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CASE STUDY: THE MOST POPULAR METHOD FOR SOLVING SYSTEMS OF LINEAR EQUATIONS

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ABSTRACT

The system of linear equations is a material that is studied from the junior high school level to the lecture level so that this material is very important material in learning mathematics. The purpose of this research is to find out what methods are easy and widely used by students in solving the system of linear equations. This research is a qualitative research with case study type. The participants of this study were 10 students of Indraprasta PGRI university. Data were collected by task-based interviews which aimed to dig deeper into the easiest and fastest method to solve the system of linear equations. The data analysis technique used in this study uses Bogdan & Biklen technique with stages: data reduction, coding, determining themes, concluding. The results showed that there are 5 methods that can be used in solving the system of linear equations, namely: Cramer Method, Ajoin Matrix Method, Gaus Method, and Gaus Jordan Method. Of the four methods, according to the results of student tests, the best value is obtained with the Cramer Method, this is reinforced by the results of interviews conducted by students who said that the Cramer method is the easiest and fastest method to solve the system of linear equations. While the Gaus method is the most difficult method to solve the system of linear equations.

Sistem persamaan linear merupakan suatu materi yang dipelajari dari tingkat SMP sampai dengan jenjang perkuliahan sehingga materi ini merupakan materi yang sangat penting dalam pembelajaran matematika. Tujuan dari penelitian ini adalah untuk mengetahui metode apa yang mudah dan banyak digunakan mahasiswa dalam penyelesaian Sistem persamaan linear. Penelitian ini merupakan penelitian kualitatif dengan jenis studi kasus. Partisipan penelitian ini adalah 10 mahasiswa universitas Indraprasta PGRI. Data dikumpulkan dengan wawancara berbasis tugas yang bertujuan untuk menggali lebih dalam tentang metode yang paling mudah dan cepat untuk menyelesaikan sistem persamaan linear. Teknik analisis data yang digunakan dalam penelitian ini menggunakan teknik Bogdan & Biklen dengan tahapan : reduksi data, koding, menentukan tema, menyimpulkan. Hasil penelitian menunjukkan bahwa ada 5 metode yang dapat digunakan dalam menyelesaikan sistem persamaan linear yaitu: Metode Cramer, Metode Ajoin Matriks, Metode Gaus, dan Metode Gaus Jordan. Dari ke empat metode tersebut sesuai hasil tes mahasiswa nilai terbaik didapat dengan Metode Cramer hal ini diperkuat dengan hasil wawancara yang dilakukan para mahasiswa menyampaikan bahwa metode Cramer adalah metode yang paling mudah dan cepat untuk menyelesaikan sistem persamaan linear.

Sedangkan metode Gaus adalah metode yang paling susah untuk menyelesaikan sistem persamaan linear.

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1. INTRODUCTION

Mathematics is one of the branches of science that underlies aspects of life and has an important role in the development of science and technology. Science and technology are rapidly going hand in hand with the development of an increasingly modern era. In Permendikbud No. 58 of 2014, it is stated that the rapid development in the field of information and communication technology today is based on the development of mathematics in the fields of number theory, algebra, analysis, theory of chance, and discrete mathematics. To master and create technology in the future, a strong mastery and understanding of mathematics is needed from an early age (Mahmudah et al., 2020). Therefore, research is increasingly encouraged so as to produce a variety of findings to determine a more effective and efficient solution. In line with the findings of the research results, students must try to use these findings so as to increase their knowledge so that they can solve problems if faced with several alternative solutions to problems. Ruseffendi (in (Zakiyah et al., 2019) argues that mathematical problem solving is a problem or problem that can be solved, but it cannot automatically be done because there are no rules or procedures to do it. Van De Walle (Ariani et al., 2017) stated that when students are involved in tasks that emphasize problem solving and also methods when solving a problem, students will automatically find new understandings in mathematics. When students are involved in solving mathematical problems, it will help students understand mathematics well because students are actively involved in mathematical thinking when they manipulate, experiment, and solve problems (Setiawan, 2015). Asfar and Nur (Tsaqib, 2020) argue that a person's ability to solve problems is very related to the level of development (knowledge) of the person, so the problems given to a person must look at the aspects of the development of their knowledge. It can be concluded that through the problem-solving process, students can find new understandings, can manipulate, experiment and can improve the development of students' knowledge.

