ISSN: 2502-2318 (Online)
ISSN: 2443-2911 (Print)

Homepage :
https://journal.uhamka.ac.id/index.php/omega

Omega : Jurnal Fisika dan Pendidikan Fisika
Vol 9,No 1(2024)

Implementation of Matrix Determinant Teaching Module in Two-Loop Closed Electrical Circuit to Improve High School Students' Physics Learning Outcomes

Wendy Kristiawan[1]* Maryani1 Hadiyanto[2]

[1]Physics Education Study Program, Faculty of Teacher Training and Education, University of Jember, Indonesia

[2]State High School 2 Jember, Jember, Indonesia

**E-mail:wendykristiawan@gmail.com*

Tel. 081334744774

ABSTRACT

The closed two-loop electrical circuit teaching module in schools is incomplete, the language is difficult to understand, the display is not attractive, and uses substitution-elimination with long stages. This study aims to improve the physics learning outcomes of high school students, as well as to determine the responses of teachers and students through a teaching module containing the matrix determinant method. This experimental research is in the form of a quantitative descriptive approach and a One Group Pretest-Posttest design. The research sample was 36 students of XII MIPA 4 and 3 physics teachers of SMAN 2 Jember. Data analysis used the N-Gain test (score) and response (percentage). The results showed that the implementation of the teaching module improved student learning outcomes with an N-Gain score of 0.82 in the high category. The teaching module received a positive response with a percentage of 93.06% from teachers and 88.39% from students in the very positive category. Thus, the implementation of the matrix determinant teaching module in a closed two-loop electrical circuit can improve the physics learning outcomes of high school students and receive a very positive response from physics teachers and students.

Keywords: Matrix Determinant, Learning Outcomes, Teaching Module, Two-Loop Closed Electrical Circuit.

INTRODUCTION

Physics learning is a scientific learning activity that emphasizes processes, scientific behavior, and work such as observing, formulating problems, making hypotheses, testing, concluding, and coming up with new things.[1]. Quality physics learning is characterized by the formation of Creative Thinking, Critical Thinking, Communication, and Collaboration skills in students [2]. Facilities, infrastructure, media, models, learning strategies, and quality teaching materials are factors that support the success of physics learning. Success through these components can improve students' physics learning outcomes [3].

Learning outcomes are changes in behavior and skills due to understanding after learning according to 3 assessments (cognitive, affective, and psychomotor)[4]. One of the factors causing low learning outcomes is that students do not understand the physics material that is explained and teachers do not use printed teaching materials optimally.[5], [6]. The low learning outcomes of the closed-loop electrical circuit material are also caused by misconceptions due to a lack of understanding of physics concepts [1]. To reduce the level of student errors in understanding the material, the printed teaching materials used should present complete and systematic material, as well as appropriate examples and practice questions, complete with effective and concise ways to answer questions on closed two-loop electrical

circuits.[7]. One example of printed teaching materials that have an influence on improving learning outcomes is teaching modules[8].

Teaching modules are materials that present complex material so that students can be more independent in achieving learning outcomes.[9]. Teaching modules generally consist of an introduction (learning information), content (materials and practice questions), and a conclusion (bibliography and author biodata).[10]. The general characteristics of teaching modules are forming attitudes, focusing on material, independent media, containing knowledge, and effective to use.[11]. Teaching modules play an important role in the learning process by helping teachers monitor student understanding.[12]. Printed teaching modules enable students to achieve learning objectives independently by encouraging independence and deepening understanding.[8]. Printed learning modules allow students to learn without time or space constraints, and adjust their style, learning speed, and preferred materials because they are easily accessible without an internet connection.[13]. Student learning outcomes increased with an n-gain result of 0.74 and high criteria through the teaching module.[11]. Therefore, teachers very often use printed teaching modules in physics learning.[14].

Kirchoff's law on closed two-loop electrical circuits in printed teaching modules is quite difficult physics material because it requires long, tiered steps and mathematical skills.[15]. Students have difficulty making equations, drawing loop directions, and knowing the flow of electric current.[4]. The material in the teaching module is also incomplete and includes unattractive images.[16]. This is what causes student learning outcomes to still be very low on the material on closed two-loop electrical circuits.[1], [3].

