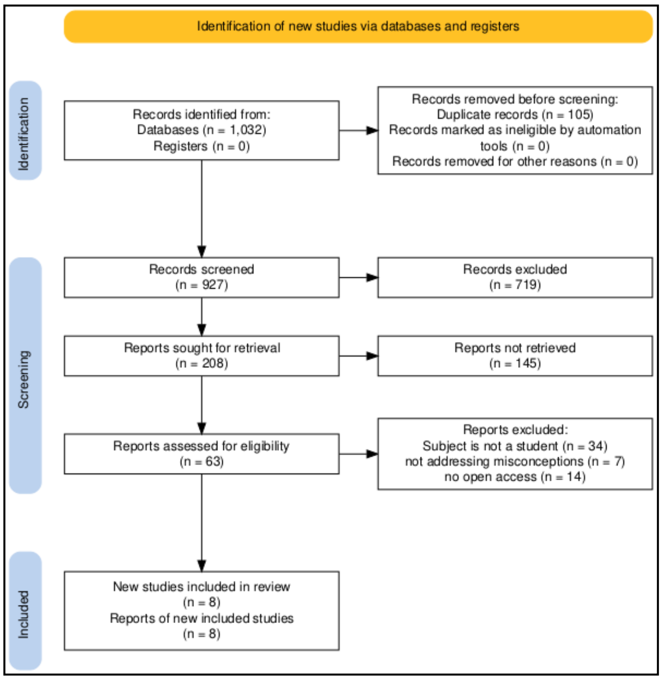

Figure 1. Flowchart of inclusion and exclusion criteria for the Systematic Literature Review

All the collected articles were then imported into Microsoft Excel, and duplicates were removed using the "Remove Duplicates" feature. As a result of this step, 105 articles were identified as duplicates from various sources, reducing the total number of articles to 927.

Next, the articles were screened based on their titles to assess their relevance to the research focus, resulting in 208 relevant articles at this stage. The researcher then reviewed the abstracts of these 208 articles to ensure that the research content aligned with the context under study. During this process, 145 articles were eliminated because their abstracts indicated that the presented research did not address the research questions. Further analysis was conducted on the remaining 63 articles, and 55 of these were subsequently excluded due to various considerations, such as the subjects not being students and the studies not specifically addressing misconceptions. Consequently, the final number of articles deemed suitable for in-depth analysis was 8. These eight articles became the primary data sources analyzed in this systematic literature review. This study focuses on answering the following research questions:

1. What have been students' misconceptions regarding momentum and impulse over the past seven years?
2. What learning strategies or approaches are effective in addressing pre-service physics teachers' misconceptions regarding momentum and impulse based on previous research findings?

In addition, to clarify the direction of the analysis, this study employs a conceptual framework that links misconceptions, conceptual understanding, and instructional interventions. Within this framework, misconceptions are viewed as factors that contribute to low levels of conceptual understanding, while instructional interventions serve as solutions to address these misconceptions, thereby improving conceptual understanding. In this study, misconceptions refer to scientifically inaccurate or incomplete understandings of momentum and impulse concepts, while conceptual understanding refers to students' ability to consistently explain and apply physics concepts across different contexts and representations.

All articles that passed the selection stage were then assessed for methodological quality to ensure that the analyzed data came from credible sources. The quality assessment was based on several indicators, namely: clarity of research objectives, appropriateness of methods, clarity of research instruments, data validity and reliability, and clarity of results and discussion. Particular attention was also given to the validity and reliability of the instruments used in the reviewed studies to ensure that the analyzed findings were derived from methodologically sound research. The articles are then categorized into three quality levels: high, moderate, and low. Only articles of moderate and high quality are used in further analysis. Following the selection and quality assessment process, data from each article are systematically extracted to facilitate analysis. The variables extracted include the author, year of publication, research method, sample size, findings on misconceptions, and the learning strategies employed.

