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Systematic Review: Misconceptions and Remediation on Momentum and Impulse

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ABSTRACT

This study aims to: (1) analyze the concepts that become misconceptions on momentum and impulse, (2) analyze the diagnostic test instrument used to identify students' misconceptions on momentum and impulse, (3) analyze the model/method/strategy/the approach used to remediate students' misconceptions on momentum and impulse, (4) analyze teaching materials/media used to remediate students' misconceptions on momentum and impulse, (5) analyze the effect of models/strategies/methods/media on improving students' conceptual understanding on momentum and impulse. The method applied in this research is a systematic review. The criteria for this study were article analysis carried out in a structured manner using descriptive statistical data analysis techniques for all research objectives and effect size to obtain research objective number 5. The database locations used in this study were Google Scholar, Neliti, Sinta, Garuda, Scopus, and Directory of Open Access Journals. The articles analyzed were twenty-six articles from national and international journals published in the last ten years. Based on the analysis that has been done, five research results were obtained. From the results of the study, it was found that: (1) concepts that often misconceptions are momentum, (2) Multiple choice tests with CRI and multiple-choice tests are often used to identify misconceptions on momentum and impulse, (3) model ECIRR is influential and widely used in remediation, (4) teaching materials/media that can be used for remediation are computer simulations, refutation text, and Concept Attainment-oriented worksheets, (5) the ECIRR model has a high influence on reducing misconceptions with an effect size 5,24. Based on the results of this study, a multiple-choice test instrument with the Certainty of Response Index (CRI) diagnostic test is suitable and easy to use to identify student misconceptions, to remediate misconceptions a good learning model is used, namely the ECIRR learning model, and can remediate misconceptions using computer simulations, refutation Concept Attainment oriented texts and worksheets as learning media/teaching materials.

Keywords : Systematic review; misconception; remediation; momentum and impulse.

I. INTRODUCTION

According to Delgado-Rodrigeus and Sillero-Arenas [1], a systematic review is a systematic step in bringing together research that has been researched to assess analytically and present research results with exciting subjects. It is also used to describe a particular topic more fully regarding the research to be discussed. This is done so that new research produces broad, more centred information and can scan for errors and biases in previous research. The importance of this systematic review research is carried out primarily as information for educators in knowing concepts that often-become misconceptions of students and the models/methods/strategies/approaches used to remediate these misconceptions on momentum and impulse materials.

Physics is a science that discusses the universe and how it works with scientific concepts that are always encountered in everyday life. In education, physics is one of the important subjects to learn because it is beneficial for the progress of science and technology. According to Pujianto et al. [2], as one of the sciences that holds benefits in the advancement of science and technology, students must be able to master physics well. But until now, in learning, students often experience misconceptions.

Wandersee, Mintze and Novak in Suparno [3]explained that the misconceptions experienced by students occur in all fields of physics. There are 300 misconceptions about mechanics, which is the most misconceptions in the field of physics from 700 research studies on misconceptions in physics. Most misconceptions about mechanics occur because mechanics is an essential primary material and is most widely studied in high school. Soeharto et al. [4] revealed that most misconceptions occur in students, namely in physics subjects with 33 material concepts.

According to Anam and Edie [5], one of the factors that cause misconceptions is an inappropriate learning strategy and model. Suparno [3] stated that the learning method used by educators when teaching was also one of the factors. Several other factors cause misconceptions, according to Suparno [3], namely students with initial thinking, associative speculation of students, wrong intuition of students, abilities of students, low enthusiasm for learning of students, educators who do not master the material properly and correctly, and textbooks with language that is difficult to understand. Suparno [3] states that the steps taken to overcome misconceptions are to find out the misconception that occurs in students, find out the causes of their occurrence, and find the right way to overcome them. One of the misconceptions in students is about the material of momentum and impulse. As one of the physics materials at school, momentum and impulse are complex topics because they describe the dynamics of objects regarding mass and velocity. Complex momentum and impulse materials cause many students to experience misconceptions [6]. The steps in overcoming the misconceptions, according to Suparno, have been carried out by several researchers, such as identifying students' misconceptions and their remediation of momentum and impulse materials.

Some researchers identify misconceptions that occur in the matter of momentum and impulse. After identification, the next step in reducing misconceptions is remediation. Various attempts to remediate students' misconceptions of momentum and impulse material have also been carried out by several researchers so that misconceptions that occur in students can decrease, including using the ECIRR model [7]; [8], Flipped Classroom model [9], and inquiry training model [10]. Wenning (2008), the ECIRR learning model adheres to a constructivist understanding that students learn by reconstructing their prior knowledge [11]. According to Jayanti et al. [12], the ECIRR learning model makes students accustomed to learning independently, students become more skilled in communicating and accustomed to critical thinking. Flipped Classroom is also able to reduce the occurrence of misconceptions. Kurniawan et al. [13], the flipped Classroom is effective and efficient if used in learning because students have learned before entering class. Sanjaya stated that the inquiry training learning model could also minimize misconceptions because it can focus students independently to think critically and analytically [14]. In addition to learning models, using learning media can also reduce students' misconceptions about momentum and impulse materials, such as computer simulations [15]. According to Tawil and Rusdiana [16], the advantage of learning using simulation is that it can increase the attractiveness of students to learn. There have been many studies on this misconception and its remediation on momentum and impulse materials. However, there has not been a systematic review study that summarizes these studies, for it is necessary to have systematic review research that will produce new information.

Based on this description, the researcher is interested in conducting research entitled "Systematic Review: Physics Misconceptions and Its Remediation on Momentum and Impulse Materials" with samples of scientific research articles at national and international levels. This systematic review study was conducted with the objectives of: (1) analyzing the concepts that became misconceptions in the momentum and impulse material, (2) analyzing the diagnostic test instrument used to identify students' misconceptions on the momentum and impulse material, (3) analyzing the model/method/strategy/approach applied to remediate student's misconceptions on momentum and impulse material, (4) analyze teaching materials/media used to remediate student's misconception on momentum and impulse, (5) analyze the effect of the model/strategy/media on improving student's understanding of the concepts of momentum and impulse.

