UEJTL: Universal Education Journal of Teaching and Learning
E-ISSN: 3047-8235
2024, Vol. 1, No. 4, pp. 117~127
DOI: https://doi.org/10.63081/uejtl.v1i4.72

Original Research

Are Feedback and Reinforcement Questions in The Recitation Program Able to Improve Students' Conceptual Mastery?

Handy Faishal Rahim[1*], Iqbal Bilgrami Biruni[2], Teddy Amin Romansyah[3], Arif Hidayat[4], and Sutopo[5]
[1, 3, 4, 5] Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Indonesia.
[2] Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Indonesia.

Article Info

Article history:

Received 07 03, 2025
Revised 01 13, 2026
Accepted 02 28, 2026

Keywords:

Multi-context
Multi-representation
Recitation program
Students' conceptual mastery

ABSTRACT

One of the primary goals of physics education is to achieve a solid conceptual understanding among learners. This conceptual understanding, which enables students to address the challenges they encounter effectively, is conceptual mastery. A higher level of conceptual mastery correlates with an increased capacity for students to tackle everyday problems successfully. This study aims to identify the improvement of students' conceptual mastery through a multi-representation-based recitation program accompanied by feedback and reinforcement questions. The method used in this research is descriptive quantitative, carried out on 36 students of the Physics Undergraduate Study Program. The recitation program is multi-representational and multi-context-based, which contains reinforcement questions and feedback used by students outside of lecture hours to help master the concepts obtained in class. The results showed the mastery of concepts of momentum and impulse students increased, indicated by the transition of student's answers and the average of students from 30.8 to 52.8. The increase in students' mastery of concepts is shown in questions in the context of determining impulses in related problems and the conservation of momentum in related problems. The multi-representation and multi-context presented in the recitation program and pretest and posttest questions affect students' mastery of concepts in solving problems.

Corresponding Author:

Handy Faishal Rahim
Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Indonesia.
Email: *handy.faishal.2003218@students.um.ac.id*

1. INTRODUCTION

A primary objective of physics education is to ensure that students comprehensively understand key concepts (Andriani et al., 2018; Azizah et al., 2020; Kaniawati et al., 2016; Nurani et al., 2018; I. Rahmawati & Sutopo, 2019). This understanding, often called concept mastery, significantly enhances students' problem-solving capabilities. A firm grasp of concepts increases students' likelihood of successfully addressing their challenges (Docktor & Mestre, 2014; Lutfiyadi & Budiyono, 2018; Taqwa & Rahim, 2022). Engaging in meaningful problem-solving practices further enhances students' conceptual understanding (Adimayuda et al., 2021; Arisanti et al., 2016; Hwang & Purba, 2021). Effective problem-solving entails that students apply their acquired concepts comprehensively, thereby facilitating the achievement of the fundamental objectives of physics education (Affriyenni et al., 2021; Diyana et al., 2020b; Michelini, 2019).

In the realm of physics education, students must possess an advanced level of comprehension to tackle the challenges they encounter effectively. A thorough grasp of fundamental concepts is crucial for students to engage with the material in physics, and the ability to interpret the context of problems is equally significant (Riwanto et al., 2019; Saepuzaman et al., 2020). Consequently, students must understand various contexts related to physics inquiries. The diverse contexts and topics students explore can enhance their understanding and mastery of physics concepts. Research conducted by S. Rahmawati et al., (2019) indicates that a prevalent deficiency among students in grasping the concepts of momentum and impulse is their inability to translate and fully comprehend the concepts presented to them accurately. This inadequacy adversely affects their problem-solving capabilities and diminishes their motivation to delve deeper into physics, particularly momentum and impulse. Translation errors often lead to misinterpretations of physics symbols and the questions posed. In contrast, conceptual errors arise from a need for more understanding of the material related to momentum and impulse (Anon et al., 2016; Oktaviyanti et al., 2016; Xu et al., 2020).

Additionally, findings from Agustina et al., (2017), and Saifullah et al., (2017) reveal that mistakes in studying momentum and impulse stem from students' insufficient conceptual knowledge. For students to effectively apply their understanding to real-world problems involving momentum, impulse, the law of conservation of momentum, and collisions, their conceptual frameworks must be coherent, robust, and comprehensive. Furthermore, many students exhibit conceptual errors when addressing problems, and their unfamiliarity with questions that present various representations often results in difficulties in strategizing solutions and misinterpreting the problems at hand (Adimayuda et al., 2021; Fayanto & Juni, 2020; Putranta & Supahar, 2019; Ramadan et al., 2020).

Multi-representation not only helps students in learning concepts but can also make them good problem solvers (Badruzzaman et al., 2015; Dianningrum et al., 2020; Puspitaningtyas et al., 2021; Safitri et al., 2020). Multi-representation can help with knowledge formation and problem-solving (De Cock, 2012; Hestenes & Hestenes, 1997; Heuvelen & Zou, 2001; Kohl & Finkelstein, 2005; Meltzer, 2005). The results of research by Taqwa (Taqwa et al., 2017) show that the student's abilities improve in completifng tests when students learn more representational formats than through giving less representational forms.

