International Journal of Education, Information Technology and Others (IJEIT), December 2025, 8 (4), 179-188
DOI: https://jurnal.peneliti.net/index.php/IJEIT/article/view/13516
p-ISSN: 2654-2528 e-ISSN: 2623-2324
Accredited by Directorate General of Strengthening for Research and Development
Available online at https://jurnal.peneliti.net/index.php/IJEIT

Improving Students' Mastery of Physics Concepts Through the Application of Multi-Representation-Based Physics Modules

Ad'hani Miftachul Jannah [1*], I Ketut Mahardika[2], Bambang Supriadi[3]

[1,2,3] Department of Physics Education, Universitas Jember

Received: 5 December 2025
Revised: 13 December 2025
Accepted: 21 December 2025

Abstract
One of the causes of low student concept mastery is learning resources such as textbooks that are limited and less interesting to read or explore by students. Modules are one of the solutions to make it easier for students to understand physics-related concepts regarding work and energy material. The module that will be applied to reduce these problems is a multirepresentation-based module. The purpose of this research is to analyze the improvement of students' concept mastery through the implementation of multirepresentation-based physics modules on the subject of effort and energy. The research was conducted on class X students at SMK Negeri 2 Jember with a pre-experimental, one-group pretest-posttest research design. The research sample was taken by purposive sampling using instruments such as tests, observations, interviews, and documentation. The improvement of concept mastery was measured using N-gain based on the comparison of pretest and posttest results. The results showed that the increase in concept mastery on work and energy material was in the medium category with N-gain value of 58,48%, the unistructural level was in the medium category with N-gain value of 60,60%, the multistructural level was in the medium category with N-gain value of 42,67%, the relational level was in the medium category with N-gain value of 48,70%, and the extended abstract level was in the low category with N-gain value of 23,48%. So, it can be concluded that the multirepresentation-based module are proven to improve students' understanding of physics concepts.

Keywords: Mastery of Concepts, Multi-representation, Physics Module, Work and Energy

(*) Corresponding Author: 190210102077@mail.unej.ac.id

How to Cite: Jannah, A., Mahardika, I., & Supriadi, B. (2025). Improving Students' Mastery of Physics Concepts Through the Application of Multi-Representation-Based Physics Modules. *International Journal of Education, Information Technology, and Others*, *8*(4), 179-188. Retrieved from https://jurnal.peneliti.net/index.php/IJEIT/article/view/13516

INTRODUCTION

Physics is a part of science that reviews events and symptoms found in everyday life. Understanding of physics concepts among students is often low because physics is considered an abstract and difficult field (Sabaruddin and Nadia, 2019). This has an impact on students' lack of ability to understand the meaning of the problem, difficulty analyzing the meaning of the problem, lack of student interest in solving problems, and lack of experience in working on high-category physics problems (Mbayowo and Pasaribu, 2021).

Based on the results of observations and interviews conducted at SMKN 2 Jember, it shows that students' mastery of concepts is still lacking because there are still many students who have wrong concepts and difficulties in solving physics problems, especially the material of effort and energy. One of the difficulties faced by students is their inability to identify problem solving that requires understanding of concepts. The grade X teacher at SMKN 2 Jember stated that there are several factors that can cause low mastery of student concepts, one of which is the limited learning resources used, where physics learning in schools still uses textbooks as the main learning source that has not significantly integrated multirepresentation and does not contain the required concepts.

Mastery of physics concepts is the ability to explain physics material into a form that is better understood by students in the learning process as a result of making observations. Mastery of physics concepts is the ability to explain physics material into a form that is better understood by students in the learning process as a result of making observations (Shidik, 2020). Concept understanding plays an important role for students to solve physics problems that are quite complicated (Nikat, 2021). One of the causes of low student concept mastery is learning resources such as textbooks that are limited in explaining abstract concepts and are less interesting for students to explore (Susilawati *et al.*, 2020). Modules are one of the solutions to make it easier for students to understand physics-related concepts regarding effort and energy material (Ulfa *et al.*, 2021).