A two-loop closed electrical circuit is generally worked on using the substitution-elimination method.[17]. However, there are many methods that can be used to solve physics problems of closed two-loop electrical circuits. Matrix determinants assisted by Cramer's rule are one of the efficient mathematical methods for solving physics problems in closed two-loop electrical circuits. Cramer's rule is a way to find the value of a variable in a Linear Equation System using a matrix determinant. The matrix determinant is the value of the sum of the main diagonal elements minus the sum of the secondary diagonal elements whose elements have been multiplied[15]. Between the closed electrical circuit of two loops with the matrix determinant has similarities in the form of varying variables. Thus, the variables are combined into equations and changed into matrix form which will later be worked on with the matrix determinant.[18].

StudyHasyim & Ramadhan (2018)found that physics has abstract concepts, is difficult to understand, and is difficult to relate to life, so to explain physics material and improve learning outcomes, teachers and students need printed teaching materials. ResearchSunni (2019)added that students had difficulty making equations, drawing loop directions, and knowing the current. The study fromErly (2020)AndHidayatulloh et al (2019)shows that students' learning outcomes in studying the material on two-loop closed electrical circuits are still very low.

Based on the explanation above about the low physics learning outcomes of students on the material of closed two-loop electrical circuits due to teaching materials containing incomplete materials, difficult to understand language, unattractive displays, and long stages of problem solving methods. Therefore, it is important to implement teaching modules that have been created with complete materials, communicative language, attractive displays, and effective methods for solving closed two-loop electrical circuit problems, namely matrix determinants. The purpose of this study was to improve and describe the physics learning outcomes of high school students, as well as to find out how teachers and students respond to the teaching modules used. In addition, through teaching modules containing solutions to solving closed two-loop electrical circuit problems using the matrix determinant method,

ω omega

Omega : Jurnal Fisika dan Pendidikan Fisika
Vol 9,No 1(2024)

ISSN: 2502-2318 (Online)
ISSN: 2443-2911 (Print)

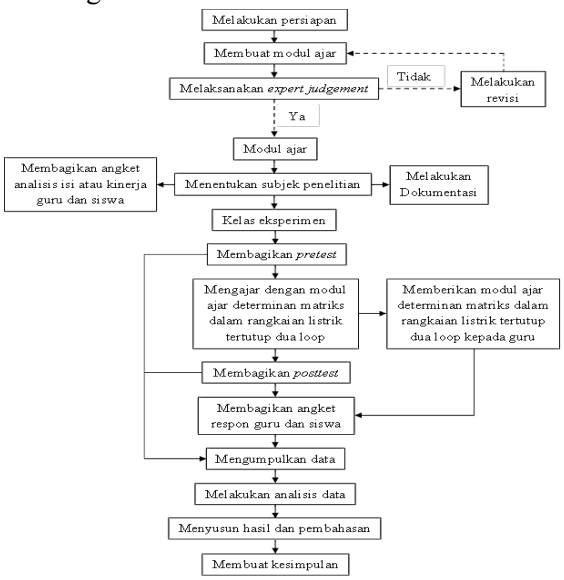
Homepage :
https://journal.uhamka.ac.id/index.php/omega

it is expected to create an effective and easy way for teachers and students.

RESEARCH METHODS

This research is an experimental research with a quantitative descriptive approach. The design used is One Group Pretest-Posttest Design.

1) Location and Time of Research
   The research was conducted at SMA Negeri 2 Jember in the odd semester of 2023/2024 which was selected using purposive sampling area.[20].
2) Research Sample
   The research sample consisted of 36 students of class XII MIPA 4 and three physics teachers.
3) Research Instruments
   Primary and supporting data are two types of data used in this study. Primary data is obtained from test results, as well as responses from physics teachers and students. The results of content analysis or performance of physics teachers and students, as well as documentation become supporting data.
4) Research Procedures
   The research procedure can be observed in Figure 1.