One of the scopes of mathematics is about the Linear Equation System (SPL). Anton, Rorres C stated that a linear equation in n variables x_1, x_2, ... ,x_n is an equation in the form a_1 x_1 + a_2 x_2+ ... +a_n x_n=b where a_1, a_2, ... , a_n and b are real constants. A number of linear equations that are finite in variables x_1, x_2, ... ,x_ndisebut SPL (Misnawati, 2018). SPL has many benefits and is very useful in fields such as physics such as SPL is used to model complex systems of equations, for example in the calculation of the motion of objects or the transfer of heat. In economics SPL is

used to solve a system of equations related to production, price and demand. In SPL, problem solving is needed whose workflow needs steps to obtain the right solution. Anton explained that to find solutions from SPL, several methods can be used to solve the Linear Equation System, namely Gauss's Elimination Method, Jordan's Gauss Elimination, Cramer's Method, Matrix Inverse Method, LU Decomposition (top-bottom triangle factorization) and Crout Decomposition (Maharani, 2020). In this study, only four methods were used, namely Gauss Elimination Method, Jordan Gauss Elimination, Cramer Method, and Matrix Inverse Method. This method has weaknesses and advantages so that to use it there are points of difficulty. The crammer method tends to use a matrix by using the matrix determinant formula. To find a determinant in the matrix is easy for most students. So that the crammer method has the opportunity to become a method that is in demand and easy to use. The matrix inverse method requires a long calculation path to determine the solution of the SPL, including determining the determinant, determining the cofactor, determining the adjoint, calculating the matrix inverse and finally by multiplying the matrix inverse by the constant of the SPL. As for the Gauss elimination method, it is used to solve the linear equation system by representing (converting) into a matrix form, the matrix is then converted into a Line Echelon form through Elementary Row Operations (OBE). Then the system is completed with reverse substitution. For the Gauss Jordan elimination method, the Gauss-Jordan elimination is a development of the Gauss elimination with simpler results. The trick is to pass the row operation from the Gauss elimination so as to produce a matrix that is Echelon-row reduced. It can also be used as one of the methods of solving linear equations by using matrices. The trick is to convert the linear equation into an augmented matrix and operate it. After becoming a reduced Echelon-row matrix, the value of its variables can be determined immediately without reverse substitution.

In this study, the aim is to test the level of problem solving in SPL and to find out which method is the easiest and most interested by students. For initial action, students are given one SPL question (which is a coefficient based on the NPM of each student) which will be solved by 4 different methods, namely Crammer rule, matrix inverse method, Gauss method and Gauss Jordan method. From the results of the work, it will be possible to analyze the obstacles of each SPL completion method from the easiest to the most difficult to use. This is very interesting to study and research more deeply because by interviewing students you will be able to find out the effectiveness of the methods used to determine which solutions are easy to use and which are complicated.

2. METHOD

The participants of this study are 30 4th semester students of the informatics engineering study program at Indraprasta University PGRI.

2.1. Research Subject

The population in the study is all students of Indraprasta University PGRI Jakarta semester 4 of the informatics engineering study program. This research was carried out from March 2024 to May 2024. The informatics engineering study program consists of 35 regular classes. The sampling technique in this study is *systematic random sampling*. The sample in this study is 10 4th semester students with high, medium and low categories.