II. METHOD

The method applied in this research is a systematic review. The systematic review is a study method that is carried out systematically to compare, assess and explain the results of relevant studies to produce a completer and more comprehensive conclusion.

Article searches are set in several database locations such as Google Scholar, Neliti, Sinta, Garuda, Scopus, and DOAJ (Directory of Open Access Journals). The rate criteria used in this study are inclusion and exclusion standard. The inclusion standard set were: 1) selected articles discussing misconceptions on momentum and impulse materials, 2) selected articles discussing remediation of misconceptions on momentum and impulse materials, 3) selected articles must be published in journals that have more than one indexer to the selected articles are guaranteed quality, 4) the selected articles are published in 2012-2022. The exclusion criteria set were: 1) articles that discussed misconceptions other than momentum and impulses, 2) articles published under

2012, 3) the article is not published in a national or international journal. Based on the inclusion and exclusion standard, twentysix articles were studied in this research.

The data analysis technique used is descriptive statistical analysis and effect size. Descriptive statistics in this study are used to describe the data from the samples that have been obtained. This study also used data analysis techniques in calculating the effect size. This data analysis technique is used to answer the formulation of the fifth research problem, namely the influence of the model/strategy/media on increasing understanding of the concept of momentum and impulse material. The effect size values of articles with codes A5, A16, A19 are already known in the articles being analyzed, for other articles the effect size calculation is carried out from the known data in the article. The calculation of the effect size is done using the following formula:

$$ES = \frac{X_{Posttest} - X_{Pretest}}{SD_{Pretest}} \quad (1)$$

$$ES = \frac{X_{eksperimen} - X_{kontrol}}{SD_{Kontrol}} \quad (2)$$

$$ES = \frac{(X_{Posttest} - X_{Pretest})E - (X_{Posttest} - X_{Pretest})C}{\frac{SD_{preC} + SD_{preE} + SD_{postC}}{3}} \quad (3)$$

$$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}} \quad (4)$$

$$ES = \frac{\sqrt{X^2}}{n} \quad (5)$$

description:
ES = effect size
$X_{Posttest}$ = mean posttest
$X_{Pretest}$ = mean pretest
SD = standard deviation
X_E = mean of experiment class
X_C = mean of control class
X^2 = score of X^2-test
n = Jumlah sampel
n_E = sum of experiment group
n_C = sum of control group
t = result of t-test [17]

Based on the effect size criteria Glass 1981 in Table 1:

Table 1. Effect Size benchmark

No	Effect Size	Benchmark
1	Effect size ≤ 0,15	Ignored
2	0,15 < Effect size ≤ 0,40	Low
3	0,40 < Effect size ≤ 0,75	Moderate
4	0,75 < Effect size ≤ 1,10	Very high
5	1,10 < Effect size ≤ 1,45	High influence

III. RESULTS AND DISCUSSION

The results of this study describe the answers to the formulation of the problem studied from twentysix articles. The eleven articles studied were articles published in national and international indexed journals. The other fiveteen articles are articles published in national indexed journals. The research results obtained are:

1. Concepts that become students' misconceptions of momentum and impulse materials

Articles that can be analyzed to find out students who have the misconception the momentum and impulse material are fourteen of twentysix articles. The following explains the concepts of momentum and impulse students in Table 2.

Table 2. Misconceptions students in the sub-materials of momentum and impulse

No	Concepts	Article code	Amount	Percentage
1	Momentum	A1[18] , A4[19], A6[20], A7[21], A9[22], A10[23], A15[24], A16[7], A17[9], A18[8], A20[6], A23[25], A25[26], A26[27]	14	100
2	Impulse	A1[18], A4[19], A6[20], A7[21], A9[22], A10[23], A15[24], A16[7], A18[8], A20[6], A23[25], A26[27]	12	85,7
3	Relationship of Momentum and Impulse	A1[18], A6[20], A7[21], A15[24], A16[7], A17[9], A18[8], A23[25], A25[26], A26[27],	10	71,4
4	Law of Conservation of Momentum	A6[20], A7[21], A15[24], A20[6], A23[25], A26[27]	6	42,9
5	Collision	A4[19], A6[20], A7[21], A9[22], A10[23], A15[24], A20[6], A23[25], A26[27]	9	64,3

Based on the analysis carried out and described in Table 2, five concepts become students' misconceptions in the material of momentum and impulse. The concept often wrong in the matter of momentum and impulse is momentum in 100% of the fourteen articles studied. Of these, fourteen articles discuss the findings of misconceptions about the concept of momentum. This is like the study by Hidayat et al. [21], that the most common misconception is the concept of momentum, especially momentum, in everyday life.
Based on the five concepts that are wrong in students in the momentum and impulse material, several forms of misconceptions occur. The form misconception that occurs in the concept of momentum is displayed in Table 3 below.

Table 3. Forms of students' misconceptions on the concept of momentum

No	Concept	Article code	Forms of misconceptions (students' assumptions)	Percentage
1	Momentum	A1[18], A9[22], A26[27]	Momentum is a scalar quantity	37,5
2		A9[22], A16[7]	Momentum depends on the type of object	25
3		A10[23], A16[7], A17[9], A18[8], A20[6], A26[27]	Momentum does not depend on the object's velocity	75
4		A18[8], A20[6], A26[27]	Momentum does not depend on the mass of the object	37,5
5		A16[7], A17[9]	Momentum is the driving force	25
6		A16[7], A18[8]	Momentum is the product of force and distance	25
7		A17[9]	Momentum is inversely proportional to mass	12,5
8		A18[8]	Momentum is inversely proportional to speed	12,5
9		A18[8]	Momentum is the force that results from two objects colliding with each other	12,5

Based on Table 3, the findings of misconceptions in the concept of momentum are nine forms of students' misconceptions. The most common forms of misconceptions that occur in students are 75% of the eight articles that discuss misconceptions about the concept of momentum, where students assume that momentum does not depend on the velocity, whereas the value of momentum rests on the object's velocity. Anggraeni and Sulinayah [22], the misconception that occurs in the concept of momentum is caused by students' preconceptions.