Picture.1 Research Procedures

5) Data collection technique
   The test (pretest and posttest) consisted of five descriptive questions. The physics teacher and student response questionnaire consisted of 24 statements and five supporting questions with indicators of ease of understanding of the content, efficiency of use, and beauty and visual appeal. The content analysis questionnaire or teacher and student performance consisted of 12 statements about learning problems. Both questionnaires used a Likert scale score in the form of a score of 5 Strongly Agree (SS), a score of 4 Agree (S), a score of 3 Quite Agree (CS), a score of 2 Less Agree (KS), and a score of 1 Strongly Disagree (STS)[20]. Documentation in the form of identity, activities, and results sheets.
6) Data analysis
   In this study, the learning outcome data and the results of teacher and student responses were analyzed. The pretest and posttest results in the form of scores were obtained through equation (1) according toIbrahim & Yusuf (2019):

$$nilai = \frac{total\ skor\ soal\ benar}{total\ skor\ soal\ seluruhnya} \times 100 \quad (1)$$

The results of the values were analyzed based on the Normalized Gain <g> test with equation (2):

$$N - Gain\ \langle g \rangle = \frac{nilai\ posttest - nilai\ pretest}{nilai\ maksimum - nilai\ pretest} \quad (2)$$

The results of the Normalized Gain <g> test are converted into categories in Table 1 below:

Table.1 Normalized Gain Level Category <g>

Limitation	Category
$0,7 \leq \langle g \rangle$	Tall
$0,3 \leq \langle g \rangle < 0,7$	Currently
$\langle g \rangle < 0,3$	Low

The response results were analyzed from the scores into percentages using equation (3):

$$Persentase = \frac{total\ skor\ yang\ diperoleh}{skor\ tertinggi} \times 100\% \quad (3)$$

ISSN: 2502-2318 (Online)
ISSN: 2443-2911 (Print)

Homepage :
https://journal.uhamka.ac.id/index.php/omega

Omega : Jurnal Fisika dan Pendidikan Fisika
Vol 9,No 1(2024)

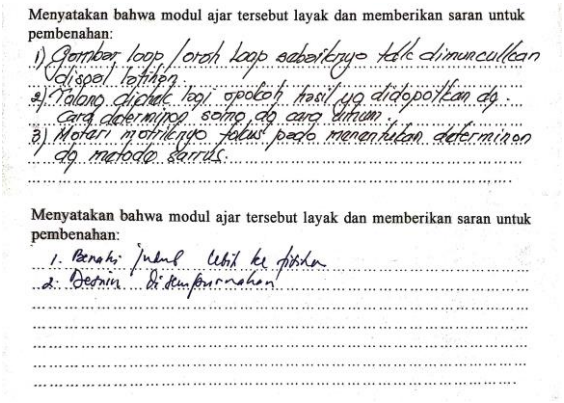
The percentage results are converted into categories in Table 2 below:

Table.2 Response Result Percentage Category

Percentage (%)	Category
$80\% < P \leq 100\%$	Very Positive
$60\% < P \leq 80\%$	Positive
$40\% < P \leq 60\%$	Quite Positive
$20\% < P \leq 40\%$	Less Positive
$1\% \leq P \leq 20\%$	Very Not Positive

RESULTS AND DISCUSSION

The matrix determinant teaching module in a closed two-loop electrical circuit is compiled with MS Word 2010 and Canva, and assessed using expert judgment before being implemented in learning. The expert judgment assessment was carried out by 2 lecturers from the Physics Education Study Program, University of Jember, which showed that the teaching module was feasible and there were suggestions for correction according to Figure 2. The suggestions related to the title of the teaching module were more emphasized on physics, the components and design of the teaching module were more refined, not showing the direction of the loop in the questions in the teaching module, checking the answer keys for all questions, and focusing on the material of the Sarrus rule matrix determinant. The teaching module contains a foreword, table of contents, chapters 1 to 5, glossary, bibliography, answer keys, and about the author. Chapter 1 introduction contains background, description, concept map, benefits, learning objectives, and usage guidelines. Chapter 2 learning activity 1 and chapter 3 learning activity 2 contain core and basic competencies, indicators, materials, summaries, questions, and tests. Chapter 4 evaluation contains the intent and purpose, materials, and evaluation questions. Chapter 5 closing contains follow-up actions and expectations.