2.2. Data Collection

This research is a qualitative research with a case study type. Qualitative research is a research process to understand human or social phenomena by creating a comprehensive and complex picture that can be presented in words, reporting detailed views obtained from informant sources, and carried out in a natural setting (Walidin et al., 2015). The procedure in this study consists of four stages, namely the preparation stage, the activity implementation stage, and the data collection and interview stage. Seidman explained that the interview was conducted so that the researcher could obtain more data so that the researcher could understand the social and cultural situation/condition through the language and expressions of the interviewee and could clarify unknown matters (Fadli, 2021). In this study, data was collected through a written test. The test given is a written test in the form of one SPL question whose question variables are adjusted to the last 3 NPMs of students. The problem is solved by four methods of completion, namely Crammer rule, matrix inverse method, Gauss method and Gauss Jordan method. After the test was carried out, an interview was conducted to dig deeper into what is believed to be the easiest and fastest method to solve the linear equation system. For the interview, students were asked to explain which of the 4 methods was the easiest, explain the methods that were difficult and students were asked to sort the methods from understood to ununderstood.

2.3. Data Analysis

From the results of the test and interview, the score of each student was analyzed The data analysis technique used in this study used the Bogdan & Biklen technique with the following stages: data reduction, coding, determining the theme, and summarizing.

3. RESULTS AND DISCUSSION

3.1. Result

In the Linear Algebra and matrix course, there are many ways that students can do to solve the linear equation system. The ways that can be done are: Cramer Method, Matrix Inverse Method, Gaus Method, and Gaus Jordan Method. Although many methods are used, the final result of the SPL settlement will produce the same answer. In each method, the maximum score that students will get has been determined. This determination was made because in the exam 1 SPL question was given, but students were asked to work with 4 methods. So it must be determined what the maximum value is for each method and finally from the four methods will get a final score of 100.

From the research that has been carried out, there are 3 classes with high, medium and low category groupings. This category is obtained from the results of the average score obtained from the test scores that have been taken. The following is the average data of the exam results of each class:

Table 1. High, Medium and Low Category Classification

Class	Grade Point Average	Category
Class A	50	Low
Class B	81	Tall
Class C	68	Keep

After obtaining classifications in three categories. Next, the data on the results of the linear equation system work with 4 methods in each class category will be presented. In each method, the maximum score that students will get has been determined. The maximum score for the Cramer Method is 26, the maximum score for the matrix Inverse Method is 26, the maximum score for the Gaus Method is 21, and the maximum score for the Jordan Gaus Method is 27. The maximum score is given because it is adjusted to the difficulty level and the many steps they have to take.

High Category Class

In the class with the high ability category, the results of the average score of SPL 81 work were obtained. The following is the result data for each method:

Table 2. Scores in the High category

Method	Grade Point Average
Cramer	25
Investments	
Matrix	20
Gaus	15
Gaus jordan	22

From the table above, it can be seen that the method that has the best average score is the Cramer method which gets an average score of 25 points. When viewed from the maximum score in the Cramer method, it is almost close to the maximum achievement because the maximum score obtained when completing SPL with the Cramer Method is 26. While the minimum average score is 15 points in the Gaus Method even though the maximum score that can be obtained is 21. After knowing from the average class score based on each method, an analysis of the results of the questionnaire was carried out after students worked on the questions. The results of the questionnaire that have been filled out by students in high-category classes can be seen in the table below:

Table 3. Results of High-Ability Classroom Data Reduction

Data reduction	Sub theme	Conclusion
Easy method		
1. The easiest Cremer method 2. The method is simpler and easier to understand 3. Use only matrix determinants 4. Calculate the determinants in each solution, then share the determinants with other determinants	**Effective** 1. The method is simpler and easier to understand **How to solve** 1. Use only matrix determinants 2. Calculate the determinants in each solution, then share the determinants with other determinants	The easiest method is the cramer method because it is the most effective and easy to understand, besides that it only calculates the determinant value of the matrix.
Difficult method		
1. Gaus's method is a difficult method 2. Still confused about the multiplication of the lines 3. The method is long and tiring 4. You have to find the identity matrix. 5. Using obe, 6. If you find a difficult number, it must be quite tiring.	**Less effective** 1. The method is long and tiring 2. If you find a difficult number, it must be quite tiring. **How to solve** 1. Still confused about multiplying the line 2. You have to find the identity matrix. 3. Using obe,	The most difficult method is the Gaus Method because this method is less effective and the way of solving collateral is quite complicated in the way of Elementary line operations.

