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# Implementation of Cramer's rule assisted by the Sarrus method in solving the problem of 2-loop unidirectional electrical circuits

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**Abstract**

Cramer's rule is used by combining matrix determinant methods applied in the presentation of solving Systems of Linear Equations (SLE). The purpose of this study was to determine the differences in student learning outcomes when using the Cramer Rule assisted by the Sarrus Method using the elimination substitution method on two-loop electrical circuit material. The research method used is the *Posttest-Only Control Design* experimental method. The results of this study are evidenced by the results of the hypothesis test which states that there is a significant difference between the learning outcomes of the control class and the learning outcomes of the experimental class. As well as the results of a very positive response from students to the implementation of Cramer's rule assisted by the Sarrus method. Thus, the conclusion of this study is that the implementation of Cramer's rule assisted by Sarrus method is proven to be effective as an alternative solution to solving two-loop electrical circuit problems.

**Keywords:** Two-loop circuit, Cramer's rule, Sarrus method.

## INTRODUCTION

Physics is one of the subjects that requires students to use relatively high intellectual abilities, so students have difficulty in understanding physics material (Dasmo et al., 2020). Matter in physics is often presented in the form of mathematical notation that has to do with the material world (Harefa, 2019)**.** Abbas & Yusuf (2018)stated that students ability to master concepts, formulas, and mathematical calculations in physics lessons is still low. Based on learning at school, physics becomes one of the lessons that are difficult for physics students to understand and avoid (Prameswari & Nana, 2020).

The difficulty of physics subjects at the high school level will affect student learning outcomes. Rizaldi &; Amri (2022) states that current student learning outcomes are still low. This research is in line with Sadiah research (2021) that states that students understanding of physics concepts is still low, so students have difficulty in achieving satisfactory learning results and achievements. Low student learning outcomes are caused because students only memorize formulas without understanding them first. So that students are easily fooled by questions that have difficult category levels and require a long time in the process (Khasanah et al., 2019).

The two-loop electrical circuit material is one of the high school level subjects that must be mastered by students (Permendikbud, 2018). According Nofitasari & Sihombing, (2017), one of the physics materials that is difficult for students to understand is the two-loop electrical circuit material that examines the concept of Kirchoff's Law. This is because in the application of the concept of Kirchoff's Law, students often fail in solving problems because students are required to analyze images and describe equations that are explained mathematically (Perdana et al., 2018). Solving problems that have been done by students, often different when proven by practicum because students are confused in applying the solving steps and are often reversed in determining the positive and negative signs of the difference in electric potential (Ilhamsyah et al., 2022).

The solution method that still uses the substitution and elimination method is one of the factors that causes low student learning outcomes on two-loop electrical circuit material. Rachmat & Amri (2022) states that current student learning outcomes are still low. The research is in line with Sadiah research (2021) that students understanding of physics concepts is still low, so students have difficulty in achieving satisfactory learning results and achievements. This is also supported by the results of an interview with a physics teacher at one of the public high schools in Jember who stated that student learning outcomes for two-loop electrical circuit material were quite low.

The problem of two-loop electrical circuits is generally solved by the elimination substitution method. However, apart from these methods, the problem of two-loop electrical circuits can also be solved by several mathematical methods. Batarius & Samane (2021) stating the problem of electrical circuits can be solved by the matrix method. Devita (2022) discusses the application of Cramer's rule as a solution to solving electrical circuit cases. Cramer's rule is an appropriate and effective solution to make it easier for students to calculate the value of the strength of electric current flowing in a two-loop electrical circuit.

Cramer's rule is used by combining matrix determinant methods applied in the presentation of solving Systems of Linear Equations (SLE) (Zaini, 2019). In Cramer's rule, the form of a system of three-variable linear equations can be shown as :

$$a_1x + b_1y + c_1z = p \quad (1)$$

$$a_2x + b_2y + c_2z = q \quad (2)$$

$$a_3x + b_3y + c_3z = r \quad (3)$$

(Wijayanti I., et al., 2018).

The above linear equation can be expressed in the form of matrix multiplication. Where A is a square matrix in the form of coefficients of variables x, y, and z. The variable can later be expressed as $I_1, I_2, I_3$. And the matrices p, q, and r are potential difference values. The matrix form of equations 1, 2, and 3 is shown by the following equation :

$$\begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} p \\ q \\ r \end{bmatrix} \quad (4)$$

(Ghodang Hironymus, 2021). With Cramer's rule, each of the x, y, and z values in equation 4 is :

$$x = \frac{\begin{vmatrix} p & b_1 & c_1 \\ q & b_2 & c_2 \\ r & b_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}}, y = \frac{\begin{vmatrix} a_1 & p & c_1 \\ a_2 & q & c_2 \\ a_3 & r & c_3 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}}, z = \frac{\begin{vmatrix} a_1 & b_1 & p \\ a_2 & b_2 & q \\ a_3 & b_3 & r \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}} \quad (5)$$