Menyatakan bahwa modul ajar tersebut layak dan memberikan saran untuk pembenahan:
1) Gambar loop loroh loop sebaiknya tdk dimunculkan dispel terlihat
2) Tolong dicheck lagi apakah hasil yg didapatkan dg cara determinan sama dg cara umum
3) Materi matrikenya fokus pada menentukan determinan dg metode sarrus

Menyatakan bahwa modul ajar tersebut layak dan memberikan saran untuk pembenahan:
1. Perbaiki judul lebih ke fisika
2. Desain Di sempurnakan

Picture. 2 Expert Judgment Results

The results of the study show the pretest and posttest scores as student learning outcomes. The pretest and posttest scores are data on the occurrence of increased student learning outcomes. Student learning outcome data is shown in Table 3 below:

Table. 3 Student Learning Outcome Data

Information	Mark	
	Pretest	**Posttest**
Number of Students	35	31
Lowest Value	27	68
The highest score	64	96
Total Value Sum	1490	2779
Average Value	42.57	89.61
Average N-Gain	**0.82**	
Category	**Tall**	

Based on Table 3, the lowest pretest score was 27 and the highest was 64, while the lowest posttest score was 68 and the highest was 96. The average pretest score was 42.57 and the posttest was 89.61, indicating a significant difference and improvement. Learning with the matrix determinant teaching module in a two-loop closed electrical circuit is given after completing the pretest and before completing the posttest. The teaching module contains material on two-loop closed electrical circuits and the Sarrus rule matrix determinant assisted by Cramer's rule as a solution to the problem.

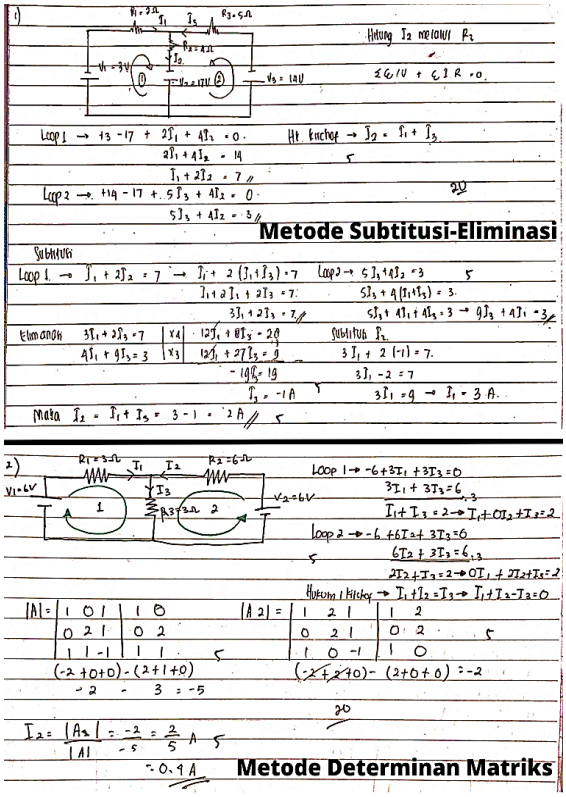
According to the data obtained from student learning outcomes, it states that the value*pretest*lower than the posttest score, which means that student learning outcomes have

ISSN: 2502-2318 (Online)
ISSN: 2443-2911 (Print)

Homepage :
https://journal.uhamka.ac.id/index.php/omega

Omega : Jurnal Fisika dan Pendidikan Fisika
Vol 9,No 1(2024)

increased through the teaching module equipped with an effective matrix determinant method to answer closed two-loop electrical circuit questions. Figure 3 shows the difference between the pretest answers using the substitution-elimination method which has longer stages and the posttest answers using the matrix determinant method which has shorter stages. This improves students' physics learning outcomes because students are helped in solving closed two-loop electrical circuit questions.



Picture.3 Substitution-Elimination Method and Matrix Determinants

To determine the improvement of student learning outcomes through the use of teaching modules, the pretest and posttest scores were analyzed using the Normalized Gain <g> test. The results of the data analysis showed an average N-Gain of 0.82. These results state that by implementing the matrix determinant teaching module in a two-loop closed electrical circuit, student learning outcomes increased in the high category.

The teaching module does not only emphasize on the completeness of the material, communicative language, efficient use, and attractive appearance. The teaching module also contains a matrix determinant method with simple and efficient steps, so that students can easily follow the stages of the matrix determinant method. Students can also maximize their time and get satisfactory results after working on two-loop closed electrical circuit problems. This is based on students' positive responses regarding the stages of the matrix determinant method which are concise and easy to follow.