From the table above, it can be taken that the easiest method is the cramer method while the most difficult method is the Gaus method. The Cramer method is easy because it uses a simpler and easier to understand method, and the solution method is Only using the next matrix determinant for each solution, then sharing the determinant with other determinants. While the most difficult method is the gaus method because many are still confused about the multiplication of the rows, the method is long and tiring, you have to find the identity matrix, use obe, if you find a difficult number, it must be quite tiring.

Medium category class

In the class with the Medium ability category, the average score of the SPL work was 68. The following is the result data for each method:

Table 4. Grades in the Medium Category Class

Method	Grade Point Average
Cramer	23
Investments	
Matrix	14
Gaus	12
Gaus jordan	15

From the table above, it can be seen that the method that has the best average score is the Cramer method with an average score of 23 points. When viewed from the maximum score in the Cramer method obtained in the medium class, it is only 3 points less than the maximum score of 26. While the minimum average score is 12 points in the Gaus Method even though the maximum score that can be obtained is 21. After knowing from the average class score based on each method, an analysis of the results of the questionnaire was carried out after students worked on the questions. The results of the questionnaire that have been filled out by students in high-category classes can be seen in the table below:

Table 5. Results of data reduction of Medium-ability class data

Data reduction	Sub theme	Conclusion
Easy method		
1. The fastest Cremer method 2. The method is simpler and does not count much 3. Use only matrix determinants 4. Once the determinants are obtained, just divide them	**Effective** 1. The method is fast, simple and does not count much **How to solve** 1. Use only matrix determinants 2. Calculate the determinants in each solution, then share the determinants with other determinants	The easiest method is the cramer method because this method is fast, simple and does not have much to do besides only calculating the value of the matrix determinant.
Difficult method		
1. Gaus's method is a difficult method 2. The method is complicated, requires logic, makes your own formula and takes a long time 3. Still in doubt about line operation 4. Involves fractional and row conversion operations.	**Less effective** 1. The method is complicated, needs logic, makes your own formula and takes a long time **How to solve** 1. Still confused about the operation of the line 2. Involves fractional and line conversion operations 3. Using obe,	The most difficult method is the Gaus Method because this method is complicated, needs logic, makes its own formula and takes a long time and the way to solve it uses the Elementary line operation method which involves fraction operations and line swapping.

From the table above, it can be taken that the easiest method is the cramer method while the most difficult method is the Gaus method. The Cramer method is easy because this method is fast, simple and does not do much calculation besides that it only calculates the determinant value of the matrix. While the most difficult method is the Gaus method because this method is complicated, needs logic, makes its own formula and takes a long time and the solution method uses the Elementary line operation method which involves fraction operations and line swapping.

Low category class

In the class with the Low ability category, the average score of the SPL work was 50. The following is the result data for each method:

Table 6. Grades in the Low Category Class

Method	Grade Point Average
Cramer	20
Investments	
Matrix	16
Gaus	11
Gaus jordan	13

From the table above, it can be seen that the method that has the best average score is the Cramer method with an average score of 20 points. When viewed from the maximum score in the Cramer method obtained in this low class, it is still 6 points less than the maximum score of 26. While the lowest average score is 11 points in the Gaus Method even though the maximum score that can be obtained is 21. After knowing from the average class score based on each method, an analysis of the results of the questionnaire was carried out after students worked on the questions. The results of the questionnaire that have been filled out by students in high-category classes can be seen in the table below:

Table 7. Results of Low-Ability Class Data Reduction

Data reduction	Sub theme	Conclusion
Easy method		
1. The easiest Cramer method 2. The method is simpler and easier to understand 3. Use only matrix determinants	**Effective** 1. The method is simpler and easier to understand **How to solve** 1. Use only matrix determinants	The easiest method is the cramer method because it is the most effective and easy to understand, besides that it only calculates the determinant value of the matrix.
Difficult method		
1. Gaus's method is a difficult method 2. The method is long, complicated, difficult and requires logical thinking and long processing time 3. If it's wrong in the middle, it's all wrong 4. Confused about defining operations in the settlement process with OBE	**Less effective** 1. The method is long, complicated, difficult and requires logical thinking and long processing time 2. If it's wrong in the middle, it's all wrong **How to solve** 1. Still confused about determining the operation in the OBE process	The most difficult method is the Gaus Method is less effective because it is long, complicated, difficult and requires logical thinking and a long processing time, If it is wrong in the middle, it must be all wrong and confused about determining the operation in the OBE process