The data obtained were analyzed using a thematic analysis and narrative synthesis approach. Thematic analysis was used to identify patterns of misconceptions that emerged across various studies, while narrative synthesis was used to summarize and compare the various learning strategies employed to address these misconceptions. This approach was chosen because the data analyzed is qualitative and diverse, making a quantitative meta-analysis impractical. Therefore, thematic analysis and narrative synthesis were considered the most appropriate approaches because the reviewed studies varied in research design, instruments, and reported findings. To enhance transparency, the entire research process is described in detail, ranging from search strategies, the use of keywords and Boolean operators, inclusion and exclusion criteria, to the article selection process using the PRISMA diagram. Additionally, the list of analyzed articles can be provided as an appendix to facilitate further exploration by other researchers.

3. RESULTS AND DISCUSSION

During the period from 2018 to 2025, the researchers successfully identified 8 articles that met the criteria and aligned with the research focus. The analysis focused on identifying recurring misconception patterns, conceptual understanding difficulties, and instructional strategies reported across the selected studies. At the beginning of the selection process in 2018, there were two usable articles, but the number decreased again in 2019. The peak in relevant articles occurred in 2018, 2024, and 2025. These findings indicate that studies related to misconceptions and conceptual understanding of momentum and impulse remain relatively limited. The distribution trend of these articles is visually depicted in Figure 2.

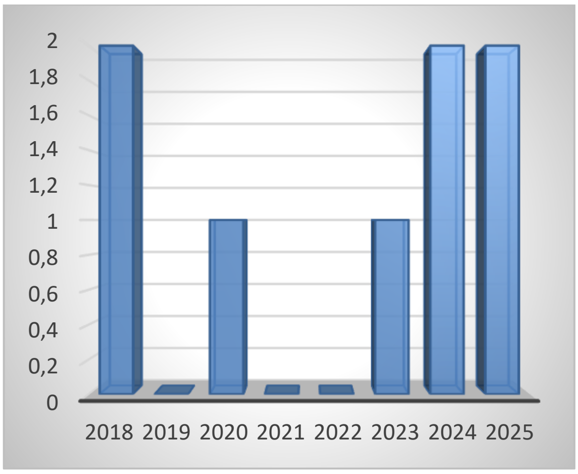

Figure 2. Distribution of research journals

Figure 2 shows that the distribution of articles on misconceptions and conceptual understanding of momentum and impulse is nearly even across each year, with 2 articles in 2018, 2024, and 2025, followed by 1 article in 2020 and 2023, and in 2019, 2021, and 2022, there were no articles relevant to the objectives of this study. This finding suggests that research specifically addressing misconceptions in momentum and impulse remains relatively limited, indicating the need for more focused investigations in this area of physics education. The article selection process in this study was conducted systematically in accordance with the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) guidelines, which include the identification, screening, eligibility, and final inclusion stages.

During the identification phase, the researcher identified a number of articles from various scientific databases using keywords relevant to the topics of misconceptions and conceptual understanding in the subject matter of momentum and impulse. From these initial search results, a total of 1,032 articles were identified Next, during the screening phase, a filtering process was conducted based on titles and abstracts to eliminate articles irrelevant to the research focus, leaving 63 articles. During the eligibility phase, the remaining articles were analyzed in greater depth by reviewing their full content to ensure they met the inclusion criteria, such as: (1) discussing momentum and impulse, (2) examining conceptual understanding or misconceptions, and (3) being empirical research articles. At this stage, several articles were excluded for failing to meet the criteria, leaving 8 articles.

The final stage is the inclusion stage, in which all articles that met the criteria were analyzed in depth in this study, resulting in a final total of 8 articles used.

Students' Conceptual Understanding and Misconceptions

To obtain a more comprehensive understanding of misconception patterns, the selected studies were analyzed based on their research focus, methods, conceptual findings, and instructional implications. Analysis of students' conceptual understanding and misconceptions by summarizing the results of various articles. This table is used to determine students' conceptual understanding and misconceptions in each study conducted. Further details are presented in Table 2.