The traditional teacher-centered approach to education is increasingly viewed as less effective in the contemporary context, where access to information is readily available through digital devices and the internet. Consequently, integrating online media into the learning process is essential for enhancing students' ability to engage with and develop the critical thinking skills acquired in the classroom. Various resources, such as e-books, online video tutorials, and educational applications, serve as valuable tools to support student learning (Auna Hidayati & Taqwa, 2023; Hastuti et al., 2016; Ramadan et al., 2020). The recitation program, as Kohl et al., (2007) described, thoroughly examines the material following lectures. Koenig et al., (2007) define *recitation* as a pedagogical strategy in which the instructor provides minimal information, poses questions, solicits student responses, and subsequently offers feedback by affirming or correcting students' understanding of specific concepts. Research by Ogilvie, (2009) indicates that the implementation of the recitation method has led to an improvement in students' conceptual mastery. This finding is corroborated by studies conducted by Diyana et al., (2020), Taqwa et al., (2017), and Dianningrum et al., (2020) demonstrating that recitation in introductory physics courses through supplementary tutorials enhances students' grasp of concepts. Incorporating a recitation program that employs multi-representation questions could further elevate students' conceptual comprehension of the physics topics being addressed. Additionally, research by Sundari et al., (2021) suggests that the application of recitation programs, along with integrated multi-representation techniques, can enhance the competencies of physics educators.

The application of learning assistance through conceptual questions that utilize multi-contextual and multi-representational approaches within this computer program must be more utilized in research. Previous studies, such as those by Diyana et al., (2020), Jayanti et al., (2016), and Reyza et al., (2017) explored implementing recitation programs to enhance students' in-depth understanding; however, they need to address the concepts of momentum and impulse specifically. This study builds upon earlier research, particularly the work of Febryanti and Taqwa, which evaluated an integrated recitation program featuring various questions designed to assess changes in students' comprehension of physics concepts. Nonetheless, that research was limited to practical testing of the recitation program without extending to sample testing. To address this gap, the current study introduces additional features, including two distinct questions: the first aimed at assessing students' conceptual mastery, and the second intended to reinforce the concepts acquired from the initial question. Furthermore, enhancements have been made to the recitation program, resulting in a more streamlined, efficient, and user-friendly experience, thereby minimizing potential confusion for students during its use.

The advantage of using a multi-representation and multi-context-based recitation program is that students also have to learn how to interpret these representations and relate them to the problems they face daily (Silaen, 2019; Waldrip, 2019; Dianningrum, 2020) (Safitri et al., 2020; Silaen et al., 2019; Waldrip et al., 2006). In addition, students must be trained to make choices among several presented representations. Based on research conducted by Diyana et al., (2020) stated that the conceptual problem training program and its feedback, in general, were able to increase students' mastery of concepts. However, the success of the recitation program in strengthening mastery of specific concepts also depends on the number of questions, the format of problem representation, and the variety of contexts presented in the recitation program itself.

2. METHOD

This study uses a descriptive type of research to obtain quantitative data. The sample for this research was selected through a purposive sampling technique. The selection process involved specific considerations, which is the essence of purposive sampling Sugiyono, (2018). This investigation employs a mixed methods research approach, utilizing an Embedded Experimental Model research design adapted from Creswell & Clark, (2007). The subjects of this study were all students of the Physics undergraduate study program at the State University of Malang who were taking Basic Physics courses for the 2020/2021 academic year. The number of research subjects was 36 students.

The instrument for assessing concept mastery is meticulously crafted to evaluate students' understanding of the fundamental principles of momentum and impulse, which are critical topics in physics (Fayanto & Juni, 2020; Rosa et al., 2018). This assessment is structured into two distinct phases: a pretest and a posttest, which feature identical questions to ensure consistency in measuring student progress and understanding throughout instruction.

The pretest is administered at the beginning of the instructional period, serving as a diagnostic tool to gauge students' initial knowledge and misconceptions regarding momentum and impulse. This baseline data is invaluable for educators, as it allows them to tailor their teaching strategies to address specific areas where students may struggle. Following the instructional period, the posttest is administered to evaluate the effectiveness of the teaching methods and to measure the growth in students' understanding of the concepts.

The concept mastery test utilized in this research has been developed in strict alignment with the Semester Learning Plan (RPS) and the Lecture Program Unit (SAP) for the introductory physics course. This alignment ensures that the assessment reflects the curriculum and adheres to the educational standards and learning objectives set forth for the course. By doing so, the assessment provides a comprehensive evaluation of students' grasp of the material, ensuring that it is both relevant and rigorous.

In addition to the assessment structure, the subsequent Table 1 presents a detailed overview of the specific topics, themes, and competencies evaluated about momentum and impulse. This table serves as a valuable reference for educators and students, outlining the key focus areas within the curriculum. It highlights the essential concepts that students are expected to master, such as the definition and calculation of momentum, the relationship between impulse and momentum, and applying these concepts in real-world scenarios.

Table 1. Topics, Skills Tested in the Discussion of Momentum and Impulse

Topic	Multi Context	Multi Representation
Momentum and Impulse	Two balls colliding with each other	Visual representation
	Identical objects that are initially at rest and then move	Graphic Representation
	Baseball hit by a bat	Verbal Representation
	Two blocks are pushed with the same force	Visual representation
	Two balls have different masses and kinetic energy	Mathematic Representation
Collision events and the law of conservation of momentum	Two identical balls colliding	Verbal Representation
	Two identical balls with different velocities collide with each other	Visual Representation
	A bullet fired into the beam	Visual Representation
	A bus at a certain speed collides with a car	Verbal Representation
	A car that brakes suddenly	Verbal Representation

The research tool utilized in this study has been rigorously subjected to empirical validation, ensuring that it meets the essential criteria required for effective data collection. This validation process confirms that the instrument is reliable and valid, making it suitable for capturing the nuances of student responses. Each response option included in this tool is carefully designed to reflect students' diverse perspectives regarding their cognitive processes when tackling various problems.

For example, in a specific scenario where a question presents five distinct response options, one of these options is explicitly identified as the correct answer. The remaining four options are strategically constructed to represent common misconceptions that students may hold. This approach allows for the identification of students' correct understanding and sheds light on the prevalent misunderstandings that can hinder their learning process. By analyzing the choices made by students, researchers can gain valuable insights into learners' cognitive strategies and the areas where misconceptions are most likely to arise.