The form of students' misconceptions of the concept of impulse was examined from seven articles that discussed misconceptions on the concept of impulse. The form misconception in the concept of impulse is displayed in Table 4 below.

Table 4. Forms of students' misconceptions on the impulse concept

No	Concept	Article code	Forms of misconceptions (students' assumptions)	Percentage
1	Impulse	A10[23]	An object with a higher density causes the foot to hurt when kicking it than an object with a lower density.	14,3
2		A16[7], A18[8]	Impulse equals force.	28,6
3		A1[18], A17[9]	An example of an impulse in everyday life is that every object that has mass is then given a push.	28,6
4		A18[8]	Impulse equals short work.	14,3
5		A20[6], A26[27]	The magnitude of the impulse is affected by the velocity of the object.	28,6
6		A26[27]	Force is directly proportional to the time-lapse.	14,3

Based on Table 4, the findings of misconceptions on the concept of impulses are as many as six forms of misconceptions that occur in students. The most common misconceptions among students are three forms misconceptions, each form of misconception is 28.6% of the seven articles studied. The findings of misconceptions on the concept of impulse as many as six forms of misconceptions. There are three forms of misconception that most often occur in the concept of impulse. First, according to the students, the impulse is the same as the force, whereas the impulse is the same as the force multiplied by the change in time. This is like the research of Naning Lusiana, 2015 in Arifin et al. [7], where the cause of students assuming the same impulse with style is the fault of reasoning and intuition students. Second, according to students, examples of impulses in everyday life are any object that has mass and is then given a thrust, whereas an example of an impulse occurs when a force is applied to an object so that the object moves and occurs in a short time. Hikmatunnisa et al. [9], this form of misconception can be caused by wrong preconceptions. Third, according to students, the magnitude of the impulse is influenced by the speed of the object, whereas what affects the impulse is the force and time-lapse.

The students' misconceptions about the concept of momentum and impulse relationships were examined from six articles that discussed misconceptions at the ideas of momentum and impulse relationships. The shape of false impression that takes place withinside the idea of the momentum and impulse courting may be visible in Table 5 below.

Table 5. Forms of students' misconceptions on the concept of momentum and impulse relationships

No	Concept	Article code	Forms of misconceptions (students' assumptions)	Percentage
1	Relationship of Momentum and Impulse	A1[18], A16[7], A17[9], A18[8], A20[6], A26[27]	Impulse equals momentum.	100
2		A26[27]	The force and the change in momentum are inversely related.	16,7

Based on Table 5, the findings of misconceptions the concept of momentum and impulse relationships are as many as two forms of misconceptions that arise in students. The maximum not unusual place form of misconception is in 100% of the six articles studied, in which college students anticipate that impulse is like momentum, while the impulse is like an alternate in momentum. This is just like the outcomes of the study by Arifin et al. [7], the maximum not unusual place shape of the false impression that happens is that scholars suppose that impulse is like momentum.

The form of students' misconceptions on the concept of the law of conservation of momentum is examined from two articles that discuss the concept of the law of conservation of momentum. The form of misconception that occurs in the concept of the law of conservation of momentum displayed in Table 6 below.

Table 6. Forms of students' misconceptions on the concept of the law of conservation of momentum

No	Concept	Article code	Forms of misconceptions (students' assumptions)	Percentage
1	Law of Conservation of Momentum	A20[6]	The law of conservation of momentum only applies when objects undergo a perfectly elastic collision.	50
2		A26[27]	The law of conservation of momentum does not apply if an object collides with a soft object.	50
3		A26[27]	The law of conservation of momentum only applies to partially elastic collisions.	50
4		A26[27]	The total momentum of the object before the collision is greater than the total momentum of the object after the collision.	50

In accordance Table 6, the findings of miskonceptions in the concept of the law of conservation of momentum are as many as four forms of misconceptions experienced by students. The first form of misconception is that student's opinion that the law of conservation of momentum only occurs when objects experience a perfectly elastic collision. Second, students argue that the law of conservation of momentum does not occur if an object collides with a soft object. Third, students argue that the law of conservation of momentum only applies to partially elastic collisions. The truth is that the law of conservation of momentum applies to all types of collisions. Fourth, students assume that the amount of momentum of objects before a collision is greater than the amount of momentum of objects after a collision, even though the law of conservation of momentum applies at the time of the collision (the momentum of the object before the collision is the same as the momentum of the object after the collision). When the collision applies the law of conservation of momentum (the object's momentum before the collision is the same as the object's momentum after the collision). Each form of the misconception that occurs is 50% of the two articles studied.

The form of students' misconceptions about the collision concept was examined from four articles that discussed the collision concept. The form of misconception that occurs in the collision concept displayed in Table 7 below.