From the table above, it can be taken that the easiest method is the cramer method while the most difficult method is the Gaus method. The easiest method is the cramer method because it is the most effective and easy to understand, besides that it only calculates the determinant value of the matrix. While the most difficult method is the Gaus method is less effective because it is long, complicated, difficult and requires logical thinking and a long processing time, If it is wrong in the middle, it must be all wrong and confused about determining the operation in the OBE process.

3.2. Discussion

From the results that have been obtained, then a table will be made related to the easiest method and the most difficult method in each class category will be made into one. This aims to find data analysis about students' understanding in completing SPL with 4 methods that have been taught.

Table 8. Analysis of Easy and Difficult Methods

Class Category	Easy Method	Difficult Method
Tall	The easiest method is the Cramer method because it is the most effective and easy to understand, besides it only calculates the determinant value of the matrix.	The most difficult method is the Gaus Jordan Method because this method is less effective and the way to solve it uses the Elementary line operation method which is quite complicated.
Keep	The easiest method is the Cramer method because this method is fast, simple and does not count much other than that it only calculates the value of the matrix determinant.	The most difficult method is the Gaus Method because this method is complicated, needs logic, makes its own formula and takes a long time and the way to solve it uses the Elementary line operation method which involves fraction operations and line swapping.
Low	The easiest method is the ramer method because it is the most effective and easy to understand, besides it only calculates the determinant value of the matrix.	The most difficult method is the Gaus Method is less effective because it is long, complicated, difficult and requires logical thinking and a long processing time, If it is wrong in the middle, it must be all wrong and confused about determining the operation in the OBE process

From the table above, we can draw the initial conclusion that the easiest method in solving SPL of the three class categories is the Cramer Method. This is also supported by the scores obtained in each category of the best value class, the best is the Cramer Method. The Cramer method is easy because it is the most effective and easy to understand, besides only calculating the value of the matrix determinants after finishing finding the determinants the last step is to divide on each determinant by the initial matrix determinants. This makes it easy for students to understand and will be able to remember for the completion of SPL, the most important thing in using the cramer method is that students must be careful in finding the determinant value in each matrix. Because if one of the determinants of the matrix is wrong, it will produce the wrong answer. The Cramer method involves the calculation of the determinants of the coefficient matrix and the determinants of the matrix formed by replacing one column of the coefficient matrix with the constant of the equation (Cordero et al., 2020) Providing an explicit formula for the solution, so that it is easy to apply in a theoretical context, Cramer's rule has significant historical and theoretical value in linear algebra. The rules are easy to understand and apply to small systems, so they are useful for educational purposes. This method requires intensive computing, especially for large systems, due to the need to calculate multiple determinants. (Brunetti, 2014). When

applied to systems with a square matrix, this method is, in a sense, more convenient compared to the Gauss method (Urdaletova et al., 2023). A very parallel methodology for solving large-scale and dense linear systems is proposed in this paper through a new application of Cramer's Rule. Numerically stable schemes are described, resulting in overall computational complexity (Nagari et al., 2008).