Multirepresentation-based modules are designed to illustrate abstract concepts through various representations, such as verbal, graphic, mathematical, and visual, so that they are expected to help students understand physics material better (Mangngella and Kendek, 2021). Verlina *et al.* (2018) in their research, suggested that there was a significant effect in the use of multirepresentation-based modules on concept mastery, meaning that the module proved effective in improving students' mastery of concepts. Based on student response data, it was found that students' opinions of the multirepresentation-based physics module were positive, indicating that students were helped by the module to understand physics concepts (Setyandaru *et al*., 2017).

The level of students' concept mastery in this study was measured using SOLO Taxonomy (Structure of the Observed Learning Outcomes). According to Piaget and Barbel (2010), after students reach a certain level in terms of SOLO regarding concepts, they will be able to continue operating at a level related to that concept. The SOLO taxonomy (Structure of Observed Learning Outcomes) categorizes the level of students' abilities at five different levels and is hierarchical, namely level 0: pre-structural, level 1: unistructural, level 2: multi-structural, level 3: relational, and level 4: extended abstract.

Based on the background that has been described, the problem formulations in this study are: how to improve students' mastery of physics concepts through the implementation of multirepresentation-based physics modules on the subject of effort and energy? The objectives of this study are to analyze the improvement of students' mastery of concepts through the implementation of multirepresentation-based physics modules on the subject of effort and energy.

RESEARCH METHOD

The research was conducted with a quantitative descriptive method by giving certain treatments to research subjects to get results in the form of consequences. The research design used was a pre-experimental one-group pretest-posttest by comparing the situation before and after treatment.

The research was conducted at SMKN 2 Jember in the even semester of the 2022/2023 school year for 2 meetings with a duration of 2 x 45 minutes at each meeting. The research sample in this study was class X-DKV. The initial stage of this research is determining the location, making instruments, and determining the population and research samples. The second stage is giving pretests to students to do learning by using multirepresentation-based physics modules and conducting posttests. The last stage is analyzing the data, compiling the results of the discussion, and drawing conclusions related to the research.

Data collection techniques in this study include interviews, conducted unstructured interviews with teachers as supporting data related to teaching materials used in class, and multirepresentation-based module implementation. Second: tests, used to obtain data related to students' concept mastery abilities. Third: documentation, used to obtain information related to the research.

The research instruments used are 1) teaching modules, as a reference in the learning process; 2) physics modules based on multirepresentation, used as teaching materials to support learning; 3) tests, using pretests and posttests to measure students' concept mastery; and 4) documentation, which can be in the form of notes, pictures, photos, and videos, and student portfolio results.

Data analysis was used to determine the improvement of students' concept mastery using the N-gain score with the formula:

$$Normalized\ Gain\ (g) = \frac{S_f - S_i}{S_{maks} - S_i} \times 100\% \quad (1)$$

After obtaining the percentage value, categorization is then carried out based on Table 1. below:

Table 1. Normalized gain (N-gain) category

No	Nilai N-gain	Criteria
1	$g \geq 70\%$	High
2	$30\% \leq g < 70\%$	Medium
3	$g < 30\%$	Low

RESEARCH RESULTS AND DISCUSSION

Based on the research objectives, data for analyzing the improvement in physics concept mastery was obtained based on the analysis of difference in pretest and posttest scores conducted before and after the implementation of the multirepresentation-based physics module with a total of 8 essay questions. The improvement in concept mastery was analyzed using normalized gain (N-gain), which is carried out at each level of SOLO taxonomy, namely unistructural, relational, and extended abstract. The results of the analysis of the improvement in students' physics concept mastery can be seen in Table 2. below:

Table 2. Improvement of Student Concept Mastery

Taxonomy Level	ΣSi	ΣSf	N-Gain (%)	Category
Unistructural	55	75	60,60	Medium
Multistructural	101	133	42,67	Medium
Relasional	110	185	48,70	Medium
Extended Abstract	44	75	23,48	Low
Average			58,48	Medium

Based on Table 2., it can be seen that the multi-representation-based physics module implemented can improve students' mastery of physics concepts at each level of the SOLO Taxonomy. This can be seen from the average increase in students' mastery of physics concepts, which is in the medium category with N-gain value of 58,48%.