Table 7. Forms of students' misconceptions on the collision concept

No	Concept	Article code	Forms of misconceptions (students' assumptions)	Percentage
1	Collision	A9[22]	A completely inelastic collision occurs when the masses of the two objects are the same.	25
2		A10[22]	After a collision, an object with a greater mass will acquire a greater force.	25
3		A20[6]	Two objects with the same mass when they collide must have a perfectly inelastic collision.	25
4		A20[6], A26[27]	A partially elastic collision is characterized by the difference in the masses of the two bodies at the time of the collision, regardless of the coefficient of restitution after the collision.	50
5		A20[6]	An inelastic collision is characterized by the difference in the masses of the two objects	25

		during the collision, regardless of the coefficient of restitution after the collision.	
6	A26[27]	A partially inelastic collision occurs when two objects of equal mass collide with each other.	25
7	A26[27]	The total kinetic energy of the objects before and before the collision is the same when experiencing a partial collision.	25
8	A26[27]	The total kinetic energy of the objects after the collision is greater than the total kinetic energy after the collision in the event of a collision of two balls that are fused together (not elastic at all).	25

Based on Table 7, the findings of misconceptions on the collision concept are as many as eight forms of misconceptions experienced by students. The most common form of misconception is 50% of the four articles studied, where students assume that a partially elastic collision is characterized by the difference in the masses of the two objects during the collision, ignoring the coefficient of restitution after the collision. Whereas a partially elastic collision occurs if the coefficient of restitution is $0 < e < 1$.

Based on research results of Anggraeni and Sulinayah [22], the factors that cause misconceptions in the concepts of momentum and impulse are the preconceptions of students, the factors that cause misconception in the concept of the law of conservation of momentum and impulses are the wrong intuitions of students. According to Anggraeni and Sulinayah [22], the factors that cause misconceptions in the material of momentum and impulse are mostly caused by associative and false negative thinking. Hestenes & Halloun (1995), false negative means that there is little information that students get, misconceptions in this condition are ignored because this happens because of the carelessness of students when giving answers [28]. The misconceptions that occur in the material of momentum and impulse are also caused by the interaction between students and their environment so that the scientific concepts formed by them are based on their intuition. Science concepts that are formed in students before class starts can lead to misconceptions because students do not know the scientifically correct concept [29]. Mufit and Fauzan [30] Learning that is mostly centered on educators can also cause misconceptions, where students are not active in building physics concepts [31], this will continue to happen when physics learning is mostly done by lecture and discussion methods, and learning by doing only a few attempts to discover the concept have been carried out. Suparno [3], besides that, the learning method is also a factor in the occurrence of misconceptions, for that interest in one learning method used must be avoided.

2. Diagnostic test instruments used to identify misconceptions

The second analysis in this study is a diagnostic test instrument applied to identify misconceptions about momentum and impulse materials. The following is presented in Table 8, the articles on diagnostic test instruments used to identify misconceptions about momentum and impulse materials.

Table 8. Misconception diagnostic test instruments on momentum and impulse materials

No	Diagnostic test instruments	Article code	Amount	Percentage
1	Two-tier multiple-choice test	A1[18], A4[19]	2	9,1
2	Multiple-choice test with Certainty of Response Index (CRI)	A2[15], A3[32], A5[33], A6[20]	4	18,2
3	Interview	A6[20], A15[24]	2	9,1
4	Four-tier multiple choice test with Certainty of Response Index (CRI)	A7[21]	1	4,5
5	Multiple-choice test	A8[34], A11[35], A12[36]	3	13,6
6	Three-tier multiple choice test	A9[22]	1	4,5
7	Multiple-choice isomorphic questions	A10[23]	1	4,5

8	Essay test with CRI Skala scale	A13[10]	1	4,5
9	Essay test with integrated mathematical representation approach CRI	A15[24]	1	4,5
10	Multiple-choice test with open reasons	A16[7], A17[9]	2	9,1
11	Four-tier test	A20[6], A26[27]	2	9,1
12	Essay test	A21[37]	1	4,5
13	Essay test with integrated mathematical and verbal representation approach CRI	A23[25]	1	4,5
14	Multiple-choice test with reasons	A19[38], A24[39]	2	9,1

Based on Table 8, there are fourteen diagnostic test instruments used in detecting students' misconceptions on momentum and impulse materials. The most widely used diagnostic tests in detecting students' misconceptions on momentum and impulse materials are the Multiple-choice test with Certainty of Response Index (CRI) and multiple-choice tests, each with a percentage of 18.2 from twentytwo articles stating the use of test instruments. diagnostic. According to [4], the advantages of the multiple choice test instrument are that it saves time in writing various topics, has many functions and can be applied at various levels of learning, the assessment of answers is very objective, the assessment is easy to do and the time required is not much, it is appropriate to use it to analyze because the variables can be used to carry out analytical activities, and can be applied to a large scope. According to Hasan (1999: 294) [40], the Certainty Response Index (CRI) is an tool used to knowing great faith of students in responding to the questions presented. However, the most widely developed four-tier diagnostic test in identifying students' misconceptions in high school physics over the last five years [41]. The latest instrument currently developed to find students' misconceptions is the five-tier diagnostic test which is the expansion of the four-tier diagnostic test. The development of the five-tier diagnostic test is the addition of a fifth tier in the form of a questionnaire containing questions to find out the sources of information used by students in answering questions [42].

3. Models/methods/strategies/approaches used to remediate misconceptions on momentum and impuls materials

The third analysis in this study is the model/method/strategy/approach applied to remediate students' misconception on the material of momentum and impulse. The following is presented in Table 9 the results of the analysis of the model/method/strategy/approach applied to remediate students' misconceptions on momentum and impulse material.