The quantitative data collected through this instrument was analyzed by calculating descriptive statistics. This statistical approach clearly and comprehensively illustrates students' understanding of the assessed concepts. Descriptive statistics, such as means, medians, and standard deviations, were employed to summarize the data, allowing for a practical interpretation of the overall performance of students. By presenting the findings in this manner, the study aims to highlight the levels of understanding among students and the patterns and trends that emerge from their responses. This information is crucial for educators and researchers, as it can inform instructional strategies and interventions designed to address identified misconceptions and enhance student learning outcomes.

The analysis of the increase in normalized gain uses the following formula (Bao, 2006).

$$\langle g \rangle = \frac{\sum_{k=1}^{N}(y_k - x_k)}{\sum_{k=1}^{N}(1 - x_k)} \quad (1)$$

$$\langle \bar{g} \rangle = \frac{1}{N}\sum_{k=1}^{N}\frac{(y_k - x_k)}{(1 - x_k)} \quad (2)$$

Information:

x_k : Student's-k pretest scores

y_k : Student's-k posttest scores

N : Number of students

The criteria for increasing the normalized gain of class according to Hake (1998), can be seen in Table 2.

Table 2. Gain Improvement Criteria

Normalized Average Gain	Improvement Criteria
$\langle g \rangle \geq 0{,}7$	High
$0{,}3 \leq \langle g \rangle < 0{,}7$	Moderate
$\langle g \rangle < 0{,}3$	Low

3. RESULTS AND DISCUSSION

3.1. Description of the Multi Representation-Multi-Context-Based Recitation Program with Feedback and Reinforcement Questions with Its Use

The recitation program is meticulously designed to enhance students' understanding of momentum and impulse through strategically crafted practice questions. These questions are not merely random inquiries; they are specifically formulated to deepen students' comprehension and facilitate a more profound grasp of these critical physics concepts. The program draws inspiration from the question format proposed by Taqwa et al., (2020), which emphasizes the importance of structured learning and cognitive engagement.

The learning process begins with students engaging with an initial question as a foundational assessment tool. This first question is crucial as it allows both students and instructors to gauge the student's current understanding of momentum and impulse. By establishing a baseline, educators can identify areas where students need additional support or clarification. Following the initial question, students are presented with subsequent questions that closely resemble the first but are formatted differently. This variation in presentation is a deliberate pedagogical strategy aimed at reinforcing the conceptual knowledge that students have acquired. By encountering similar concepts in diverse formats, students are encouraged to think critically and apply their understanding in various contexts, solidifying their grasp of the material.

The recitation program is comprehensive, comprising ten questions focused specifically on momentum, eight questions dedicated to impulse, and an additional eight questions that address both momentum and impulse in an integrated manner. Furthermore, the program includes ten questions that explore collisions and the law of conservation of momentum, providing students with a holistic view of how these concepts interrelate in real-world scenarios. Each question in the recitation program is carefully developed based on the references outlined in Table 3, ensuring that the content is relevant and aligned with established educational standards. This structured approach not only aids in reinforcing students' understanding but also promotes a systematic exploration of the subject matter.

Moreover, the competencies students are expected to master throughout this program are clearly defined and elaborated upon, as illustrated in Table 3. This clarity in expectations allows students to understand the specific skills and knowledge they should aim to acquire, fostering a sense of purpose and direction in their learning journey. By the end of the program, students will be engaged with a diverse array of questions that challenge their understanding and encourage them to think critically about the principles of momentum and impulse, ultimately leading to a more robust and nuanced comprehension of these essential physics concepts.

Table 3. Percentage level of student representation and scientific consistency (n = 125)

Recitation Program	Developed abilities (Q Number)
Package 1: Momentum	Comparing the magnitude of momentum based on mass and velocity information (1, 2) Define momentum as a vector quantity (3, 4) Determine the change in momentum in two-dimensional motion (5, 6) Representing the change in momentum in a $\vec{p} - t$ graph (7, 8) Determine the momentum ratio based on mass and kinetic energy information (9, 10)
Package 2: Impuls	Determine the impulse based on the function of force versus time (1, 2) Determine the impulse based on the average force and time interval information (3, 4) Identify the impulses acting on an object based on the curves on the graph $\vec{F} - t$ (5, 6) Determine the average force based on the curve formed on the graph $\vec{F} - t$ (7, 8)
Package 3: Momentum dan Impulse	Determine the velocity of an object based on the impulse (1, 2) Determining the change in momentum of an object (3, 4) Determining momentum based on information on mass, altitude, initial velocity (5, 6) Determine the impulse of an object using the momentum change equation based on mass, velocity, and also the direction of motion of the object (7, 8)
Package 4: The Law of Conservation Momentum	Determining the combined velocity of an object based on mass, altitude, and image representation (1, 2) Determine the speed of an object based on the equation of the law of conservation of momentum (3, 4) Determine the combined velocity of an object based on the equation for an inelastic collision (5, 6) Determine the momentum of an object that splits in half and forms a perpendicular (7, 8) Determine the combined velocity of an object based on the equation for the partially elastic collision (9, 10)

The practice questions are crafted in various representational formats and contexts to enhance students' skills. Conceptual practice questions and feedback are presented in a multiple-choice format. Each answer option is designed to reflect the students' most probable reasoning. The feedback varies for each option, taking into account the potential thought processes students may exhibit when selecting an answer based on the challenges identified in previous studies (Diyana et al., 2020a; Kaniawati et al., 2016; Munfaati et al., 2014; Nur'aini et al., 2020; Reyza et al., 2017; Sadaghiani, 2011), as well as the difficulties encountered during lectures and the researcher's own experiences. For incorrect responses, the feedback aims to help students recognize their misconceptions.