The unistructural level experienced an increase in the medium category with an N-gain value of 60,60%. Although the improvement at this level is medium, it still indicates that most students were able to understand a basic aspect of the concept taught better after implementation, compared to the pretest. Students at this stage generally begin to be able to recall facts, provide definitions, and answer basic questions correctly. Examples of students' pretest responses at the unistructural level can be seen in Figure 1. below.

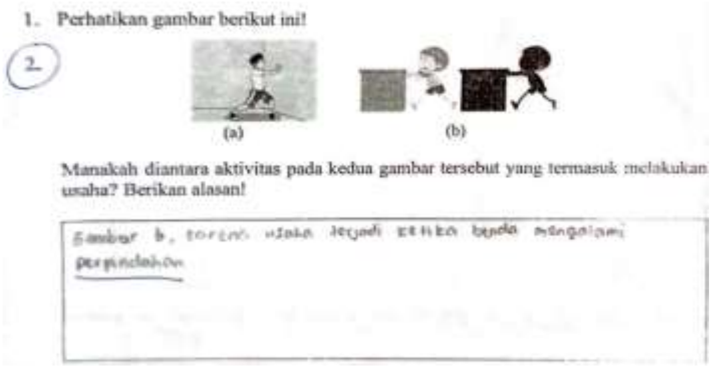


Figure 1. Unistructural level pretest answers

In the pretest, students do not yet fully understand the aspects of work. Their answers are still direct statements based on what is presented in the picture, namely the object is moving. Despite choosing the correct activity, students were unable to represent the concept from the image format into another format, resulting in inaccurate answers. This can occur when students are not accustomed to learning concepts in multiple representations, making it difficult to understand concepts when presented in different representations.

In the posttest conducted after implementing the module, students were not only able to remember the definition of work, but were also able to relate the variables that cause work to occur. Examples of students' post-test responses at the unistructural level can be seen in Figure 2. below.

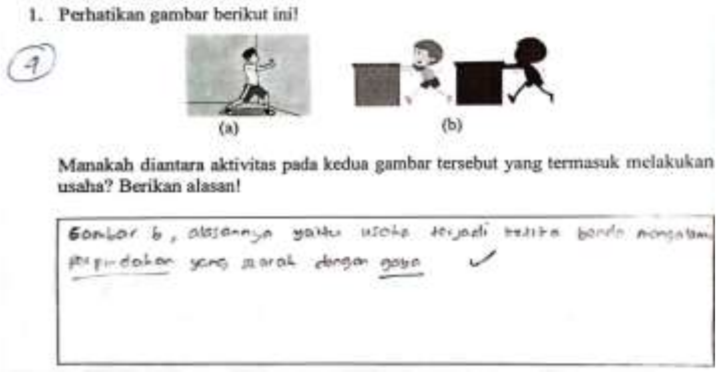


Figure 2. Unistructural level post-test answers

Based on the students' answers to the image above, they know that the activity performing the work is image b because the activity in the image experiences a displacement in the same direction as the applied force. Therefore, when the displacement is not zero, the activity experiences work. From the answers given, students are able to understand one aspect of the topic presented.

The multistructural level experienced an increase in conceptual mastery in the moderate category, with an N-gain value of 42.67%. This indicates that the multirepresentation-based physics module helps students understand separate aspects of a topic. Examples of students' pretest answers at the multistructural level can be seen in Figure 3 below.