Table 9. Models/methods/strategies/approaches to remediate misconceptions

No	Models / methods / strategies / learning approaches used	Article code	Percentage	Syntax/Learning Steps
1	React strategy	A1[18]	5,6	1. Relating 2. Experiencing 3. Applying 4. Cooperating 5. Transferring
2	TSTS (two stay two stray) type cooperative learning model	A2[15], A3[32]	11,1	1. Delivery of goals and motivation by educators. 2. Presentation of information by educators. 3. Group formation. 4. Group discussion to find the correct concept. 5. Evaluation and awards
3	ECIRR (Elicit, Confort, Identify,	A4[19], A16[7],	16,7	1. Elicit

	Resolve, Reinforce) models	A18[8]		2. Confront 3. Identify 4. Resolve
4	Text transformation method	A5[33]	5,6	1. Students change the contents of textbooks into notes in their language. 2. The teacher checks the notes made. 3. Teachers provide feedback for improvement
5	POE learning model (Predict, observe, explain)	A11[35]	5,6	1. Predict 2. Observe 3. Explain
6	Generative learning model	A12[36]	5,6	1. Introduction (preparation). 2. Focusing. 3. Challenge, with concept introduction. 4. Application.
7	Inquiry training learning model	A13[10]	5,6	1. Students are given a activity and steps to solve it. 2. Students find the problem, examine the problem, and formulate a provisional answer. 3. Collect data and test it by conducting experiments. 4. Compile, formulate and explain the results. 5. Analyze the steps to get effective steps.
8	Flipped classroom model	A17[9]	5,6	1. Orientation 2. Instruction 3. Test
9	Conceptual interactive approach	A19[38]	5,6	1. Conceptual focus 2. Classroom interaction 3. Research base material 4. Use of text
10	Model ICI (Interactive Conceptual Instruction)	A20[6], A26[27]	11,1	1. Conceptual focus 2. Use of text 3. Research base material classroom interaction 4. Classroom interaction
11	Model concept attainment	A21[37]	5,6	1. Introduction 2. Formulating a hypothesis 3. Analysis 4.Closing and application
12	Model evidence-based learning	A22[43]	5,6	1. Determine the identification of learning steps. 2. Collect student assignments. 3. Analyze the results of the tasks carried out by students. 4. Stimulate students to focus on learning. 5. Implement changes to get feedback.
13	Project-based learning models	A24[39]	5,6	1. Open learning with challenging questions. 2. Planning a project. 3. Develop a schedule of activities. 4. Supervise the running of the project. 5. Assessment of the resulting product. 6. Evaluation

14	PDEODE strategy (Predict, Discuss, Explain, Observe, Discuss, Explain)	A25[26]	5,6	1. Predict 2. Discuss 3. Explain 4. Observe 5. Discuss 6. Explain

The results of the third study found in this study were the model/method/strategy/approach used to identify misconceptions in the material of momentum and impulse. Of the eighteen articles on learning models/methods/strategies, the ECIRR learning model is the most widely used to remediate misconceptions on momentum and impulse materials. According to Khomaria and Nasrudin [44], the ECIRR model can reduce misconceptions at the identify stage, where students can feel the misconceptions that occur, and at the reinforce stage it is done by replacing the wrong concept with the correct new concept. Jayanti et al. [12], explained the advantages of the ECIRR learning model, namely to familiarize students independently so that they can build their understanding, improve students' communication skills, improve, and familiarize students to think critically about the problems they face. Even so, each learning model/method/strategy has its advantages and is equally used to remediate students' misconceptions so that students understand the concept according to the correct concept.

4. Teaching material/media used to remediate misconceptions on momentum and impuls materials

The fourth analysis in this study is the teaching materials/media applied to remediate students' misconceptions about momentum and impulse. The following is presented in Table 10 the results of the analysis of the model/method applied to remediate students' misconceptions of the material of momentum and impulse**.**

Table 10. Teaching materials/media to remediate misconceptions on momentum and impulse materials

No	Teaching materials/media	Article code	Advantages
1	Computer simulation	A8[34]	1. Students are easier to understand the material. 2. Overcome the lack of practical tools and facilitate practical activities. 3. Students can use it independently. 4. Learning becomes more effective. 5. Can be used anytime and anywhere.
2	Refutation Text	A14[45]	1. Can encourage and fix students in understanding concepts. 2. Can increase students' learning motivation because reading materials are different from books in general.
3	Concept Attainment-oriented worksheets	A21[37]	1. Can increase the enthusiasm of students during learning. 2. Can form positive suggestions from the results of student interactions with the environment. 3. Generating student motivation.

The results of the fourth study found in this study were teaching materials/media used to remediate misconceptions on momentum and impulse materials. Based on Table 10, the use of teaching materials/media in remediating misconceptions on momentum and impulse materials has their respective advantages and can reduce misconceptions. The media used to remediate misconceptions on momentum and impulse materials is a computer simulation. Tawil and Rusdiana [16], states that learning using simulation can attract the attention of students, students are easier to master the material, train students in critical thinking, and make it easier for students to remember concepts. Computer simulation is effective in improving mastery of the concept of momentum and impulse [34]. In addition to the media, teaching materials used in remediating misconceptions on momentum and impulse materials are refutation text. Hynd, 2001 in Sinatra and Broughton [46], states that refutation text is a text that clearly describes a misconception and then is followed by a refutation. Refutation text teaching materials can reduce students' misconceptions, this is like research by Budi et al. [47] who states

that refutation text can reduce students' misconceptions. Then, concept attainment-oriented worksheets can also be used to reduce misconceptions. Concept Attainment-oriented worksheets have a significant effect on students' conceptual understanding [37]. In addition to computer simulation, refutation text, and Concept Attainment-oriented worksheets, the teaching materials used to reduce misconceptions have been developed in research Defrianti et al. [48] namely teaching materials based on cognitive conflict Real integration experimental video analysis. Cognitive conflict-based teaching materials real integration video analysis, this experiment is very valid in terms of content, construct, grammar, and form and is very practical.

5. The influence of learning models/strategies/method/media on increasing students' concept understanding of momentum and impulse materials

The fifth analysis in this research is the effect size of the learning model/strategy/media on increasing students' understanding of the concept of momentum and impulse. The following is presented in Table 11 the results of the calculation of the effect of the learning model/strategy/media on increasing students' understanding of the concept of momentum and impulse.