Table 2. Tabulation of article analysis

Author	Location	Method	Variable	Results
(Rosa et al., 2018)	PGRI University of Madiun	Descriptive survey	Variables: mastery of concepts and science literacy competencies	Only 27.68% of students correctly understood the concepts and possessed science literacy; 40.18% held misconceptions. The highest incidence of misconceptions occurred regarding the concepts of impulse during a fall, one-dimensional and two-dimensional impulse, and the momentum-time graph.
[20]	Sriwijaya	*Research and*	Development	The researchers successfully

Author	Location	Method	Variable	Results
	University	*Development* (R&D)	and Validity of *Conceptual Change Texts* (CCT)	produced 21 valid and practical units of Newtonian mechanics CCTs to improve students' conceptual understanding and remediate their misconceptions. CCTs can be used in introductory physics courses and in high school mechanics instruction.
[8]	United States (Ohio State University), China (East China Normal University and high schools)	Mixed methods (quantitative and qualitative: tests, ANOVA, EFA, think-a-lots interviews)	Dependent variable: level of knowledge integration (novice, transitional, expert) Other variables: understanding of the concept of momentum, test performance, knowledge structure, question context	Students' understanding is divided into three levels: novice, transitional, and expert. The majority of U.S. students are at the transitional level, where their knowledge remains fragmented. Chinese students demonstrate a more mature integration of knowledge because their curriculum emphasizes impulse and momentum. The deepest level of understanding relates to the ability to connect force, time, impulse, and changes in momentum.
(Amira Setiani et al., 2023b)	Malang State University, Indonesia	Mixed method (descriptive: qualitative and quantitative)	Student misconceptions regarding the concepts of momentum and impulse; instrument: four-tier diagnostic test	Students' conceptual understanding remains low: 46% partially understand, 30% understand the concepts, 10% have negative misconceptions, 9% have misconceptions, and 5% have positive misconceptions. Misconceptions occur regarding: momentum, impulse, the force–time relationship, graphs, and collisions
(Rahim et al., 2024)	Malang State University, Indonesia	Descriptive using a survey method (9 multiple-choice questions with explanations, descriptive statistical analysis)	Dependent variable: level of conceptual understanding Other variables: resources (students' thinking processes when solving momentum-impulse problems)	Students' conceptual understanding of momentum and impulse remains low. The level of conceptual understanding in the Functional Understanding (MPG) category is also low, at only 13.12%. The highest level of student understanding is found in the Specific Misconception category, at 28.86%. In determining the maximum momentum, the change from the F(t) graph, not a single student achieved the level of understanding in the Sound Understanding (SU) category. The most active resource in this question is 'momentum will change when the force changes'
[23]	Mataram University,	Quantitative	Independent variables:	An interactive learning approach using demonstrations,

Author	Location	Method	Variable	Results
	Indonesia		interactive learning (impulse and impact force); dependent variables: understanding of the concept of momentum and student engagement	simulations, and exercises based on impulse and impulse energy effectively enhances students' understanding of momentum. This approach connects physics concepts to real-world phenomena, making the material more meaningful and encouraging student participation.
(Adimayuda et al., 2025)	University in Garut, Indonesia	Mixed method (convergent parallel design)	Independent variable: technology-based T-MORE model; dependent variables: conceptual understanding and misconceptions regarding momentum and impulse	The study concluded that the T-MORE model proved effective in reducing misconceptions and improving students' scientific understanding of momentum and impulse, as evidenced by a significant increase in the "scientific conception" category and a substantial decrease in the "misconception" and "no conception" categories following the instructional intervention.
(Wu et al., 2025)	University of Connecticut and Purdue University, USA	Quantitative (psychometric analysis: CTT, IRT, EFA)	Variables: students' conceptual structure regarding energy and momentum (based on EMCS), instrument quality	Three items proved to be the most problematic psychometrically. After removing these items, the 4-factor model became clearer and more stable. Energy items were divided into two clusters: (a) single-concept items, (b) mixed-concept items. The 2-factor structure (Energy vs. Momentum) remained stable and consistent with the original EMCS design. Learning gains were very low or negative, indicating the need for improvements in active pedagogy