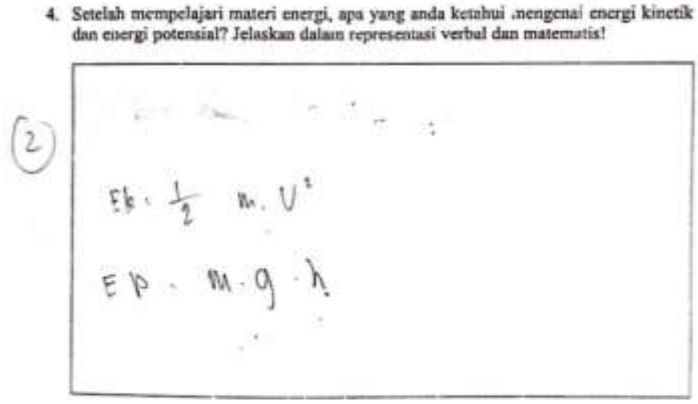


Figure 3. Multistructural level pre-test answers

In the pretest, students' answers were still direct statements, thus not demonstrating conceptual understanding. This may be because, before using the multi-representation-based module, physics learning tended to focus on memorizing formulas and terms, rather than understanding the meaning of a concept. For example, students knew the formula for kinetic energy but did not understand that kinetic energy arises from moving objects. Furthermore, this could be because students were not yet accustomed to linking various forms of representation (verbal, mathematical, pictorial, and graphical). Therefore, when asked to explain using two forms of representation simultaneously, students were only able to write partially, for example, only stating the definition without the formula, or vice versa.

After implementing a multi-representation-based physics module, students have progressed from simply memorizing terms to understanding the meaning and basic representation of concepts. The multi-representation-based physics module contains material that interprets the concepts of work and energy through multiple representations, so students gain conceptual reinforcement through consistent application. Examples of students' posttest answers can be seen in Figure 4 below.

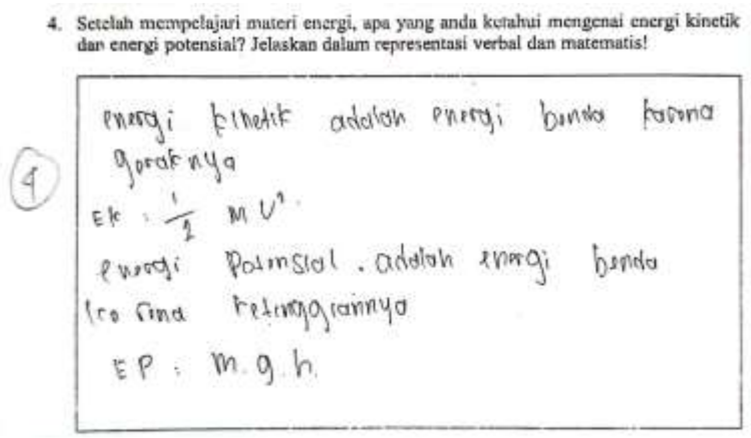


Figure 4. Multistructural level post-test answers

Based on the students' posttest responses, it appears that they were able to verbally explain the meaning of both concepts correctly. Furthermore, they were able to represent the concepts mathematically using appropriate formulas. Their responses demonstrated a strong foundational understanding of two aspects of the topic: potential energy and kinetic energy.

The relational level experienced an increase in conceptual mastery in the medium category, with an N-gain value of 48,70%. That indicates that the implementation of the multi-representation-based physics module was still effective in improving students' understanding of physics concepts. This means that some students began to be able to use aspects of the problem and connect them to find solutions. Examples of students' pretest answers at the relational level can be seen in Figure 5. below.

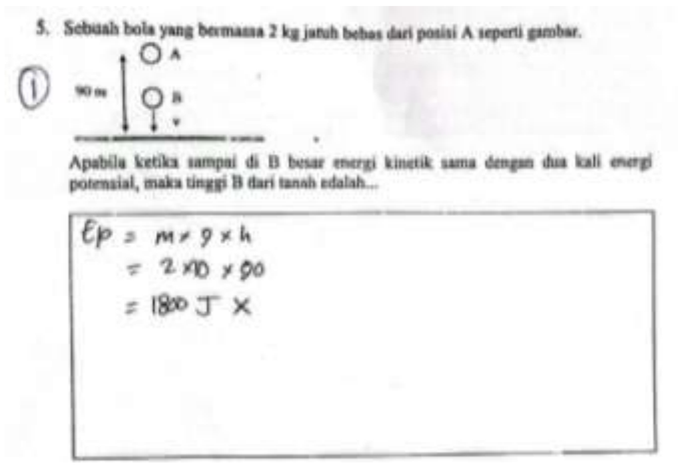


Figure 5. Relational level pretest answers

In the pretest, students are able to recall some aspects of the concept, but lack a complete understanding of the concepts and are unable to logically connect them. Students understand the equations for kinetic and potential energy, but are unable to determine the relationship between the two concepts using the law of conservation of energy. Consequently, students are unable to correctly and precisely solve problems that present the law of conservation of energy.