Table 11. The influence of learning models/strategies/media on increasing students' concept understanding on momentum and impulse materials

No	Learning model/strategy/method/media	Article code	Effect size	Category
1	React strategy	A1[18]	0,64	Moderate
2	TSTS (two stay two stray) models	A3[32]	4,46	High influence
3	Text transformation method	A5[33]	1,65	High influence
4	Inquiry training model	A13[10]	0,84	High
5	PhET simulation-assisted ECIRR model	A16[7]	0,38	Low
6	ECIRR model	A18[8]	5,24	High influence
7	Interactive conceptual model	A19[38]	1,67	High influence
8	Concept attainment-oriented student worksheet	A21[37]	2,04	High influence
9	PDEODE strategy	A25[26]	0,34	Low

The fifth result of this research is the effect size of the learning model/strategy/media in remediating students' misconceptions of the material of momentum and impulse. The highest learning model/strategy/media influence is the ECIRR model, with an effect size of 5.24 with high influence criteria. This shows that the ECIRR model has a high influence effect on remediating students' misconceptions. This is like the research of Hastuti et al. [49], understanding students' concepts with the ECIRR model in minimizing misconceptions is very high.

IV. CONCLUSION

The concepts that become students' misconceptions the momentum and impulse material, namely the concept of momentum, impulse, momentum and impulse relationship, the law of conservation of momentum, collisions, and the most common misconceptions is the concept of momentum. The diagnostic test instrument was found to identify students' misconceptions of the momentum and impulse material. Multiple choice test with Certainty of Response Index (CRI). The learning model/method/strategy that is widely used to remediate misconceptions about momentum and impulse material is the ECIRR model. Media/teaching materials used in remediating students' misconceptions of momentum and impulse materials are computer simulations, refutation text, and Concept Attainment-oriented worksheets. Based on the results of this study, a multiple-choice test instrument with the Certainty of Response Index (CRI) diagnostic test is suitable and easy to use to identify student misconceptions. To remediate misconceptions, a good learning model is used, namely the ECIRR learning model, and can remediate misconceptions using computer simulations, refutation Concept Attainment oriented texts and worksheets as learning media/teaching materials. The results of this study can be used as a

guide in remediation of students' misconceptions on the material of momentum and impulse and for other researchers it can be used as a guide in conducting research with the same theme.

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REFERENCES

[1] M. Delgado-Rodríguez and M. Sillero-Arenas, "Systematic review and meta-analysis," *Med. Intensiva (English Ed.*, vol. 42, no. 7, pp. 444–453, 2018, [Online]. Available: https://doi.org/10.1016/j.medine.2017.10.012.

[2] A. Pujianto, Nurjannah, and I. W. Darmadi, "Analisis Konsepsi Siswa Pada Konsep Kinematika Gerak Lurus," *JPFT (Jurnal Pendidik. Fis. Tadulako Online)*, vol. 1, no. 1, pp. 16–21, 2013.

[3] P. Suparno, *Miskonsepsi & Perubahan Konsep dalam Pendidikan Fisika*. Jakarta: PT. Gramedia, 2013.

[4] Soeharto, B. Csapó, E. Sarimanah, F. I. Dewi, and T. Sabri, "A Review of Students' Common Misconceptions in Science and Their Diagnostic Assessment Tools," *J. Pendidik. IPA Indones.*, vol. 8, no. 2, pp. 247–266, 2019.

[5] A. C. Anam and S. S. Edie, "Penerapan Strategi POE (Predict-Observe-Explain) Untuk Memperbaiki Miskonsepsi Fisika Pada Sub Pokok Bahasan Arus Dan Tegangan Listrik Bagi Peserta Didik Kelas X SMA Teuku Umar Semarang," *Unnes Phys. Educ. J.*, vol. 4, no. 2, pp. 25–31, 2015.

[6] G. Triyani, A. Danawan, I. Suyana, and I. Kaniawati, "An investigation of students' misconceptions about momentum and impulse through interactive conceptual Instruction (ICI) with computer simulation," *J. Phys. Conf. Ser.*, vol. 1280, no. 5, 2019.

[7] R. Arifin, E. Tandililing, and Hamdani, "Integrasi Remediasi Miskonsepsi Peserta Didik dengan Model Pembelajaran ECIRR Berbantuan PHET Simulation Momentum dan Impuls di SMA," *J. Pendidik. dan Pembelajaran Khatulistiwa*, vol. 8, no. 6, pp. 1–13, 2019.

[8] Jamilah, H. T. M. Silitonga, and Hamdani, "Integrasi Remediasi Miskonsepsi Tentang Momentum dan Impuls Menggunakan Model ECIRR," *J. Pendidik. dan Pembelajaran Khatulistiwa*, vol. 8, no. 10, pp. 1–11, 2019.

[9] D. Hikmatunnisa, S. Sahala, and D. Mahmudah, "Remediasi Miskonsepsi Menggunakan Model Flipped Classroom Materi Impuls dan Momentum di SMA," *J. Pendidik. dan Pembelajaran Khatulistiwa*, vol. 8, no. 3, 2019.

[10] R. A. Sani and R. Aulia, "Upaya Mengatasi Miskonsepsi Siswa dengan Menggunakan Model Pembelajaran Inquiry Training pada Materi Pokok Momentum dan Impuls di Kelas X SMA Negeri 3 Binjai T.P 2017/2018," *J. Ikat. Alumni Fis. Univ. Negeri Medan*, vol. 4, no. 3, pp. 16–21, 2018.

[11] M. Effendi, S. Koes, S. Negeri, and P. Bondowoso, "Pengaruh Model Pembelajaran ECIRR Terhadap Penguasaan Konsep Fisika Pada Siswa SMK," *J. Pendidik. Sains*, vol. 4, no. 3, pp. 113–121, 2016.

[12] N. P. W. Jayanti, S. Zulaikha, and I. K. Ardana, "Model Pembelajaran ECIRR Berbantuan Alat Peraga Berpengaruh terhadap Hasil Belajar Sains Siswa," *J. Mimb. PGSD Univ. Pendidik. Ganesha*, vol. 2, no. 1, 2014.

[13] A. Kurniawan *et al.*, *Model Pembelajaran Era Society 5.0*. Cirebon: Penerbit Insania, 2021.