*Pretest*and posttest have the same characteristics of questions. Students' pretest answers show that the five questions are not finished, the electric current unit is not written, difficulty in substituting and eliminating equations, difficulty in determining the direction of the loop and the direction of the electric current, composing and simplifying equations, and writing the correct calculation answers. This is what causes the low pretest score. Based on students' posttest answers, the five questions are completely answered and some are able to write the correct calculation answers. This causes the posttest score to be higher than the pretest score.

To find out the impressions of physics teachers' and students' reactions to the teaching module after it was used, a response questionnaire was given. The summary results of the response questionnaire are shown in Table 4 below:

Table.4 Physics Teacher and Student Response Questionnaire Results

Information	Results	
	Teacher	Student
Highest response value	119	120
Lowest response value	109	95
Total Value of Each Indicator:		
1. Ease of Understanding Content	111	1130

ISSN: 2502-2318 (Online)
ISSN: 2443-2911 (Print)

Homepage :
https://journal.uhamka.ac.id/index.php/omega

2. Efficiency of Use	112	1051
3. Beauty and Visual Appeal	112	1107
Percentage of Each Indicator:		
1. Ease of Understanding Content	92.50%	91.13%
2. Efficiency of Use	93.33%	84.76%
3. Beauty and Visual Appeal	93.33%	89.27%
Category of Each Indicator:		
1. Ease of Understanding Content	Very Positive	Very Positive
2. Efficiency of Use	Very Positive	Very Positive
3. Beauty and Visual Appeal	Very Positive	Very Positive
Total Value of All Indicators	335	3288
Average Percentage of All Indicators	93.06%	88.39%
Average Category of All Indicators	Very Positive	Very Positive

Table 4 shows the highest response value for teachers at 119 and students at 120, while the lowest for teachers at 109 and students at 95. The indicator with the highest total value and percentage is efficiency of use, and beauty and visual interest at 119 percentage 93.33% very positive category for teachers. The indicator with the highest total value and percentage for students is ease of understanding the content at 1130 percentage 91.13% very positive category.

The teaching module used is easy to understand and follow the material, because it uses communicative language, so that teachers and students give very positive responses. This is evidenced by the total value of the ease of understanding content indicator of 111 and a percentage of 92.50% for physics teachers, and a total value of 1130 and a percentage of 91.13% for students. These results indicate that there is knowledge received by teachers and students, namely the matrix determinant method for working on two-loop closed electrical circuit problems. The teaching module contains a concise and complete summary, as well as examples and practice questions equipped with simple stages that are in accordance with the material.

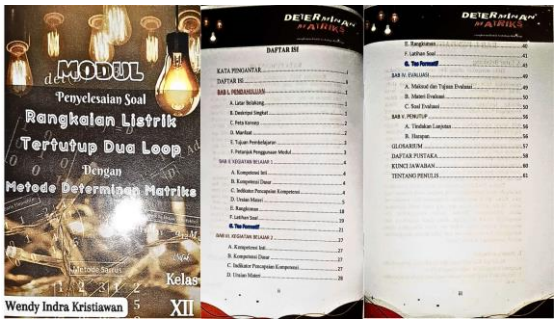
In the efficiency of use indicator, the teaching module received a very positive response because it is convenient to use and provides a method for working on questions. Physics teachers gave a total score for the indicator of 112 with a percentage of 93.33%. The total score for the efficiency of use indicator given by students was 1051 with a percentage of 84.76%. The teaching module helps answer difficult questions with a simple method, so it can be used as a reference for learning and teaching. The teaching module is also practical to hold, so it can be read anytime and anywhere, and is supported by durable conditions.

The teaching module in Figure 3 received very positive responses on the indicators of beauty and visual interest, such as design and visual components (cover, layout, content, images, and writing) are appropriate and attractive. The total value of the indicator given by the physics teacher was 112 with a percentage of 93.33%. Students also gave a total value of the indicator for the teaching module of 1107 with a percentage of 93.33%. The teaching module is presented with the right size and font that can be read. The size of the images displayed in the teaching module is clear and consistent.