After implementing the module, students experienced increased abilities at the relational level. Students who reached the relational level were able to connect aspects of the concepts learned to solve the problems presented. Examples of students' posttest responses at the relational level can be seen in Figure 6. below.

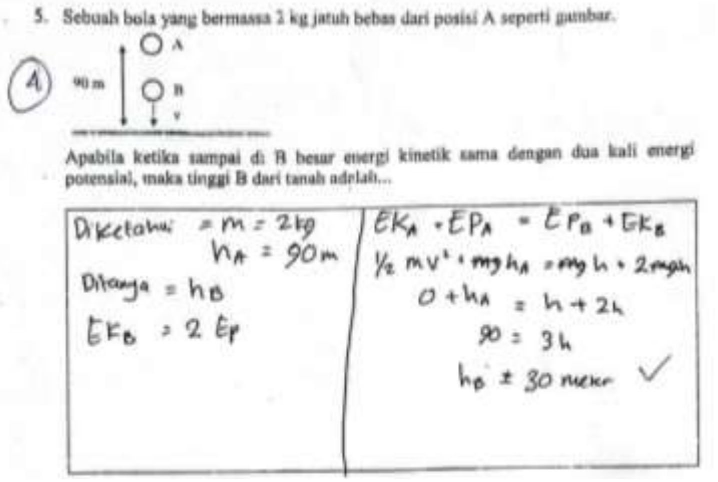
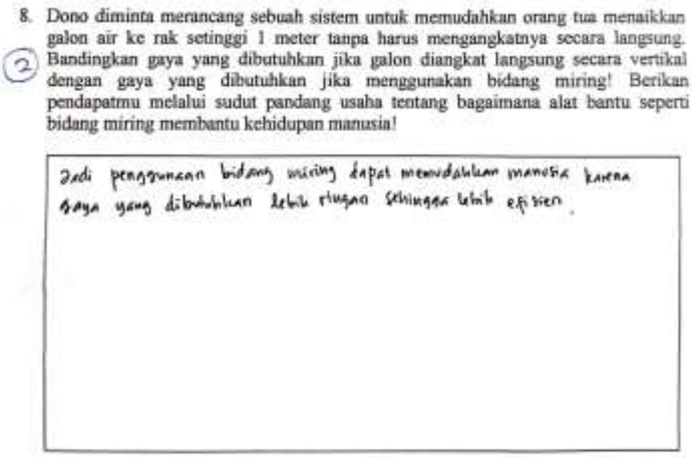


Figure 6. Relational level post-test answers

Based on the students' answers, they were able to demonstrate the contribution of all aspects of the problem, thus integrating the concepts within it. Students were able to discover the relationship between kinetic and potential energy through the law of conservation of energy, thus finding the correct solution to the problem presented. The improvement in students' mastery of physics concepts at the relational level indicates that the multi-representation-based physics module effectively improves students' mastery of physics concepts. The module facilitates a learning process that encourages students to seek causal relationships between concepts, such as the concept of work, changes in kinetic and potential energy, and the application of the law of conservation of energy. The example questions and practice questions integrated within the module train students to analyze problems comprehensively, identify information, and connect various concepts to find solutions to the problems presented.

The extended abstract level experienced an increase in the low category with an N-gain value of 23.48%. Although the increase was lower than previous levels, students still experienced an increase in conceptual mastery between before and after the implementation of the multi-representation-based physics module. This indicates that the implemented multi-representation-based physics module was able to improve students' conceptual mastery at the extended abstract level. Examples of students' pretest answers at the extended abstract level can be seen in Figure 7 below.