Table 2 presents the results of an analysis of eight research articles, indicating that the rate of misconceptions among students is high and their conceptual understanding of momentum and impulse remains low. Additionally, several of the articles mentioned above propose strategies or solutions capable of improving students' conceptual understanding. Overall, the reviewed studies indicate that students' misconceptions are not isolated conceptual errors but are closely related to fragmented knowledge structures and difficulties in connecting multiple physics concepts simultaneously. Various forms of misconceptions are also highlighted in the research findings, as shown in Table 3

Table 3. Misconceptions in Momentum and Impulse Material

Author	Misconception
(Rosa et al., 2018)	The impulse when falling onto a mat is greater than when falling onto the floor. The impulse in 1D and 2D collisions is the same. Unable to correctly plot a p–t graph even though they know the formula. Mistakes in understanding the force–time–momentum relationship.
Syuhendri et al., 2018 [20]	Heavy objects fall faster than light objects. Normal force and gravitational force are considered action–reaction pairs.

Author	Misconception
	Force is proportional to velocity, not acceleration. An object will continue to move only if a force is acting on it. Rotating objects have centrifugal force as an actual force. Objects with greater mass exert a greater action force.
Wu et al., 2020 [8]	Momentum is simply p = mv, so there is no connection to impulse. Momentum is always conserved, even if the system experiences an external force. Impulse is considered a separate concept, Newton's Third Law is misunderstood; students assume that heavier objects exert greater forces. Thinking based on "surface features": choosing formulas based on the appearance of the problem, not on physical analysis.
(Amira Setiani et al., 2023b)	Momentum is influenced only by mass, not by velocity. The total momentum of an isolated system is not constant. Objects of equal mass can have different velocities during a collision, without considering the principle of conservation of momentum. Changes in velocity are influenced only by force and time, without considering the area under the force-time curve as impulse. In collisions on a smooth surface, not all objects move; motion is determined by momentum transfer and the nature of the collision (elastic/inelastic).
(Rahim et al., 2024)	Momentum changes when the force changes (not when there is an impulse or the area under the F–t curve). The F(t) graph is interpreted locally: students look at the peak force value, not the area (impulse). A constant force indicates the greatest change in momentum (even though it depends on the area, not the shape of the graph). Assuming that momentum always increases when force increases, regardless of the duration of the force.
M. Taufiq et al., 2024 [23]	Misinterpreting the graph: students focus only on the shape or slope, not its physical meaning. Assuming that a large force always produces a large impulse, when in fact impulse also depends on the duration of the collision. Assuming impulse is the same as force, when in fact impulse is the same as the change in momentum.
(Adimayuda et al., 2025)	Failing to understand the importance of the duration of the interaction; for example, an object that stops quickly is considered safer Momentum is determined only by mass Momentum is lost after a collision, especially if the object comes to a stop. Momentum depends only on force, Objects in a collision always move at the same speed after the collision. Momentum is not a vector quantity, so direction is not considered. Impulse is equal to force (equating the two). Impulse depends on initial velocity (new misconception). Momentum can exist without motion
(Wu et al., 2025)	Difficulty integrating energy and momentum (Q16). Students cannot relate momentum conservation (collisions) to energy conservation (pendulum motion). Integration of energy–momentum where momentum is conserved only when external impulse is zero (collision phase). Mechanical energy is conserved only when there are no significant non-conservative forces (swing phase) Errors in the concept of impulse–momentum (Q22, Q23). Failure to identify key variables (average force, collision time). Using kinematics/uniform linear motion when the problem involves momentum

