Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6, 1307-1319
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i6.8103

Algorithmic thinking skill of prospective ICT teachers in solving mathematical task

Ariesta Kartika Sari[1]*, Tatag Yuli Eko Siswono[2], Agung Lukito[3]
[1,2,3]Doctoral Program in Mathematics Education, The Faculty of Mathematics and Natural Sciences (FMIPA), Surabaya State University (UNESA), East Java, Indonesia; ariesta.20002@mhs.unesa.ac.id (A.K.S.) tatagsiswono@unesa.ac.id (T.Y.E.S.) agunglukito@unesa.ac.id (A.L.).

Abstract: Algorithmic thinking is also one of the competencies we must develop in digital literacy and the ICT era. This study aims to determine the algorithmic thinking skills of prospective ICT teachers viewed from the accuracy and systematics in the steps to solve a mathematical problem. This research uses a descriptive quantitative approach, with a non-experimental design. The sampling technique was purposive sampling. The participants were 85 students of the informatics education program as prospective ICT teachers. Data analysis refers to the results and steps of task completion. Analysis of the participants' work results provides information that their algorithmic thinking ability is not optimal. This is indicated by 67% of participants who are not accurate and not systematic in completing algebraic mathematics tasks. It means prospective ICT teachers need to improve their algorithmic thinking skills when producing solutions to solve tasks. The novelty of the research lies in the appropriate and systematic category indicators, as well as the existence of four models for solving mathematical tasks that demonstrate the participants' algorithmic thinking skills. In the future, we should explore the components of algorithmic thinking and how to improve this skill, especially in the domains of mathematics and informatics education.
Keywords: *Algebra learning, Algorithmic thinking, Mathematical tasks, Problem-solving, Prospective ICT teachers.*

1. Introduction

In the 21st century, education systems increasingly embed digital competencies in their curricula. Competence in using information technology and computers and digital literacy are essential skills students need to acquire to thrive in the digital age. Future ICT teachers and students need to master the skills of working in a digital environment and develop computational and algorithmic thinking skills [1]. The development of algorithmic thinking in the 21st century is an integral part of modern digital literacy, as the ability to learn and thrive in a digital environment [2]. As contained in Assessment Framework 2023, the DigComp Framework describes five competence areas: communication, content creation, safety, and problem-solving [3]. Algorithmic thinking and problem-solving strategies are essential principles of computer science [4]. Not only for computer science, algorithmic thinking is also needed in modern education, especially in problem-solving. As Yustitia, et al. [5] said, modern education focuses on student-centered learning, aiming to provide students with key cognitive abilities such as: (1) critical thinking, (2) problem-solving, (3) metacognition, (4) communication, (5) collaboration, (6) creativity and innovation, and (7) information literacy. Additionally, algorithmic thinking is one of the abilities that support computational thinking. Following what Aminah et al. revealed, student activities in learning are always associated with technology and student thinking activities, and students are expected to be able to think computationally [6]. Therefore, algorithmic thinking is an essential topic in the 21st century.

History: Received: 26 March 2025; Revised: 23 May 2025; Accepted: 26 May 2025; Published: 16 June 2025
* Correspondence: ariesta.20002@mhs.unesa.ac.id

2. Literature Review

Algorithmic thinking is also one of the competencies we must develop in digital literacy and the ICT era [7, 8]. Through literature study, there are several things related to algorithmic thinking. Algorithmic thinking is a system of thinking with a construction sequence from the results obtained, which builds a series of actions and leads to achieving goals [8]. Algorithmic thinking is also concerned with precisely described routine procedures that can be applied and followed systematically to a conclusion [9]. According to Gejn and Junerman [10] the way of forming algorithmic thinking is through the systematic and directed application of structural approach ideas. So, algorithmic thinking is a system of ways of thinking with a systematic construction sequence of actions to find solutions/achieve goals [10, 11].

Algorithmic thinking is one type of thinking that is needed to support the computational thinking process. This refers to the fact that computational thinking is an activity related to problem-solving activities [12]. So, some aspects of computational thinking include automation, abstraction, algorithmic thinking, and modeling [13-15]. This is in line with what was revealed by Smith & Angeli, computational thinking as a thought process that utilizes elements such as abstraction, generalization, decomposition, algorithmic thinking, and debugging [16]. Algorithmic thinking is a required computational thinking skill [17]. By strengthening algorithmic thinking, we can also enhance problem-solving skills, learning, and understanding of computer science, especially related to programming or algorithms [13, 14]. There has been research on algorithmic thinking in the field of mathematics education, but it is still limited to the elementary and secondary education levels [9].