[14] E. M. Ginting and M. A. Haibuan, "Pengaruh Model Pembelajaran Inquiry Training Terhadap Hasil Belajar Siswa Pada Materi Pokok Suhu Dan Kalor," *J. Penelit. Bid. Pendidik.*, vol. Volume 23, no. 1, pp. 56–61, 2017.

[15] A. Samsudin, W. Liliawati, A. Dedy, E. Suhendi, and I. Kaniawati, "The Use of Computer Simulation in Cooperative Learning to Minimize Students ' Misconceptions of Momentum and Impulse," *Int. Conf. Adv. Educ. Technol.*, vol. 14, no. 16, pp. 72–74, 2014.

[16] M. Tawil and D. Rusdiana, "Efektivitas Pembelajaran Berbasis Simulasi Komputer pada Topik Superposisi Gelombang untuk Meningkatkan Pemahaman Konsep Mahasiswa," *J. Sains dan Pendidik. Fis.*, vol. 7, no. 2, pp. 108–119, 2011.

[17] K. Becker and K. Park, "Effects of Integrative Approaches Among Science, Technology, Engineering and Mathematics (STEM) Subjects on Students' Learning : A Preliminary Meta- Analysis.," *J. STEM Educ.*, vol. 12, no. 5&6, pp. 23–37, 2011.

[18] E. Ultay, "Implementing react strategy in a context-based physics class: Impulse and momentum example," *Energy Educ. Sci. Technol. Part B Soc. Educ. Stud.*, vol. 4, no. 1, pp. 233–240, 2012.

[19] E. Ayu Maulida and Suliyanah, "Profil Miskonsepsi Siswa Dalam Model Ecirr Berbantuan Phet

Simulation Pada Materi Momentum, Impuls, Dan Tumbukan," *J. Inov. Pendidik. Fis.*, vol. 5, no. 3, pp. 202–205, 2016.

[20] N. S. Alawiyah, Ngadimin, and A. Hamid, "Identifikasi miskonsepsi siswa dengan menggunakan metode indeks respon kepastian (IRK) pada materi impuls dan momentum linear di SMA negeri 2 banda aceh," *J. Ilm. Mhs.*, vol. 2, no. 2, pp. 272–276, 2017.

[21] A. Hidayat, S. H. B. Prastowo, and B. Supriadi, "Identifikasi Miskonsepsi Momentum, Impuls dan Tumbukan melalui Tes Diagnostik Empat Tahap pada Siswa SMA Kelas XII," *Pros. Semin. Nas. Pendidik. Fis.*, vol. 2, no. 1, pp. 1–11, 2017.

[22] D. M. Anggraeni and Suliyanah, "Diagnosis Miskonsepsi Siswa Pada Materi Momentum, Impuls, Dan Tumbukan Menggunakan Three-Tier Diagnostic Test," *Inov. Pendidik. Fis.*, vol. 6, no. 3, pp. 271–274, 2017.

[23] N. E. Diyanahesa, S. Kusairi, and E. Latifah, "Development of Misconception Diagnostic Test in Momentum and Impulse Using Isomorphic Problem," *J. Phys. Theor. Appl.*, vol. 1, no. 2, pp. 145–156, 2017.

[24] Z. Anggraini, I. K. Mahardika, and A. Harijanto, "Tingkat Miskonsepsi Siswa SMAN Jember Kelas X Pada Materi Momentum Dan Impuls Melalui Pendekatan Representasi Matematik Terintegrasi CRI," *FKIP e-PROCEEDING*, vol. 3, no. 2, pp. 6–12, 2018.

[25] I. K. Mahardika, Z. Anggraini, A. Doyan, and I. W. Sugiartana, "Approach to Representation of CRI Integrated Mathematics and Verbal (R-MV) to Analyze Misconception of Momentum and Impuls Materials," *J. Penelit. Pendidik. IPA*, vol. 6, no. 2, pp. 232–237, 2020.

[26] Y. Apriyanti, S. S. Sitompul, and M. M. S. Hidayatullah, "Remediasi Miskonsepsi Menggunakan Strategi Predict , Discuss , Explain , Observe , Disucss , Explain (PDEODE) Tentang Momentum Dan Impuls Peserta Didik SMA Negeri 1 Selimbau," *J. Pendidik. dan Pembelajaran Khatulistiwa*, vol. 10, no. 5, pp. 1–10, 2021.

[27] I. Kaniawati, G. Triyani, A. Danawan, I. Suyana, A. Samsudin, and E. Suhendi, "Implementation of Interactive Conceptual Instruction (ICI) With Computer Simulation : Impact of Students ' Misconceptions on Momentum and Impulse Material," *J. Ilm. Pendidik. Fis. Al-BiRuNi*, vol. 10, no. 1, pp. 1–17, 2021.

[28] R. Istiyani, A. Muchyidin, and H. Rahardjo, "Analisis Miskonsepsi Siswa pada Konsep Geometri Menggunakan Three-Tier Diagnostic Test," *Cakrawala Pendidik.*, vol. 37, no. 2, pp. 223–236, 2018.

[29] F. Mufit and A. Fauzan, *Model Pembelajaran Berbasis Konflik Kognitif (PbKK) (Disertai Penerapan Untuk Remediasi Miskonsepsi pada Sains dan Matematika)*. Malang: CV IRDH, 2019.

[30] F. Mufit, Festiyed, A. Fauzan, and Lufri, "The application of real experiments video analysis in the CCBL model to remediate the misconceptions about motion's concept," *J. Phys. Conf. Ser.*, vol. 1317, no. 1, 2019.

[31] F. Mufit, "The study of misconceptions on motion's concept and remediate using real experiment video analysis," *Asean Comp. Educ. Res. Netw. Conf.*, pp. 1–7, 2018.