Conversely, for correct answers, the feedback reinforces their successful reasoning. Furthermore, after students correctly answer the questions, problem-solving will be elaborated upon in video tutorials to deepen their understanding. Discussing each question also mitigates the likelihood of students arriving at correct answers through mere guessing. Students who select incorrect options must revisit the questions until they arrive at the correct answer. For further details, the design of the recitation program is illustrated in Figure 1 below.

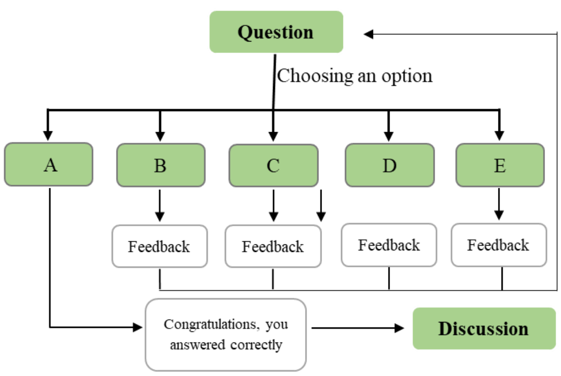


Figure 1. Flow of Recitation Program Use (Example of Correct Option is A)

After students choose an answer, feedback must be given as soon as possible to both students who answered incorrectly or correctly (Diyana, 2020). The feedback given aims to: (1) Show the misconceptions of students who chose the wrong answer. (2) Strengthen the concept of students who have chosen the correct answer. (3) Confirm the answer by the scientific concept because not all students who choose the correct answer know the appropriate concept.

This recitation program serves as a personalized educational tool. It is designed to be utilized independently by students during non-lecture hours, facilitated by an offline computer application. The program is structured in a phased manner. Specifically, the topics of momentum and impulse comprise 36 questions, organized into four packages: Package 1 contains ten questions, package 2 includes eight questions, package 3 also has eight questions, and Package 4 consists of ten questions, corresponding to the first sub-chapter. This recitation program incorporates updated prior research problems, eliminating video content's cumbersome nature. Students can conveniently access the video links provided, which redirect them to the YouTube platform, enhancing the recitation program's usability.

3.2. Descriptive Statistics

Table 4. Descriptive statistic of pretest and posttest data (*n* = 125)

Statistics	**Pretest**	**Posttest**
N	36	36
Mean	3.1111	7.0278
Median	3.0000	7.0000
Std. Deviation	1.87887	1.76451
Skewness	.596	.517
Std. Error of Skewness	.393	.393
Minimum	1.00	4.00
Maximum	8.00	12.00

Table 4 shows that the mastery of the concepts of momentum and impulse students increased from pretest to posttest. This data can be seen from the posttest average value, which is higher than the pretest value. For example, the average student concept mastery score increased from 2.42 to 6.50; if assessed, it would be 24.20 to 65.00. However, to see the statistical significance of the difference in pretest and posttest scores, a paired samples t-test was used (Table 5).

Table 5. Paired sample t-test

	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
	Lower	Upper			
Pretest - Posttest	-4.41771	-3.41563	-15.869	35	.000

The different tests were conducted to determine how much the difference increased students' conceptual mastery ability. Previously, the data normality prerequisite test was performed. The normality test was carried out to choose the data distribution on the variables using the One-Sample Kolmogorov-Smirnov Test with the help of SPSS. Data is declared normally distributed if $p > 0.05$.

The paired-sample t-test was obtained with a significance value of 0.000. This value is smaller than 0.05, meaning there is a significant difference between the pretest and posttest scores. That is, Ha is accepted, and Ho is rejected. Using multi-representation and multi-context-based recitation programs can improve students' conceptual mastery of momentum and impulse materials.

Table 6. N-gain individually per question

No.	Pretest	Posttest	N-gain	Category
1	11	28	0,68	Moderate
2	9	13	0,15	Low
3	20	33	0,81	High
4	6	19	0,43	Moderate
5	2	5	0,09	Low
6	9	15	0,22	Low
7	10	22	0,46	Moderate
8	10	17	0,27	Low
9	10	25	0,58	Moderate
10	13	27	0,61	Moderate

Table 6 shows the increase in student scores for each item in the discussion of momentum and impulse. The discussion of items will focus on items with the same indicators when given by students at the posttest. Increasing mastery of the concept will be discussed by looking at the highest N-gain value. The item discussed because it shows an increase in students' mastery of concepts is number 3. At the same time, the difficulties experienced by students will also be discussed by looking at the low N-gain value. The items discussed that show the difficulties that students still experience at the posttest are numbers 2, 5, 6, and 8.

3.3. Improving Student Concept Understanding

The increase in concept mastery was analyzed when after giving the recitation program experienced by all students or groups; it could be seen the significance of the correlation between pre test scores and individual Ngain. The improvement of concept mastery will be discussed by looking at the highest N-gain value. The item with the highest N-Gain value is question number 4, which is 0.81. Each item has a different discussion context. The context discussed is the baseball being hit by the bat (number 4). Items and crosstabulation of student answer choices are shown in Figure 2.

Question Number 4

A baseball of mass 70 g is moving to the right with a speed of 4 m/s. The ball is hit so that it reverses direction with speed immediately after being hit is 3 m/s to the left. If the contact time of the bat with the bat is 0.1 seconds, the impulse acting on the bat by the bat is….