As Blannin and Symons [14] said, algorithmic thinking is an important and strategic focus area for learning in primary schools, as demand for these technological skills increases in the workplace [14]. Algorithmic thinking involves problem-solving skills, such as confidence and persistence when facing a particular problem, so that the ability can be used by K-12 students in understanding, applying, and developing simple algorithms [18]. The research on Students' Computational Thinking Process in Solving PISA Problems concluded that "the problem-solving steps applied by students are less coherent because they did not use algorithmic thinking in solving problems of PISA [19]. A case study of the fifth and sixth-grade study groups also resulted in the conclusion that students' algorithmic thinking skills are low [20]. On the other hand, Algorithmic thinking is one of the competencies we must develop in ICT [7]. So, in this regard, for students in the informatics education program who will also become teachers in the field of information technology and computers (ICT), we consider it necessary to master ICT/digital literacy and also think algorithmically. The students in informatics education as prospective ICT teachers, need to have the ability to think algorithmically in solving problems.

Polya said that problem-solving is one of the unique human activities [21]. In line with Henra, et al. [22] said that solving mathematical problems certainly has complex solutions, cannot be solved quickly, and requires a deep cognitive process [22]. Therefore, one of the most important educational tasks is to develop students' problem-solving thinking [23]. Based on the author's empirical experience and the results of interviews with one of the author's colleagues who teaches informatics education, the prospective ICT teachers still experience difficulties in solving mathematical problems.

Participants' ability to think algorithmically in doing assignments will be reviewed from the accuracy and systematics in the steps to solve a mathematical problem. By knowing this, lecturers will get an overview of the condition of the ability to think logically, systematically, and precisely in obtaining solutions to mathematical problems. Therefore, the purpose of the article is following - to determine the algorithmic thinking skills of the students as prospective ICT teachers that viewed from the accuracy and systematics in the steps to solve a mathematical problem/task.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 1307-1319, 2025
DOI: 10.55214/25768484.v9i6.8103

3. Research Method

3.1. Research Design

This study uses a descriptive quantitative approach. We did not give any treatment or manipulation to the participants before and during the study, to determine and describe the algorithmic thinking skill of the student. Therefore, the approach used in this research is descriptive quantitative with a non-experimental design. We did the non-experimental design without treating or intervening with the variables studied [24].

3.2. Research Subject

The sampling technique we used in this study was purposive sampling. We selected prospective ICT teacher students from the 2021 and 2022 classes of the informatic education program in of Universitas Trunojoyo Madura - Indonesia, who had gained knowledge about the material on solving linear equation systems in linear algebra learning. As many as 86 participants were willing to take part in this study. They were willing to complete mathematical assignments using the linear row operation method (a solution method that had been introduced in learning linear algebra material in their lectures). Previously, the author sent invitations via WhatsApp chat to ask if they were willing to become participants in our research.

3.3. Research Procedure

Referring to the research flow [25] then this research process flow is presented in the following Figure 1.

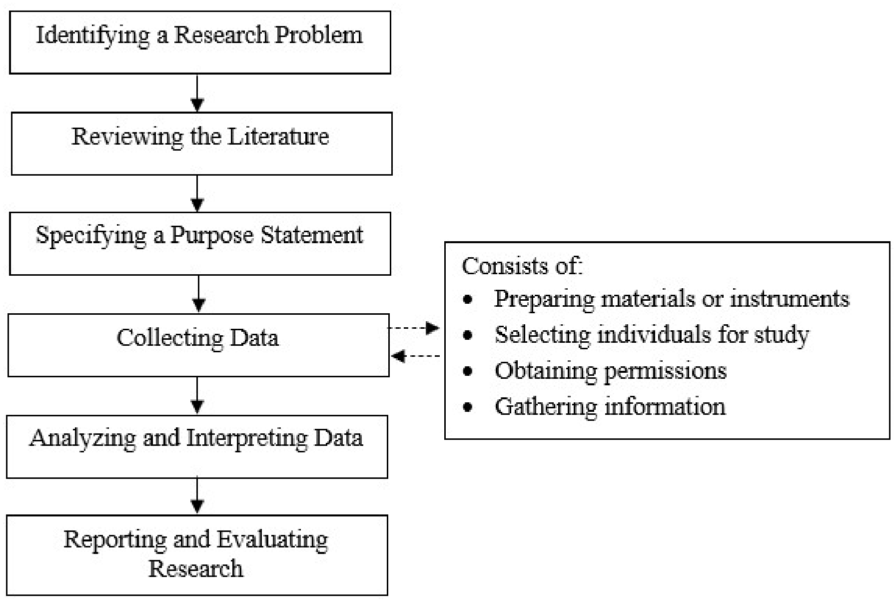

Figure 1.
The Research Process Flow.