[32] A. D. Sutrisno, A. Samsudin, W. Liliawati, I. Kaniawati, and E. Suhendi, "Model Pembelajaran Two Stay Two Stray (TSTS) dan Pemahaman Siswa tentang Konsep Momentum Dan Impuls," *J. Pengajaran MIPA*, vol. 20, no. 1, pp. 38–42, 2015.

[33] Soeharto, "Implementation of Text Transformation in Physics Education To Reduce Students' Misconception," *J. Educ. Teach. Learn.*, vol. 1, no. 2, pp. 56–60, 2016.

[34] I. Kaniawati, "Pengaruh Simulasi Komputer Terhadap Peningkatan Penguasaan Konsep Impuls-Momentum Siswa SMA," *J. Pembelajaran Sains*, vol. 1, no. 1, pp. 24–26, 2017.

[35] H. Nurpatmawati, N. Islami, and Fakhruddin, "Analisis Perubahan Tingkat Konsepsi Sains Fisika Siswa Menggunakan Model Pembelajaran POE (Predict-Observe-Explain) pada Materi Momentum dan Impuls Kelas X MAN 1 Pekanbaru," *J. Online Mhs. Fak. Kegur. dan Ilmu Pendidik.*, vol. 4, no. 2, pp. 1–9, 2017.

[36] I. N. Sugiana, A. Harjono, H. Sahidu, and G. Gunawan, "Pengaruh Model Pembelajaran Generatif Berbantuan Media Laboratorium Virtual Terhadap Penguasaan Konsep Fisika Siswa pada Materi Momentum dan Impuls," *J. Pendidik. Fis. dan Teknol.*, vol. 2, no. 2, pp. 61–65, 2017.

[37] T. S. Sandi, Festiyed, Y. Darvina, and W. S. Dewi, "Pengaruh LKS Berorientasi Concept Attainment pada Pemahaman Konsep Fisika Siswa SMA," *Pillar Phys. Educ.*, vol. 12, no. 3, pp. 409–416, 2019.

[38] H. T. M. Silitonga, T. Djudin, E. Oktavianty, and Rooshardini, "The Implementation of Integrated Remediation with Conceptual Interactive Learning on Momentum and Impulse in Senior High School," *J. Phys. Conf. Ser.*, vol. 1171, no. 1, 2019.

[39] L. Puspitasari, B. Astuti, and M. Masturi, "Penerapan Project Based Learning (PjBL) Terbimbing untuk Meningkatkan Keaktifan dan Pemahaman Siswa pada Konsep Momentum, Impuls, dan Tumbukan," *Phys. Educ. Res. J.*, vol. 2, no. 2, pp. 69–82, 2020.

[40] S. Hasan, D. Bagayoko, and E. L. Kelley, "Misconceptions and the certainty of response index (CRI)," *Phys. Educ.*, vol. 34, no. 5, pp. 294–299, 1999, doi: 10.1088/0031-9120/34/5/304.
[41] A. N. Santoso and W. Setyarsih, "Literatur Review Miskonsepsi Fisika Peserta Didik SMA dan Instrumen Diagnostiknya," *J. Pendidik. Fis. Tadulako Online*, vol. 9, no. 1, pp. 34–44, 2021.
[42] I. Rosita, W. Liliawati, and A. Samsudin, "Pengembangan Instrumen Five-Tier Newton's Laws Test (5TNLT) Untuk Mengidentifikasi Miskonsepsi dan Penyebab Miskonsepsi Siswa," *J. Pendidik. Fis. dan Teknol.*, vol. 6, no. 2, pp. 297–306, 2020.
[43] U. Muflihatin, N. Islami, and F. Z, "Improving The Understanding Of Concepts Of Momentum and Impuls of Students by Implementation of Evidence Based Learning Models in Class X Senior High School," *J. Geliga Sains Pendidik. Fis.*, vol. 7, no. 2, pp. 138–145, 2019.
[44] I. N. Khomaria and H. Nasrudin, "Penerapan Model Pembelajaran Ecirr Untuk Mereduksi Miskonsepsi Pada Materi Kesetimbangan Kimia Kelas XI MIA Di SMA Negeri 1 Pacet," *Unesa J. Chem. Educ.*, vol. 5, no. 1, pp. 98–106, 2016.
[45] Yulia, H. T. M. Silitonga, and E. Oktavianty, "Pengambangan Bahan Bacaan Refutation Text Sebagai Media Untuk Meremediasi Miskonsepsi Materi Momentum dan Impuls," *J. Pendidik. dan Pembelajaran Khatulistiwa*, vol. 7, no. 9, pp. 1–14, 2018.
[46] G. M. Sinatra and S. H. Broughton, "Bridging reading comprehension and conceptual change in science education: The promise of refutation text," *Read. Res. Q.*, vol. 46, no. 4, pp. 374–393, 2011.
[47] F. S. Budi, Hairida, and R. Muharini, "Pengaruh Penyediaan Bacaan Berbentuk Refutation Text untuk Meremediasi Miskonsepsi Siswa Tentang Konsep Asam Basa di Kelas XI IPA SMA Negeri 4 Pontianak," *J. Pendidik. Mat. dan Sains*, vol. 2, no. 2, pp. 154–159, 2014.
[48] R. Defrianti, F. Mufit, Gusnedi, W. S. Dewi, and Z. Hidayat, "Design of Cognitive Conflict-Based Teaching Materials Integrating Real Experiment Video Analysis on Momentum and Impulse to Improve Students' Concept Understanding," *Pillar Phys. Educ.*, vol. 14, no. 2, pp. 97–108, 2021.
[49] W. Hastuti, S. Suyono, and S. Poedjiastoeti, "Reduksi Miskonsepsi Siswa pada Konsep Reaksi Redoks Melalui Model ECIRR," *J. Penelit. Pendidik. Kim. Kaji. Has. Penelit. Pendidik. Kim.*, vol. 1, no. 1, pp. 78–86, 2014.