The solution of equation 5, can be obtained using the help of matrix determinants. The determinant of a matrix is defined as the sum of all elementary product products calculated from the elements of a square matrix (Purba et al., 2021). The determinant of the matrix can be determined in several ways or methods namely by the Sarrus method, the minor method of cofactors (Chio condensation method), and row reduction (Salihu method) (Rahma et al., 2020). The Sarrus method is one of the determinant methods of the matrix by subtracting the product of the right diagonal by the product of the left diagonal as the following equation :

$$detA = |A| = \begin{bmatrix} a_1 & b_1 & c_1 & a_1 & b_1 \\ a_2 & b_2 & c_2 & a_2 & b_2 \\ a_3 & b_3 & c_3 & a_3 & b_3 \end{bmatrix} \quad (6)$$

(Maharani, 2020).

Based on the description, this study aims to determine the differences in student learning outcomes when using the Cramer Rule assisted by the Sarrus Method using the elimination substitution method on two-loop electrical circuit material. The novelty of this research is the use of matrix determinants in the form of Cramer's Rule assisted by Sarrus' method which is used as a quick way to solve two-loop electrical circuit problems. This is in line with research by Devita (2022) on the use of Cramer's rule to simplify the calculation of the strong value of electric current in an electrical circuit. In addition, it is also supported by Nurullaeli's research (2020) on the application of the Gauss-Jordan & Cramer numerical approach to analyze electrical circuits in closed circuits. Cramer's rule assisted by the Sarrus

Method is expected to be an alternative solution to solving the problem of two-loop electrical circuits in a simple, precise, and efficient way.

## METHODS/EXPERIMENTS

This research uses an experimental method. The form of experimental design in this study is *Posttest-Only Control Design* as shown in Figure 1:

| | | |
|---|---|---|
| **R** | **X** | **O2** |
| **R** | | **O4** |

Figure 1. *Posttest-Only Control Design*

The data analysis technique in this study used the *Independent Sample T-test* through the SPSS 23 application. This analysis aims to test hypotheses or compare posttest results of experimental and control class students. Statistical hypotheses in this study:

$H_0$ : There is no significant difference between student learning outcomes when using the sarrus-assisted cramer rule and the substitution and elimination methods in two-loop electrical circuit materials.

Ha: There is a significant difference between student learning outcomes when using the sarrus method assisted cramer rule and the substitution and elimination methods in two-loop electrical circuit materials.

Hypothesis testing is based on the significance level values as follows: 1) If the sig value ≥ 0.05 then $H_0$ is accepted and Ha is rejected 2) If the sig value is < 0.05 then $H_0$ is rejected and Ha is accepted (Muhid A., 2019).

In addition, there is also an analysis of student responses using the Likert Scale obtained from the distribution of response questionnaires to students. The response questionnaire used 4 indicators with a total of 10 statements (5 positive statements and 5 negative statements). Analysis of student response results can be known using the following equation:

$$Presentase\ (P) = \frac{Jumlah\ jawaban\ responden}{Skor\ Maksimum} \times 100\%$$

Percentage results (P) can be classified on the response score criteria described in the following Table 1 :

Table 1. Student Response Percentage Interval

| Student Response Percentage Interval (%) | Criterion |
|---|---|
| 80% ≤ P < 100% | Very Positive |
| 60% ≤ P < 80% | Positive |
| 40% ≤ P < 60% | Quite Positive |
| 20% ≤ P < 40% | Less Positive |
| P < 20% | Very Less Positive |

Source: Arikunto (2020).

## RESULTS AND DISCUSSION

### RESULT

The results of the research obtained from this study are the results of quantitative data processed through the SPSS 23 application. *Posttest* score data was obtained from the control class and experimental class with a total of 30 students per class each. Determination of control classes and experimental classes using *random sampling techniques* and homogeneity tests in the SPSS 23 application The *posttest form* given to students is in the form of a written test (description) totaling 5 questions. Learning outcomes data, briefly shown in the following Table 2:

Table 2. Value Data *Posttest*

| | ***Posttest*** | |
|---|---|---|
| | **Experimental Class** | **Control Class** |
| Top Rated | 98 | 98 |
| Lowest Value | 78 | 40 |
| **Average** | 90,17 | 71,43 |

From Table 2, the average in the control class was 71.43 and the average score in the experimental class was 90.17. The total *posttest* score obtained by the control class was 2143 and the total p*osttest score of the* experimental class was 2705. Thus, the average score of the experimental class *posttest* results is higher than the control class *posttest* results . Furthermore, the *posttest* results are processed through SPSS 23 to be tested for the Independet Sample T-Test.