3.4. Instruments, and Data Collection Techniques

The data were collected using an essay test of the mathematical task. The mathematics assignment in this study is related to the problem of linear equation systems on the topic of linear algebra in the curriculum of the informatics education study program. Figure 2 presents the mathematical task.

ISSN: 2576-8484
Vol. 9, No. 6: 1307-1319, 2025
DOI: 10.55214/25768484.v9i6.8103

If the linear equation is known as follows:

$$10x_1 + 8x_2 = 82$$

$$6x_1 + 8x_2 = 62$$

Determine the values of x_1 and x_2 using the Gaussian elimination method!

Figure 2.
The Mathematical Task Used in This Study.

After solving the task in Figure 2, the author analyzes the participants' work according to the predetermined categories. Categories are made based on accuracy and systematic steps (algorithms) to produce the right solution for the system of linear equations. The categories of participants'' work are based on the appropriate and systematic algorithm, consisting of: model A (appropriate and systematic), model B (Appropriate and unsystematic), model C (Inappropriate and systematic), and model D (Inappropriate and unsystematic).

The research mathematical task is the problem of linear equations system by Gaussian elimination. The steps for solving a system of linear equations in this study refer to the steps for solving a system of linear equations using the Gauss elimination method [26].

a) Step I: Form an augmented matrix of the system of linear equations.
b) Step II: Form the augmented matrix into row echelon form, reduced by using elementary row operations (the procedure produces a row echelon form and is called Gaussian elimination).
c) Step III: Express the solution of the linear equations system.

Thus, we determine the indicators of accuracy and systematic categories based on the stages in solving a system of linear equations using the Gaussian elimination method. The following Table 1 presents indicators of accuracy and systematic categories in solving mathematical problems in this study.

Table 1.
The Indicators of Accuracy and Systematic Categories.

Categories	Indicators
Appropriate	Appropriate in forming the augmented matrix
	Appropriate in determining the solution
	Appropriate in reducing augmented matrices to row echelon form
	Appropriate in performing elimination procedures using elementary row operations
Systematic	Systematic in solving a system of linear equations according to the procedure of the Gaussian elimination method.
	Systematic in reducing augmented matrices to row echelon form.

If any of the appropriate category indicators are not met, then we decide that the student's work is inappropriate. Likewise, if any of the systematic category indicators are not met, then we decide that the participant's work results are not systematic.

In this study, we used the problem of a system of linear equations in two variables with a single solution, the solution of which will be found using the Gaussian method. Figure 3 shows the alternative solutions steps for Model A (appropriate and systematic) in solving the task. Here, theoretically, Figure 3 presents a flow chart for the sequence of steps in the alternative solution of the task in this research.