Table 3 shows that students have many misconceptions. And judging by the pattern, these misunderstandings stem from a set of misconceptions they had encountered in the previous material on Newton's laws. It is known that momentum and impulse are closely related to Newton's Laws because momentum is mass considered in terms of velocity, while impulse is force considered in terms of the duration of an object's motion; thus, if understanding of Newton's Laws is incomplete, it will impact the understanding of momentum and impulse. Another reason for the high prevalence of student misconceptions is the incorrect identification of the central concept; students are still often confused about when to use the momentum-impulse theorem and when to use the law of conservation of momentum. These findings support the Knowledge Integration perspective, which explains that students often fail to organize related concepts into coherent conceptual frameworks. As a result, students tend to rely on memorizing formulas procedurally rather than understanding the physical meaning underlying momentum and impulse phenomena. It is important to remember that determining the presence or absence of external forces is crucial. Students must be able to determine that if the external force acting on an object is 0, then the Law of Conservation of Momentum can be used; however, if the external force acting on the object is not zero, then the impulse-momentum theorem is the appropriate solution to use.

From what has been explained, it is clear that it is crucial to improve students' conceptual understanding of momentum and impulse; this can be achieved through the use of learning strategies or approaches. Based on the articles analyzed, the following strategies or approaches are suitable for improving students' conceptual understanding of momentum and impulse.

The Multiple Representations Approach

The reason why the multirepresentational approach is a relevant solution is that it presents physics concepts through various forms of representation such as verbal descriptions, diagrams, graphs, images, tables, mathematical equations, and simulations with the aim of helping students understand concepts from multiple perspectives [26]. This diverse presentation encourages students to build connections between ideas, transfer information from one form of representation to another, and develop representational competencies that are important in physics [27]. Through the integration of various representations, students' knowledge structures become more comprehensive and are not limited to a single presentation format [28].

This approach has been shown to enhance conceptual understanding because each representation highlights specific aspects of physical phenomena; for example, diagrams clarify visualizations, graphs reveal relationships between variables, while equations provide quantitative clarity [29]. When students combine various representations, their understanding becomes more structured and deeper[30]. Furthermore, multirepresentation effectively reduces misconceptions because the consistency among representations allows students to reassess their initial understanding and correct erroneous concepts [26]. A number of studies show that multirepresentation-based learning consistently improves conceptual understanding while reducing misconceptions across various physics topics, ranging from motion to optics [26]

The Knowledge Integration Approach

According to research conducted by the Center for the Study of, the knowledge integration approach helps students synthesize various key concepts including impulse, force, duration of interaction, and changes in momentum nto a cohesive body of knowledge. Through the use of conceptual framework representation [31], [32], researchers assess how well students connect these concepts, thereby revealing whether their knowledge remains fragmented (novice), is beginning to form but is not yet complete (transition), or is already consistently organized like an expert's understanding (expert) [33], [34]. Thus, this approach not only examines the extent to which students master specific concepts but also how they connect these concepts within a logical pattern of reasoning .

This strategy is considered effective in strengthening conceptual understanding because it emphasizes the importance of relationships between concepts. When students can correctly connect various ideas, they will build a deeper understanding rather than merely memorizing [32]. Additionally, this approach makes it easier for educators to identify which parts of students' knowledge structures are still incorrect or unconnected [30], so that misconceptions—which are the source of learning errors can be addressed more effectively. Given that many misconceptions arise due to incorrect conceptual relationships for example, confusion between the effects of force, contact time, and changes in momentum [27], this integrative approach helps reorganize students' understanding so that conceptual errors can be minimized and mastery of the material improved [27].