ISSN: 2502-2318 (Online)
ISSN: 2443-2911 (Print)

Homepage :
https://journal.uhamka.ac.id/index.php/omega

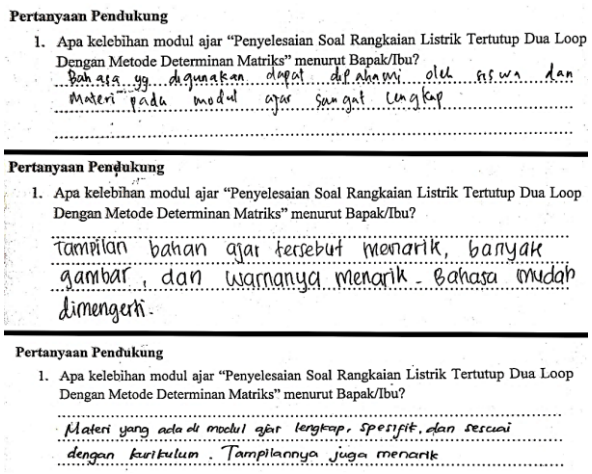
Omega : Jurnal Fisika dan Pendidikan Fisika
Vol 9,No 1(2024)



Picture.4 Matrix Determinant Teaching Module in Two-Loop Closed Electrical Circuits

Teachers and students gave very positive responses to the applied teaching module. Table 4 proves that the total value of all indicators is 335 with a percentage of 93.06% from teachers and 3288 with a percentage of 88.39% from students. The existence of this very positive response can be used to ensure that the matrix determinant method teaching module is feasible and effective to be implemented in learning the material of two-loop closed electrical circuits.

The physics teacher response questionnaire contains criticism and suggestions for the teaching module written in 5 supporting questions. According to the first question in Figure 4, complete material, attractive appearance, and easy-to-understand language are the advantages of the teaching module. However, the lack of diverse practice questions and student activities are the answer to the second question about the shortcomings of the teaching module. The things that are liked about the teaching module in the third question are the material, language, and appearance. The lack of varied questions and student activities are the things that are disliked about the teaching module in the fourth question. Suggestions and criticisms for the teaching module in the fifth question are that student activities and practice questions are developed, the display color is harmonized, and the use of language is appropriate to the student's level.



Picture.5 Answers to Supporting Questions for the First Questionnaire on Teacher

CONCLUSION

Based on the results of the discussion that has been explained, the conclusion obtained is that the implementation of the matrix determinant teaching module in a closed two-loop electrical circuit can improve the physics learning outcomes of high school students with an N-Gain score of 0.82 in the high category. In addition, the implementation of the matrix determinant teaching module in a closed two-loop electrical circuit received a response from physics teachers with a percentage of 93.06% and students with a percentage of 88.39% in the very positive category.

ACKNOWLEDGEMENT

The researcher would like to thank the Physics Education Study Program, Faculty of Teacher Training and Education, University of Jember.

REFERENCES

[1] M. Hidayatulloh, I. Wiryokusumo, and DA Walujo, "Remediation of students' misconceptions on dynamic electricity material using interactive ebooks," *J. Educator. Phys. and Technol.*, vol. 5, no. 2, pp. 30–39, 2019.

[2]Ş. S. Anagün, "Teachers' perceptions about the relationship between 21st century skills and managing constructivist learning environments," *Int. J. Instr.*,

vol. 11, no. 4, pp. 825–840, 2018, doi: 10.12973/iji.2018.11452a.

[3] R. Erly, "Application of experimental methods to improve student learning outcomes on the material on the use of static electricity, dynamic electricity, and direct current electricity in class XII TKR SMKN 1 Lobalain," *J. Science. Educator. Exacta*, vol. 6, no. 3, pp. 272–284, 2020.

[4]MA Sunni, "The influence of the use of PhET (physics education technology) software media as a learning medium on the physics learning achievement of high school students,"*J. Explor. STMIK Mataram*, vol. 9, no. 1, p. 54, 2019, doi: 10.35200/explore.v9i1.215.