(A) 7×10^{-3} kg m/s ke kiri
(B) 7×10^{-3} kg m/s ke kanan
(C) 49×10^{-2} kg m/s ke kiri
(D) 49×10^{-2} kg m/s ke kanan
(E) It can't be determined, the impulse depends on the force exerted by the bat

Crosstabulation Pretest-posttest

		Posttest			Total
		B	C*	D	
Pretest	A	0	5	0	5
	B	1	5	0	6
	C*	0	18	2	20
	D	0	1	0	1
	E	0	4	0	4
Total		1	33	2	36

Figure 2. Questions and Crosstabulation of Student Answer Choices

In question number 4 with the correct answer option C, when the pretest was found students who answered option B with the thought that $\vec{I} = \vec{F}\,\Delta t$ which does not pay attention to the direction of motion of objects that should be to the left (-). However, when students were given recitation questions accompanied by feedback in the same context as the pretest/posttest questions, most students could interpret impulses. $\vec{I} = m\,\Delta\vec{v}$ and also, students have been able to determine the direction of motion of objects in the form (+) or (-)

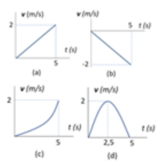
in the equations listed in the problem by choosing option C. The increase in students' ability to understand the concept of impulses is thought to be due to the habit of thinking in a consistent discussion of questions.

The recitation program significantly enhances students' capacity to construct and refine their conceptual understanding of momentum and impulse. Including tiered questions featuring diverse representations allows students to adapt more effectively to varying contexts of inquiry. Furthermore, the program's accessibility promotes efficient use of time in learning, and immediate feedback enables students to identify their errors. Moreover, students' enthusiasm for engaging with the recitation program positively influences their grasp of concepts and motivation to learn. Nonetheless, the infrequent use of the program has led to a sense of unfamiliarity with the application among students. Gradually, as they become more accustomed to the program, students will enhance their comprehension of physics concepts and develop proficiency in addressing problems presented in multiple representations and patterns.

3.4. Difficulties in Understanding Momentum and Impulses

Students' difficulties are indicated by the N-gain value of low category questions. The items with a low N-Gain value are number 2 with a value of 0.15, number 5 with a value of 0.09, number 6 with a value of 0.22, and number 8 with a value of 0.27. For example, the context discussed in problem number 2 is analyzing the direction of momentum and impulse, numbers 5 and 6 compare the momentum and impulse of two objects on the same trajectory, and number 8 evaluates the velocity after a possible collision in the case of a 1-dimensional collision. Figure 3 shows examples of questions and student answer choices where the n-gain question has the lowest value. Students continue to encounter challenges when addressing physics problems that require graphical representations. Many students perceive physics problems primarily as narrative scenarios, leading to a lack of familiarity with solving issues presented in graphical formats. This skill is essential for those aiming to understand physics concepts comprehensively. Students must become adept at interpreting quantities depicted in graphs, as this can enhance their comprehension of the relationships expressed in formulas. While students are generally proficient in interpreting problems presented in mathematical and verbal forms, skills cultivated since early education, there is a noticeable deficiency in their ability to engage with alternative representations. Consequently, introducing a variety of practice questions that utilize diverse representation methods is a necessary strategy for physics students.

Question Number 2



Four identical objects of mass m are initially at rest and then move to the right at different speeds. The velocity of each object while moving in 5 seconds follows the following v-t graph.
The ratio of the magnitude of the change in momentum of the object in 5 seconds is...
(A) $\Delta p_{(a)} > \Delta p_{(b)} > \Delta p_{(c)} < \Delta p_{(d)}$
(B) $\Delta p_{(a)} > \Delta p_{(b)} < \Delta p_{(c)} < \Delta p_{(d)}$
(C) $\boldsymbol{\Delta p_{(a)} = \Delta p_{(b)} = \Delta p_{(c)} > \Delta p_{(d)}; \Delta p_{(d)} = 0}$
(D) $\Delta p_{(a)} = \Delta p_{(b)} = \Delta p_{(c)} > \Delta p_{(d)}; \Delta p_{(d)} > 0$
(E) $\Delta p_{(a)} = \Delta p_{(b)} > \Delta p_{(c)}; \Delta p_{(c)} < \Delta p_{(d)}$

Crosstabulation Pretest-posttest

		Posttest					
		A	B	C*	D	E	Total
Pretest	Others	1	0	1	0	2	4
	A	1	0	0	1	2	4
	B	0	2	3	2	4	11
	C*	0	1	5	0	3	9
	D	0	0	3	0	2	5
	E	0	0	1	0	2	3
Total		2	3	13	3	15	36

Figure 3. Questions and Crosstabulation of Student Answer Choices

In number 2, the difficulty experienced by students is to compare the momentum based on the velocity graph information as a function of time. Students tend to have difficulty understanding graphical questions, so they are fooled by what is asked in the question by stating that "big momentum" does not pay attention to direction. In the correct answer choice C, as many as 5 (13.89%) students consistently give reasons for changes in the momentum of objects $\Delta\vec{p} = m(0-0) = \Delta\vec{p} = 0$, and can also determine the change in momentum of other objects with a value of 2 regardless of its direction during the pretest and posttest. However, when given a recitation program, students think that the answer E is the correct answer; it can be seen from the increase in students when the pretest only three people chose E, then increased by 15 students who chose E. They still think that comparing momentum still pays attention to the direction too.

Recitation in momentum and impulse learning is essential because providing programs in the form of conceptual questions and direct feedback helps students find solutions to problems (Jayanti et al., 2016). The information presented in the recitation program was insufficient for fostering a comprehensive understanding, thereby offering only limited support for students' conceptual grasp. Additionally, the recitation program influences students' motivation to engage with and explore physics content more thoroughly, particularly due to certain features it possesses. In light of the numerous deficiencies identified within this recitation program, there is an expectation for enhancements and the incorporation of more contemporary features to promote students' autonomy and active engagement in their learning process. Appropriate feedback by research (Diyana et al., 2020b; Reyza et al., 2017) can help students understand concepts they feel lack reinforcement.