The Cognitive Conflict Approach

The Cognitive Conflict Approach is a learning strategy that deliberately exposes students to situations or information that contradict their prior conceptions, thereby creating a cognitive dissonance that drives the reconstruction of knowledge [35], [36]. When students discover that their predictions or prior knowledge do not align with the phenomena or scientific evidence presented, they experience a state of conflict that compels them to evaluate their knowledge structure [37], [38]. This intellectual tension creates an internal drive to seek new, more coherent explanations, allowing for a more profound process of conceptual change [39], [40]. Furthermore, this approach is effective in reducing misconceptions because when students realize that their initial conceptions cannot explain the demonstrated phenomena, they become more open to accepting scientific concepts that are more logical and consistent, thereby allowing misconceptions to be permanently replaced [34]

Learning based on demonstrations/experiments, slow-motion videos, and contextual applications

Learning through demonstrations or experiments allows students to directly observe scientific phenomena, making the connection between concepts and real-world events clearer, while also creating cognitive conflict when initial predictions do not match the observed results [42] [43], which ultimately encourages conceptual reconstruction and the reduction of misconceptions; this effectiveness is reinforced through the use of videos, including slow-motion footage and animations that help visualize fast-moving phenomena or details difficult to observe directly [44] [45], and allow students to replay and review processes at their own learning pace; this has been shown to enhance conceptual understanding in recent studies, such as the research on the use of science experiment videos [35], [47], overall, the combination of demonstrations/experiments, videos, and real-world contexts provides a concrete, visual, and relevant learning experience, leading to stronger and more stable conceptual changes, as also reported in a study on the effectiveness of demonstration media and videos in science learning by [48]-[51]

The findings imply that physics instruction should emphasize conceptual integration and conceptual change rather than procedural problem-solving alone. Educators are encouraged to use multiple representations, cognitive conflict activities, conceptual change texts, and contextual demonstrations to help students meaningfully connect force, impulse, momentum, and energy concepts. In addition, diagnostic assessments such as four-tier tests can be implemented regularly to identify misconceptions early in the learning process. This study is limited by the relatively small number of eligible articles and the dominance of qualitative findings among the reviewed studies. In addition, the review only included articles published in English and Indonesian between 2018 and 2025, which may limit the generalizability of the findings. Future studies are recommended to investigate the long-term effectiveness of conceptual change-oriented instructional approaches across different educational levels and cultural contexts. Further research is also needed to explore the role of digital learning technologies and interactive simulations in supporting knowledge integration in momentum and impulse learning.

4. CONCLUSION

Analysis of eight articles published between 2018 and 2025 reveals that students' understanding of momentum and impulse remains low, while the prevalence of misconceptions is high and consistently emerges across various aspects, particularly regarding the relationship between force, time, and impulse; F–t and p–t graphs; applications of the law of conservation of momentum; and the integration of momentum and energy concepts. Most misconceptions stem from an incomplete understanding of Newton's laws, making it difficult for students to determine the conditions for applying the impulse–momentum theorem or the law of conservation of momentum. The research findings also confirm that improvements in students' understanding can be achieved through various approaches, such as knowledge integration, multi-representation, cognitive conflict, conceptual change-based remediation, and learning based on demonstrations, slow-motion videos, and contextual applications. These approaches have been proven capable of strengthening knowledge structures, improving interconceptual connections, and effectively reducing misconceptions through rich, visual, integrated, and content-based learning that reconstructs concepts. …effectively reducing misconceptions through rich, visual, integrated, and content-based learning that reconstructs concepts. Theoretically, this study contributes to physics education literature by providing a focused synthesis of misconception patterns in momentum and impulse learning and emphasizing the importance of conceptual integration in developing meaningful understanding. Practically, the findings suggest that instructional approaches based on multiple representations, knowledge integration, cognitive conflict, conceptual change texts, and contextual demonstrations are effective in reducing misconceptions and improving conceptual understanding.

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AUTHOR CONTRIBUTIONS

DAI contributed to the preparation of the original draft, including the results, discussion, methodology, and conclusions sections; S, N, and P. are responsible for correcting, reviewing, and editing the manuscript.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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