The most difficult method in completing SPL from the three class categories is the Gaus Method. This is also supported by the scores obtained in each category of the best grade class, the Gauss Method. Gaus's method is less effective because it is long, complicated, difficult and requires logical thinking and a long processing time, If it is wrong in the middle, it must be all wrong and confused about determining the operation in the OBE process. The thing that makes it difficult for students to do SPL with the Gaus method is that students' ability in fractional numbers is sometimes still very lacking, this can cause students to stop halfway if they encounter the problem of adding fractional numbers. In addition, students are still confused in determining what operations and numbers to use in the OBE method is possible because students have not gotten an easy concept or instead are looking for what number and what operations to use, even though the numbers and operations in OBE are only the opposite of previously known numbers and operations. Solve a system of linear equations and determine whether a set of vectors is linear independently. This algorithm converts the input matrix into a matrix in the form of a row echelon (column) (Morancho, 2015). Gaussian elimination (GE) is an important direct method that converts an early linear system into an equivalent, easily solved upper triangle system. To ensure numerical stability and reduce the effects of rounding errors that can overcome the solution, most direct methods include a pivoting strategy. The diagonal dominant matrix (DD) is numerically stable during the GE method (Marrakchi & Kaaniche, 2023). We use the elementary row operation of the augmented matrix of the apparent linear equation system to generate the reduced row shape. This method is discussed in detail and illustrated with numerical examples.

Effectiveness of the Cramer method

The effectiveness of Cramer's method in the context of mathematical pedagogy can be evaluated through various theoretical and practical perspectives, including:

1. Pedagogical Theory and Mental Construction

   The use of Cramer's rule to help teacher educators analyze students' mental constructions. This approach aims to design alternative teaching strategies that can improve the understanding and application of Cramer's rules. (Ndlovu & Brijlall, 2019) applying Cramer's rule reveals that many PMTs demonstrate a procedural understanding of the method. This suggests that they operate at the action-stage of the Action-Process-Object-Schema (APOS) theory of action. The lack of related schematic construction negatively impacts their ability to build the necessary mental constructs, which suggests that a deeper conceptual understanding is necessary for effective learning.
2. Mathematical Intuition and Logic

The development of mathematical intuition and logic found that these elements positively influenced the effectiveness of students' education. Effective strategies such as problem-based learning and mathematical reasoning are essential to improve students' abilities in learning mathematics, which can be applied to teaching methods involving Cramer's rules (Popova et al., 2022).

3. HOTS Development

Improving Higher Level Thinking Skills (HOTS) is essential for solving pedagogical problems in mathematics. A study that aimed to improve HOTS through a structured learning process found that the modules developed were valid, practical, and effective. This suggests that incorporating HOTS-focused strategies can improve understanding and application of Cramer's rules in educational settings (Siregar et al., 2019).

Implications of the Cramer Method in Mathematics Education

The Cramer method can help students understand the nature of solutions in a system of linear equations, especially when dealing with square matrices, this method is useful for describing the uniqueness of the solution in the system (Urdaletova et al., 2023). The use of the Cramer method in teaching can facilitate the identification of student errors through diagnostic tools, such as dichotomous trees, which can be helpful in determining specific algebraic errors (Kulik & Chukhray, 2023). Apply an inquiry-based learning (IBL) approach to make learning the Cramer method more engaging and relevant by connecting it to real-life applications (Robinson & Aldridge, 2023). Provide continuous professional development for teachers to improve their pedagogical knowledge and technological competence, ensuring they are well equipped to teach the Cramer method effectively (Dhol et al., 2024).

4. CONCLUSION

Of the four methods to complete SPL when viewed from the results of student tests and strengthened by the results of interviews, the easiest method to complete SPL is the Cremer Method. The Cramer method is easy because it is the most effective and easy to understand, besides only calculating the value of the matrix determinants after finishing finding the determinants the last step is to divide on each determinant by the initial matrix determinants. Meanwhile, the most difficult method to complete SPL is the Gauss method. Gauss's method is less effective because it is long, complicated, difficult and requires logical thinking and long processing time. If it is wrong at the beginning or in the middle of operation, it is certain that there is confusion in determining the operation in the OBE process. After knowing that the cramer method is the easiest method to do SPL and in the future it can be developed more deeply in order to achieve the desired goals because the cramer method is more interesting and relevant by connecting it with real-life applications.

REFERENCES

Ariani, S., Hartono, Y., & Hiltrimartin, C. (2017). *Kemampuan Pemecahan Masalah Matematika Siswa Pada Pembelajaran Matematika Menggunakan Strategi Abduktif-Deduktif Di Sma Negeri 1 Indralaya Utara*. *3*(1), 25–34.