The student's comprehensive grasp of the concept has yet to reach its full potential, as they remain unaccustomed to engaging with questions that utilize diverse representations. Nevertheless, this research serves as a foundation for further investigations aimed at creating analogous educational media to assist students in discovering more effective and accessible learning methods. Additionally, several issues were identified, stemming from the students' incomplete understanding of the concepts, which led to confusion regarding specific questions. This uncertainty hindered their confidence in the answers they provided, ultimately resulting in low N-Gain values recorded in this study.

4. CONCLUSION

Students' understanding of the concept of momentum and impulse after using a multi-representation and multi-context-based recitation program received a positive response from students who used the program. In understanding the concept of momentum and impulse, students experienced an increase in understanding. However, many difficulties still occurred, indicating that there were four questions with an N-gain value per question in the low category. Feedback and reinforcement questions in the recitation program have a less significant effect. Future research is anticipated to enhance the development of methodologies that facilitate updates regarding the applications and contexts of questions utilized. This improvement aims to acclimate students to engage with questions presented in various representational contexts. Furthermore, it is crucial to emphasize the comprehension of concepts acquired through video feedback, ensuring that students possess a clear and confident understanding of these concepts moving forward.

ACKNOWLEDGEMENTS

Thank you to UM for providing financial support.

DECLARATION OF INTEREST

There is no conflict of interest in this study.

RESEARCH FUNDING

This research was funded by the Internal State University of Malang in 2022. With number: 19.5.838/UN32.20.1/LT/2022.

ETHICAL STATEMENT

All students agreed to be respondents without coercion. All student information and identities were kept confidential in the research report.

AI USE STATEMENT

The author uses Grammarly to check for grammatical errors.

REFERENCES

Adimayuda, R., Sari, L., Ismail, A., Amalia, I. F., Gumilar, S., & Samsudin, A. (2021). Assessing two-dimensional collisions second-years students using PhET simulations on momentum and impulse concept. *Journal of Physics: Conference Series*, *1869*(1). https://doi.org/10.1088/1742-6596/1869/1/012204

Affriyenni, Y., Swalaganata, G., Kurniawan, B. R., & Taqwa, M. R. A. (2021). Development of Android-based application: An effort to enhance students' conceptual understanding in fundamental physics. *AIP Conference Proceedings*, *2330*(March). https://doi.org/10.1063/5.0043428

Agustina, K., Kristiyanto, W. H., & Noviandini, D. (2017). Learning design of problem based learning model based on recommendations of sintax study and contents issues on physics impulse materials with experimental activities. *International Journal of Active Learning*, *2*(2), 68–81. https://doi.org/10.15294/ijal.v2i2.10802

Andriani, R. D., Sunyono, & Abdurrahman. (2018). enhancing student s ' activity and science concept mastery using guided inquiry-based practical manual. *Jurnal Pendidikan Progresif*, *8*(1), 1–9. https://doi.org/10.23960/jpp.v8.i1.201801

Anon, D. T., & Mursyid, S. (2016). Remediasi miskonsepsi pada perpindahan kalor menggunakan model direct instruction berbantuan media animasi di man. *Jurnal Pendidikan Dan Pembelajaran Khatulistiwa*, *5*(12), 1–14. https://doi.org/10.26418/jppk.v5i12.17813

Arisanti, W., Sopandi, W., & Widodo, A. (2016). Analisis penguasaan konsep dan keterampilan berpikir kreatif siswa sd melalui project based learning. *Jurnal Pendidikan Dasar*, *8*(1). https://ejournal.upi.edu/index.php/eduhumaniora/article/view/5125/3586

Auna Hidayati, R., & Taqwa, M. R. A. (2023). Computer based recitation program development with feed back in newton's law topic. *International Journal of Education and Teaching Zone*, *2*(1), 113–129. https://doi.org/10.57092/ijetz.v2i1.49

Azizah, Z., Taqwa, M. R. A., & Assalam, I. T. (2020). Analisis pemahaman konsep fisika peserta didik menggunakan instrumen berbantuan quizizz. *Jurnal Pendidikan Sains & Matematika*, *8*(2), 1–11. https://doi.org/10.23971/eds.v8i2.1707

Badruzzaman, D. R., Kaniawati, I., & Utari, S. (2015). Profil konsistensi representasi dan konsistensi ilmiah siswa sma negeri di kota bandung pada materi kinematika gerak lurus. *Seminar Nasional Fisika (SINAFI)*, *November*, 26–38.

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

Creswell, J. W., & Clark, V. L. P. (2007). Research design: Qualitative, quantitative, and mixed methods approaches. In *Sage Publications*.