[5]MI Fakhri, S. Bektiarso, and Supeno, "Use of animation learning media assisted by Macromedia Flash in physics learning on the topic of momentum, impulse, and collisions for class X SMA," *J. Physics Learning.*, vol. 7, no. 3, pp. 271–277, 2018, [Online]. Available: https://jurnal.unej.ac.id/index.php/JPF/article/view/8599

[6] M. Situmorang, "Development of high school chemistry textbooks through learning innovation and integration of character education to improve student learning outcomes," *Semirata FMIPA Univ. Lampung*, vol. 1, no. 1, pp. 237–246, 2013.

[7]SM Putri, F. Azmi, and N. Khairina, "Improving students' understanding and knowledge through Kirchoff's law practicum at junior high schools," *JMM (Journal of the Independent Community)*, vol. 6, no. 2, pp. 843–849, 2022, [Online]. Available: http://journal.ummat.ac.id/index.php/jmm

[8]R. Pratama, M. Alamsyah, and S. Noer, "Analysis of teacher needs for module development to improve students' critical thinking skills," *EduBiologia (Biological Sci. Educ. Journal)*, vol. 2, no. 1, pp. 7–13, 2022, doi: 10.30998/edubiologia.v2i1.9769.

[9]RN Friantini, R. Winata, and JI Permata, "Development of contextual modules for social arithmetic for grade 7 junior high school," *J. Cendekia (Educator's Journal. Mat.*, vol. 4, no. 2, pp. 562–576, 2020, doi: 10.31004/cendekia.v4i2.278.

[10]W. Agustinaningsih,*Elevating Teaching Materials, Grounding Physics Media*. Sleman: Sleman: DEEPUBLISH Digital, 2023.

[11] E. Ibrahim and M. Yusuf, "Implementation of physics learning modules using the contextual REACT model on the concept of work and energy," *J. Phys.*, vol. 1, no. 1, pp. 1–13, 2019, doi: 10.34312/jpj.v1i1.2281.

[12]E. Kosasih, *Development of Teaching Materials*. Jakarta: Jakarta: PT Bumi Aksara, 2020.

[13]RD Meidy, S. Patmanthara, and MZ Arifin, "Development of printed teaching materials with a discovery learning model for the subject of basic computers and networks for class X," *J. Educator. (Theory and Practice)*, vol. 3, no. 2, pp. 126–133, 2018, doi: 10.26740/jp.v3n2.p126-133.

[14]DN Marpaung and JJ Pongkendek, "Junior high school chemistry learning module based on scientific approach on acid and base material based on the 2013 curriculum," *J. Educator. Kim. Indones.*, vol. 5, no. 1, pp. 44–50, 2021, [Online]. Available: https://ejournal.undiksha.ac.id/index.php/JPK/index

[15]K. Anam and Y. Arnas, "Cramer method for electrical circuit analysis solutions using Scilab," *J. Ilm. Blue Sky Aviation*, vol. 12, no. 1, pp. 61–68, 2019, [Online]. Available: https://journal.ppicurug.ac.id/index.php/jurnal-ilmiah-aviasi/article/view/144

[16] S. Susanto and N. Kristiana, "Designing flashcards of physicist caricatures as learning media for junior high school students," *J. Barik*, vol. 3, no. 3, pp. 30–44, 2022, [Online]. Available: https://ejournal.unesa.ac.id/index.php/JDKV/article/view/48083%0A https://ejournal.unesa.ac.id/index.php/JDKV/article/download/48083/ 40144

[17]Y. Aini and Riswandi, *Conquer Basic Physics 2*. Yogyakarta: Yogyakarta : DIVA Press, 2020.

[18]P. Batarius and IPAN Samane, "Analysis of the Gauss-Jordan method in determining current in an electric circuit," *J. Matrix Science*, vol. 23, no. 3, pp. 279–290, 2021.

ISSN: 2502-2318 (Online)
ISSN: 2443-2911 (Print)

Homepage :
https://journal.uhamka.ac.id/index.php/omega

[19]F. Hasyim and A. Ramadhan, "The adequacy of mathematical skills for prospective physics teachers," *J. Inov. Educator. Phys. and Integr.*, vol. 1, no. 2, pp. 1–6, 2018.

[20]Sugiyono, *Quantitative, Qualitative, and R&D Research Methods*. Bandung: Bandung: CV ALFABETA, 2013.