Dhol, B. S., Chauhan, S. S., & Kumar, N. (2024). A study of models and determinants in maths education using smart and intelligent technology. *AIP Conference Proceedings*, *3072*(1). https://doi.org/10.1063/5.0198724

Fahrudin, D., Mardiyana, & Pramudya, I. (2019). The analysis of mathematic problem solving ability by polya steps on material trigonometric reviewed from self-regulated learning. *Journal of Physics: Conference Series*, *1254*(1). https://doi.org/10.1088/1742-6596/1254/1/012076

Kulik, A., & Chukhray, A. (2023). The Principle of Control by Diagnosis - the Fundamental Principle of Computer-based Learning Process Intellectualisation. *2023 13th International Conference on Dependable Systems, Services and Technologies, DESSERT 2023*. https://doi.org/10.1109/DESSERT61349.2023.10416498

Maharani, N. (2020). Perbandingan Tingkat Pemahaman Mahasiswa STMIK STIKOM Indonesia Pada Metoda Sarrus dan Metoda Cramer pada Penyelesaian Sistem Persamaan Linier. *PENDIPA Journal of Science Education*, *4*(2), 66–73. https://doi.org/10.33369/pendipa.4.2.66-73

Mahmudah, W., Matematika, P. P., & Gresik, U. Q. (2020). *Analisis Kesalahan dalam Menyelesaikan Soal Sistem Persamaan Linear pada Aljabar Linier Elementer*. *5*, 449–456.

Misnawati. (2018). Metode Cramer Untuk Menentukan Solusi Sistem Persamaan Interval Linear. *Buletin Ilmiah Math. Stat. Dan Terapannya (Bimaster)*, *07*(4), 247–254.

Ndlovu, Z., & Brijlall, D. (2019). Pre-service mathematics teachers' mental constructions when using Cramer's rule. *South African Journal of Education*, *39*(1). https://doi.org/10.15700/saje.v39n1a1550

Popova, Y., Abdualiyeva, M., Torebek, Y., Yelshibekov, N., & Omashova, G. (2022). Improving the effectiveness of senior graders' education based on the development of mathematical intuition and logic: Kazakhstan's experience. *Frontiers in Education*, *7*. https://doi.org/10.3389/feduc.2022.986093

Robinson, J., & Aldridge, J. (2023). Changing Perceptions of the Learning Environment and Attitudes Towards Mathematics Through Inquiry-Based Learning: Girls in Middle School Classrooms in the UAE. In *Gender in STEM Education in the Arab Gulf Countries*. https://doi.org/10.1007/978-981-19-9135-6_4

Setiawan, S. (2015). Meningkatkan Kemampuan Berpikir Kritis Matematis Siswa SMP dengan Menggunakan Model Penemuan Terbimbing. *Jurnal Ilmiah UPT P2M STKIP Siliwangi*, *2*(1).

Siregar, B. H., Kairuddin, Siregar, N., & Fudholi, A. (2019). Enhancing the prospective teachers' higher order thinking skills in solving pedagogical problems. *International Journal of Innovative Technology and Exploring Engineering*, *8*(12), 640–643. https://doi.org/10.35940/ijitee.K1941.1081219

Urdaletova, A., Sklyar, S., Kydyraliev, S., & Burova, E. (2023). Using the Cramer-Gauss Method to Solve Systems of Linear Algebraic Equations with Tridiagonal and Five-Diagonal Coefficient Matrices. In *Lecture Notes in Networks and Systems: Vol. 544 LNNS*. https://doi.org/10.1007/978-3-031-16075-2_31

Zakiyah, S., Hidayat, W., & Setiawan, W. (2019). *Analisis Kemampuan Pemecahan Masalah dan Respon Peralihan Matematik dari SMP ke SMA pada Materi SPLTV Mosharafa : Jurnal Pendidikan Matematika Mosharafa : Jurnal Pendidikan Matematika*. *8*, 227–238.