De Cock, M. (2012). Representation use and strategy choice in physics problem solving. *Physical Review Special Topics - Physics Education Research*, *8*(2), 1–15. https://doi.org/10.1103/PhysRevSTPER.8.020117

Dianningrum, M. C., Sutopo, & Hidayat, A. (2020a). Students' understanding of circular motion with multi representational approach. *AIP Conference Proceedings*, *2296*(November). https://doi.org/10.1063/5.0031000

Dianningrum, M. C., Sutopo, & Hidayat, A. (2020b). Students ' understanding of circular motion with multi representational approach. *International Conference on Science and Apllied Science (ISCAS2020)*, *2296*(020102). https://doi.org/10.1063/5.0031000

Diyana, T. N., Sutopo, & Sunaryono. (2020a). Concept enhancement of undergraduate students in static fluid by using assisted web-based recitation program. *AIP Conference Proceedings*, *2296*. https://doi.org/10.1063/5.0031001

Diyana, T. N., Sutopo, & Sunaryono. (2020b). The effectiveness of web-based recitation program on improving students' conceptual understanding in fluid mechanics. *Jurnal Pendidikan IPA Indonesia*, *9*(2), 219–230. https://doi.org/10.15294/jpii.v9i2.24043

Docktor, J. L., & Mestre, J. P. (2014). Synthesis of discipline-based education research in physics. *Physical Review Special Topics - Physics Education Research*, *10*(2), 1–58. https://doi.org/10.1103/PhysRevSTPER.10.020119

Fayanto, S., & Juni, D. (2020). Physics teaching: development of lectora inspire with multiple-representation approach to reduce of misconception. *Physics Teaching: Development of Lectora*, *4*(2), 159–170. http://jurnal.abulyatama.ac.id/index.php/dedikasi

Hastuti, A., Sahidu, H., & Gunawan. (2016). Pengaruh model pbl berbantuan media virtual tehadap kemampuan pemecahan masalah fisika. *Jurnal Pendidikan Fisika Dan Teknologi*, *2*(3), 129–135. https://doi.org/10.29303/jpft.v2i3.303

Hestenes, D., & Hestenes, D. (1997). *Modeling Methodology for Physics Teachers*. *935*. https://doi.org/10.1063/1.53196

Heuvelen, A. Van, & Zou, X. (2001). Multiple representations of work–energy processes. *American Association of Physics Teachers*, *69*(2), 184–194. https://doi.org/10.1119/1.1286662

Hwang, W. Y., & Purba, S. W. D. (2021). Effects of ubiquitous-physics app on students' inquiry behaviors and learning achievements. *Asia-Pacific Education Researcher*, *31*(4), 439–450. https://doi.org/10.1007/s40299-021-00585-7

Jayanti, I. B. R., Wartono, & Sutopo. (2016). Dampak program resitasi terhadap topik hukum iii newton. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *1*(2), 256–264. http://dx.doi.org/10.17977/jp.v1i2.6130

Kaniawati, I., Samsudin, A., Hasopa, Y., Sutrisno, A. D., & Suhendi, E. (2016). The influence of using momentum and impulse computer simulation to senior high school students' concept mastery. *Journal of Physics: Conference Series*, *739*(1). https://doi.org/10.1088/1742-6596/739/1/012060

Koenig, K. M., Endorf, R. J., & Braun, G. A. (2007). Effectiveness of different tutorial recitation teaching methods and its implications for TA training. *Phys. Rev. ST Phys. Educ. Res., 3*, 1–9. https://doi.org/10.1103/PhysRevSTPER.3.010104

Kohl, P. B., & Finkelstein, N. D. (2005). Student representational competence and self-assessment when solving physics problems. *Phys. Rev. ST Phys. Educ. Res. 1,* 010104, 1–11. https://doi.org/10.1103/PhysRevSTPER.1.010104

Kohl, P. B., Rosengrant, D., & Finkelstein, N. D. (2007). Strongly and weakly directed approaches to teaching multiple representation use in physics. Phys. *Rev. ST Phys. Educ. Res. 3,* 010108 1–10. https://doi.org/10.1103/PhysRevSTPER.3.010108

Lutfiyadi, M., & Budiyono, A. (2018). Pengaruh model pembelajaran problem based learning berbantuan media permainan kareka (kartu remi fisika) terhadap penguasaan konsep fisika siswa sma. *National Conference on …*, *September*, 247–254. http://proceeding.uim.ac.id/index.php/nacomse/article/view/173

Meltzer, D. E. (2005). Relation between students ' problem-solving performance and representational format Relation between students ' problem-solving performance and representational format. *American Association of Physics Teachers*, *73*(5), 463–478. https://doi.org/10.1119/1.1862636

Michelini, M. (2019). Mathematics in Physics Education. In *Mathematics in Physics Education*. https://doi.org/10.1007/978-3-030-04627-9

Munfaati, Y. N., Haryoto, D., & Sutopo. (2014). Penerapan pembelajaran inkuiri terbimbing disertai resitasi pada materi kalor : studi kasus di sma negeri 1 ponorogo. *Jurnal Online Universitas Negeri Malang*, 1–12.

Nur'aini, D. A., Lestari, P. D., & Kurniawan, B. R. (2020). Pengembangan asesmen formatif berbasis komputer untuk mengetahui penguasaan konsep siswa pada materi hukum bernoulli. *Jurnal Riset Pendidikan Fisika*, *5*(2), 106–112. https://dx.doi.org/10.17977/um058v5i2p106-112

Nurani, D. C., Sarwanto, S., & Rintayati, P. (2018). Influence of guided inquiry-based outdoor learning on the concept mastery of thematic learning by fourth-grade students at primary school. *International Journal of Multicultural and Multireligious Understanding*, *5*(4), 485–491. http://dx.doi.org/10.18415/ijmmu.v5i4.207

Ogilvie, C. A. (2009). *Changes in students ' problem-solving strategies in a course that includes context-rich , multifaceted problems*. 1–14. https://doi.org/10.1103/PhysRevSTPER.5.020102

Oktaviyanti, D., Tandililing, E., & Mahmuda, D. (2016). Remediasi miskonsepsi siswa menggunakan pembelajaran learning cycle 3e pada materi fluida statis di man. *Jurnal Pendidikan dan Pembelajaran Khatulistiwa*, *5*(12), 1–12. https://doi.org/10.26418/jppk.v5i12.17765