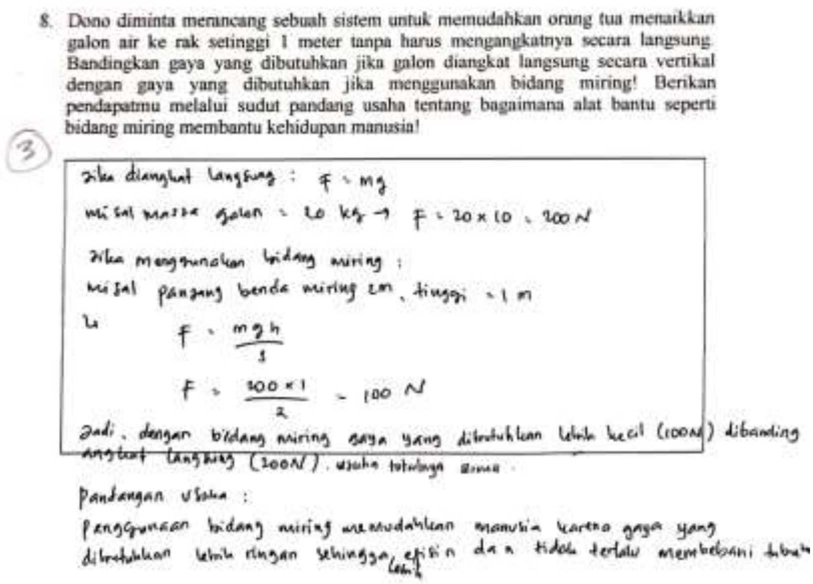

8. Dono diminta merancang sebuah sistem untuk memudahkan orang tua menaikkan galon air ke rak setinggi 1 meter tanpa harus mengangkatnya secara langsung. Bandingkan gaya yang dibutuhkan jika galon diangkat langsung secara vertikal dengan gaya yang dibutuhkan jika menggunakan bidang miring! Berikan pendapatmu melalui sudut pandang usaha tentang bagaimana alat bantu seperti bidang miring membantu kehidupan manusia!

Jadi penggunaan bidang miring dapat memudahkan manusia karena gaya yang dibutuhkan lebih ringan sehingga lebih efisien.

Figure 7. Extended abstract level pretest answers

In the pretest, students were able to understand the basic concepts related to force, although they had not yet connected them to displacement. Students still experienced difficulties when faced with questions that required them to generalize concepts, form hypotheses, and transfer concepts to new situations. Students' inability to grasp and connect these basic concepts will impact their ability to apply them to new situations that require advanced thinking.

After implementing the multi-representation physics module, some students began to draw general conclusions from the problems presented. However, most students still struggled to generalize and apply energy concepts to new, more complex situations. Examples of posttest responses from students who reached the extended abstract level can be seen in Figure 8 below.


8. Dono diminta merancang sebuah sistem untuk memudahkan orang tua menaikkan galon air ke rak setinggi 1 meter tanpa harus mengangkatnya secara langsung. Bandingkan gaya yang dibutuhkan jika galon diangkat langsung secara vertikal dengan gaya yang dibutuhkan jika menggunakan bidang miring! Berikan pendapatmu melalui sudut pandang usaha tentang bagaimana alat bantu seperti bidang miring membantu kehidupan manusia!

Jika diangkat langsung : $F = mg$

misal massa galon = 20 kg → $F = 20 \times 10 = 200$ N

Jika menggunakan bidang miring :

misal panjang benda miring 2m, tinggi = 1 m

$F = \frac{mgh}{s}$

$F = \frac{100 \times 1}{2} = 100$ N

Jadi, dengan bidang miring gaya yang dibutuhkan lebih kecil (100N) dibanding angkat langsung (200N). usaha totalnya sama.

Pandangan usaha :

penggunaan bidang miring memudahkan manusia karena gaya yang dibutuhkan lebih ringan sehingga lebih efisien dan tidak terlalu membebani tubuh

Figure 8. Extended abstract level post-test answers

In the posttest, students were able to apply the concepts they learned to new situations. They were able to connect the information to determine the force required when lifting the gallon directly and when using an inclined plane, although they had not yet related it to displacement. Furthermore, they understood that the total effort required was the same, allowing them to draw the correct conclusion. However, the increase in the low category indicates that most students have not yet reached the extended abstract level. This is due to several factors, including limited and relatively short implementation time, students' learning habits that are still oriented towards memorization, and the lack of activities in the module that guide students in generalizing concepts across contexts.