Before the Independent sample T-test, the data normality test was carried out first with the results of the SPSS normality test shown in the following Table 3:

Table 3. Data Normality Test

**Tests of Normality**

| | | Kolmogorov-Smirnova | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | Class | Statistics | Df | Sig. | Statistics | Df | Sig. |
| Posttest *Results* | Control Class | .155 | 30 | .065 | .956 | 30 | .251 |
| | Experimental Class | .096 | 30 | .200* | .952 | 30 | .197 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

From the table, it is known that the significance value of the control class posttest results is 0.251 and the significance value of the experimental class posttest results is 0.197. Both values of significance of posttest results are more than 0.05 (Sig. > 0.05), so it can be stated that the data obtained are normally distributed. Once it is known that the data is normally distributed, it can be continued by conducting an independent sample T-test to test the research hypothesis. The Independent Sample T-test aims to find out whether the proposed research hypothesis will be accepted or rejected. The results of the independent sample T-test with SPSS 23 are shown in the following Table 4.

Table 4. Test Results Independent Sample T-test SPSS

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | |
|---|---|---|---|---|---|---|
| | | F | Sig. | t | Df | Sig. (2-tailed) |
| Posttest *Results* | Equal variances assumed | 37.103 | .000 | -5.912 | 58 | .000 |
| | Equal variances not assumed | | | -5.912 | 35.071 | .000 |

From the Table 4, it can be known the significance value (Sig. 2 tailed) of 0.000 (Sig. < 0.05), so that it can be concluded that the determination of the hypothesis that H 0 is rejected and Ha is accepted, which means that there is a significant difference between student learning outcomes when using the sarrus method-assisted cramer rule with the substitution and elimination methods on the two-loop electrical circuit material.

In addition, there are results of student response questionnaire analysis using the Likert Scale with the results shown in Table 5:

Table 5. Results of Student Response Analysis

| | **Student Response Indicators** | **Result** |
|---|---|---|
| 1 | Responses in Question Solving | 81% |
| 2 | Motivation | 80% |
| 3 | Interest | 80% |
| 4 | Satisfaction | 83% |
| | **Average percentage of overall indicators** | **81%** |

In accordance with the table of intervals of student response percentages, it can be concluded that student responses to the use of Cramer's rule assisted by the Sarrus method in solving two-loop electrical circuit problems are very positive with an overall average percentage gain of 81%. Each indicator of student response has a different percentage value. The difference in the percentage value of student responses can be seen in Table 4.

## DISCUSSION

The results of this study showed that Cramer's rule assisted by the Sarrus method was able to improve students' ability to solve two-loop electrical circuit problems. This is evident through the differences in learning outcomes that have been tested with SPSS shown in Table 4. Where, the average *experimental class Posttest* results are higher than the average *control class Posttest* results. The highest score obtained in the control class was 98 and the lowest was 40. While in the experimental class, the highest score obtained was 98 and the lowest score was 78.

In the implementation of learning in schools, currently solving the problem of two-loop electrical circuits at the SMA/SMK/MA level still uses many elimination substitution methods. This method is enough to make students difficult in doing two-loop electric circuit problems because the completion stage is quite long. Meanwhile, if you use Cramer's rule assisted by the Sarrus method, students are faster in doing and obtaining high learning results, because the completion step using the Cramer rule assisted by the Sarrus method is quite short.

The factor causing significant differences in *posttest results* is because the solution step using the Cramer rule assisted by the Sarrus method has fast mathematical operation stages and does not involve complicated mathematical calculation processes. This also affects the efficiency of time allocation for working on the questions. The use of Cramer's rule with the help of the Sarrus method is more efficient than using the elimination substitution method. This statement is in accordance with the literature that the Sarrus-assisted Cramer's Rule can be used to facilitate the calculation of the strong value of electric current in a closed electrical circuit (Devita, 2022).

This is also supported by the results of interviews with students. Most students answered that the use of Cramer's rule with the help of the Sarrus method can make it easier for students to determine the value of current strength because students do not need to do a long elimination substitution stage. However, there are also some students who still have difficulty in doing problems using Cramer's rule with the help of the Sarrus method because understanding mathematical concepts is still lacking.

Based on the results of the analysis of student responses in Table 5, the percentage of students in the response indicator in solving the question was 81%, the motivation indicator was 80%, the interest indicator was 80%, and the satisfaction indicator was 83%. Thus, overall, the average percentage of student responses was 81%. The results concluded that the implementation of Cramer's rule assisted by the Sarrus method had a very positive influence on student learning outcomes. Thus, Cramer's rule assisted by the Sarrus method can be used as an alternative solution in solving the problem of two-loop electrical circuits. Thisis in line with the opinion that an interesting learning will make students feel happy and make it easier for students to absorb knowledge, and this can be seen from student responses during the learning process.(Kartini et al., 2020)

## CONCLUSION

The implementation of Cramer's rule assisted by the Sarrus method proved effective as an alternative solution to solving the problem of two-loop electrical circuits. This is also evidenced by the results of the hypothesis test which states that there is a significant difference between the learning outcomes of the control class and the learning outcomes of the experimental class. In addition, there was also a very positive response from students to the implementation of Cramer's rule with the help of the Sarrus method.

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