Puspitaningtyas, E., Hasanah, S., Kusairi, S., & Purwaningsih, E. (2021). Physics students' responses when asked to select and solve motion kinematics problems in various representations. *AIP Conference Proceedings*, *2330*(March). https://doi.org/10.1063/5.0043437

Putranta, H., & Supahar. (2019). Synthesis of the Cognitive Aspects' Science Literacy and Higher Order Thinking Skills (HOTS) in Chapter Momentum and Impulse. *Journal of Physics: Conference Series*, *1397*(1). https://doi.org/10.1088/1742-6596/1397/1/012014

Rahmawati, I., & Sutopo. (2019). Computer-assisted recitation program to improve students' conceptual understanding. *AIP Conference Proceedings*, *2194*. https://doi.org/10.1063/1.5139829
Rahmawati, S., Kusairi, S., & Sutopo. (2019). Analisis penguasaan konsep siswa yang belajar materi momentum dan impuls berbasis scientific approach disertai formative assessment berbantuan WEB. *Jurnal Pembelajaran Sains*, *3*(1), 1–6. http://dx.doi.org/10.17977/um033v3i1p1%20-%206
Ramadan, E. M., Jumadi, J., & Rahmawati, D. U. (2020). Physics online learning devices based on guided discovery model for high school class x on momentum and impulse material. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *6*(2), 163–172. https://doi.org/10.21009/1.06203
Riwanto, D., Azis, A., & Arafah, K. (2019). Analisis pemahaman konsep peserta didik dalam menyelesaikan soal-soal fisika kelas x mia sma negeri 3 soppeng. *Jurnal Sains Dan Pendidikan Fisika*, *15*(2), 23–31. https://doi.org/10.35580/jspf.v15i2.11033
Rosa, G. C., Cari, C., Aminah, N. S., & Handhika, J. (2018). Students' understanding level and scientific literacy competencies related to momentum and impulse. *Journal of Physics: Conference Series*, *1097*(1), 0–8. https://doi.org/10.1088/1742-6596/1097/1/012019
Sadaghiani, H. R. (2011). Using multimedia learning modules in a hybrid-online course in electricity and magnetism. *Physical Review Special Topics - Physics Education Research*, *7*(1), 1–7. https://doi.org/10.1103/PhysRevSTPER.7.010102
Saepuzaman, D., Karim, S., Feranie, S., Sari, I. M., & Sriyansyah, S. P. (2020). Pre-class tutorial (pct) to improve understanding of prospective physics teacher concepts in basic physics course. *Proceedings of the 7th Mathematics, Science, and Computer Science Education International Seminar, MSCEIS 2019*. https://doi.org/10.4108/eai.12-10-2019.2296495
Safitri, I., Kaniawati, I., & Rusnayati, H. (2020). Penerapan multirepresentasi pada pembelajaran inkuiri terbimbing terhadap penguasaan konsep dari gaya belajar. *Jurnal Pendidikan Fisika Dan Teknologi*, *6*(2), 169. https://doi.org/10.29303/jpft.v6i2.1870
Saifullah, A. M., Sutopo, S., & Wisodo, H. (2017). Senior high school students' difficulties in solving impulse and momentum problems. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 1–10. https://doi.org/10.15294/jpii.v6i1.9593
Silaen, S. S., Sudjito, D. N., & Sudarmi, M. (2019). Pengembangan tes diagnostik multi representasi eksternal (mre) untuk mengetahui profil kemampuan representasi konsep. *Publikasi Pendidikan*, *9*(2), 98. https://doi.org/10.26858/publikan.v9i2.8477
Sugiyono. (2018). *Metode Penelitian Kuantitatif*. Alfabeta.
Sundari, P. D., Dewi, W. S., Saputra, D., Mairizwan, M.-, & Hidayat, R. (2021). The improvement of physics teachers' competence in developing an interactive recitation programs to remediate students' misconception. *Indonesian Journal of Science and Mathematics Education*, *4*(3), 242–252. https://doi.org/10.24042/ijsme.v4i3.10053
Taqwa, M. R. A., & Hidayat, A. (2017). Deskripsi penggunaan program resitasi dalam meningkatkan kemampuan membangun free-body diagrams (fbds). *Jurnal Pendidikan Fisika Tadulako Online*, *5*(1), 52–58. https://doi.org/10.22487/j25805924.2017.v5.i1.8411
Taqwa, M. R. A., Hidayat, A., & Sutopo, S. (2017). Konsistensi pemahaman konsep kecepatan dalam berbagai representasi. *Jurnal Riset Dan Kajian Pendidikan Fisika*, *4*(1), 31. https://doi.org/10.12928/jrkpf.v4i1.6469
Taqwa, M. R. A., & Rahim, H. F. (2022). Students' conceptual understanding on vector topic in visual and mathematical representation: a comparative study. *Journal of Physics: Conference Series*, *2309*, 1–6. https://doi.org/10.1088/1742-6596/2309/1/012060
Taqwa, M. R. A., Zainuddin, A., & Riantoni, C. (2020). Multi representation approach to increase the students' conceptual understanding of work and energy. *Journal of Physics: Conference Series*, *1567*(3). https://doi.org/10.1088/1742-6596/1567/3/032090
Waldrip, B., Prain, V., & Carolan, J. (2006). *Learning junior secondary science through multi-modal representations*. Learning Junior Secondary Science through Multi-Modal Representations, *11*(1). https://ejrsme.icrsme.com/article/view/7752
Xu, W., Liu, Q., Koenig, K., Fritchman, J., Han, J., Pan, S., & Bao, L. (2020). Assessment of knowledge integration in student learning of momentum. *Physical Review Physics Education Research*, *16*(1), 10130. https://doi.org/10.1103/PHYSREVPHYSEDUCRES.16.010130