Based on the results obtained, it is known that the multi-representation-based physics module is able to provide an increase in students' mastery of concepts at each stage including unistructural, relational, extended abstract. This is in line with the research of Verlina et al. (2018) which stated that there is a significant influence in the use of multi-representation-based modules on increasing students' mastery of concepts as seen through the results of the pretest and posttest. Mahardika et al. (2020) in their research also stated that multi-representation applied in physics learning can improve students' mastery of concepts and reasoning.

CONCLUSION

Based on the results of the research, data analysis, and discussion, it can be concluded that students experienced an increase in mastery of the concept of effort and energy after the implementation of a multirepresentation-based physics module. This is shown through the Students experienced an increase in mastery of the concept of work and energy at the unistructural level in the medium category with an N-Gain value of 60,60%. At the multistructural level, the increase in concept mastery experienced by students was in the medium category with an N-gain value of 42,67%. At the relational level, the increase in concept mastery experienced by students was in the medium category with an N-gain value of 48,70%. At the extended abstract level, there was an increase in concept mastery in the low category with an N-gain value of 23,48%.

BIBLIOGRAPHY

A. A. Verlina, C. Ertikanto, and I. Wahyudi. (2018). Pengaruh penggunaan modul kontekstual berbasis multirepresentasi pada pembelajaran hukum gravitasi newton terhadap pemahaman konsep siswa. Jurnal Pembelajaran Fisika, 6(1), pp. 82-93.

E. J. Mangngella, and Y. Kendek. (2021). Pengaruh model problem based learning dengan pendekatan multirepresentasi terhadap hasil belajar siswa pada materi usaha dan energi. Jurnal Kreatif Online, 9(3), pp. 32-40.

E. M. Ulfa, Subiki, and L. Nuraini. (2021). Efektivitas penggunaan modul fisika terintegrasi STEM (science, technology, engineering, and mathematics) materi usaha dan energi di SMA. Jurnal Pembelajaran Fisika. 10(4), pp. 136-142.

I. K. Mahardika, I.G. Rasagama, L. Indrianto, A. Doyan, and Supeno. (2020). Validity of physical learning module based on multiple representation and higher order thinking skill. Journal of Physics: Conference Series. 1465(1), pp. 1-5.

J. Piaget and I. Barbel. (2010). Psikologi Anak Terjemahan Miftahul Jannah Cetakan 1. Yogyakarta: Pustaka Belajar.

M. A. Shidik. (2020). Hubungan antara motivasi belajar dengan pemahaman konsep fisika peserta didik MAN Baraka. Jurnal Kumparan Fisika, 3(2), pp. 91–98.

R. F. Nikat. (2021). Exploration of students' argumentation skill assisted format representation in solving electrical concept. Jurnal Pendidikan Sains. 9(1), pp. 42-50.

R. Mbayowo, & M. Pasaribu. (2021). Analisis kemampuan berpikir tingkat tinggi siswa dalam menyelesaikan soal fisika bentuk representasi gambar di SMA Negeri se-kabupaten Morowali Utara. Wahana Pendidikan Fisika. 7(2), pp. 177-186.

S. Susilawati, P. Pramusinta, & E. Saptaningrum. (2020). Penguasaan konsep siswa melalui sumber belajar e-modul gerak lurus dengan software flipbook maker. Unnes Physics Education Journal, 9(1), pp. 36-43.

Sabaruddin, & L. Nadia. (2019). Pengembangan modul fisika pada materi tekanan di MTsN. Jurnal Pendidikan Fisika dan Fisika Terapan. 5(2), pp. 74-80.

T. A. Setyandaru, S. Wahyuni, & P. D. Putra. (2017). Pengembangan modul pembelajaran berbasis multirepresentasi pada pembelajaran fisika di SMA/MA. Jurnal Pembelajaran Fisika. 6(3), pp. 218-224.