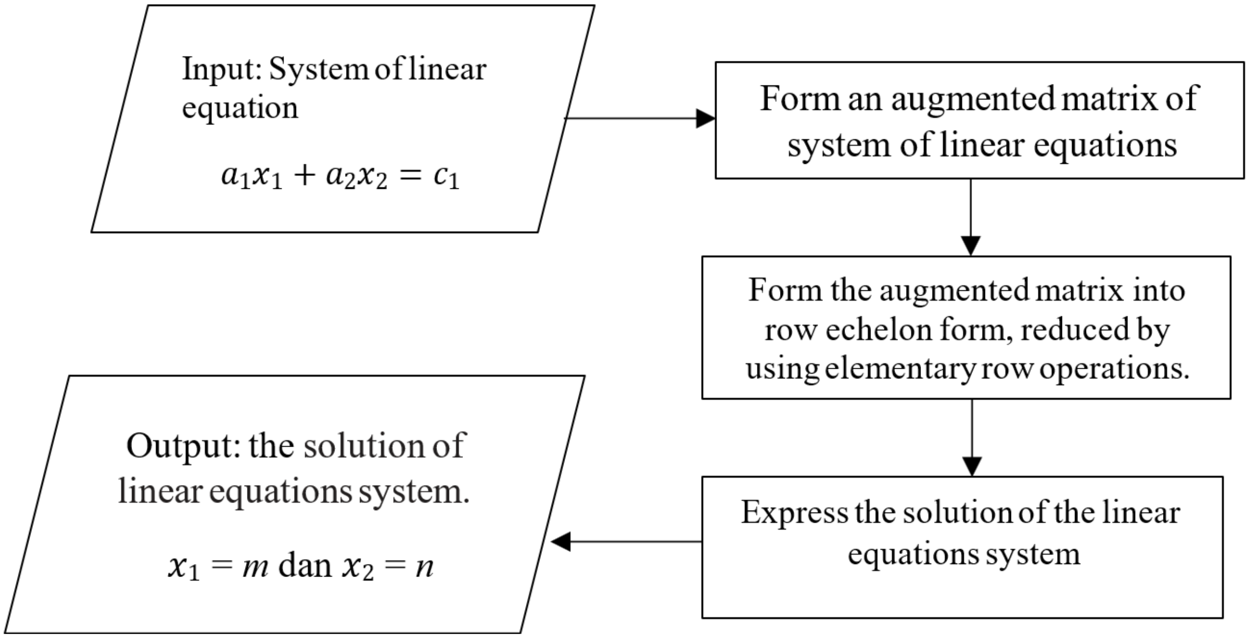

Figure 3.
An alternative order in solving a system of linear equations using the Gaussian elimination method.

Here, Figure 4 shows the alternative solutions steps for Model A (Appropriate and systematic) in solving the task in this research.

Solving linear equation system	**Steps**
The linear equation system is $10x_1 + 8x_2 = 82$ $6x_1 + 8x_2 = 62$ So, the augmented matrix of the linear equation system: $\left[\begin{array}{cc\|c} 10 & 8 & 82 \\ 6 & 8 & 62 \end{array}\right]$	Step I: form an augmented matrix of the system of linear equations.
$\left[\begin{array}{cc\|c} 10 & 8 & 82 \\ 6 & 8 & 62 \end{array}\right] \xrightarrow{\frac{1}{10}r_1} \left[\begin{array}{cc\|c} 1 & \frac{4}{5} & \frac{41}{5} \\ 6 & 8 & 62 \end{array}\right]$ $\xrightarrow{r_2 + (-6)r_1} \left[\begin{array}{cc\|c} 1 & \frac{4}{5} & \frac{41}{5} \\ 0 & \frac{16}{5} & \frac{64}{5} \end{array}\right]$ $\xrightarrow{\frac{5}{16}r_1} \left[\begin{array}{cc\|c} 1 & \frac{4}{5} & \frac{41}{5} \\ 0 & 1 & 4 \end{array}\right]$	Step II: form the augmented matrix into row echelon form, reduced by using elementary row operations
The corresponding system of equations is $x_1 + \frac{4}{5}x_2 = \frac{41}{5}$ $x_2 = 4$ So, the system has a unique solution, namely, $x_1 = 5, x_2 = 4$	Step III: express the solution of the linear equations system

Figure 4.
The alternative solution in solving linear equations system by Gaussian elimination method.

DOI: 10.55214/25768484.v9i6.8103

4. Analysis and Discussion

4.1. Analysis

After analyzing the participant's work in solving mathematical tasks, we present the results obtained with the categories of model A (appropriate and systematic), model B (appropriate and unsystematic), model C (inappropriate and systematic), and model D (inappropriate and unsystematic) in the chart. Figure 4 is a percentage chart of algorithmic thinking categories based on accuracy and systematicity in completing mathematical tasks.

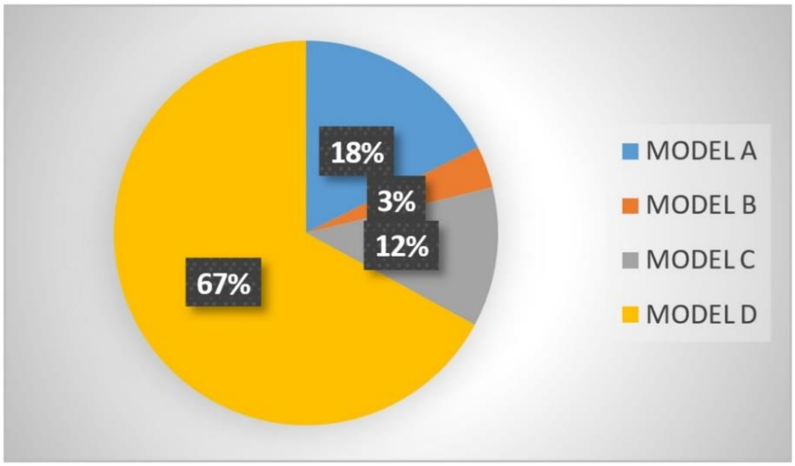

Figure 4.
Percentage of algorithmic thinking categories based on accuracy and systematicity.

According to the results of descriptive analysis, we obtained 18% of participants categorized into Model A, 3% of participants categorized into Model B, 12% of participants categorized into Model C, and 67% of participants categorized into Model D. This provides information that the participants' algorithmic thinking ability is not yet optimal. This is indicated by the presence of 67% of participants who are less appropriate and less systematic in completing the tasks given. Details of the percentage of male and female participants in each algorithmic thinking category are presented in the chart of Figure 5.

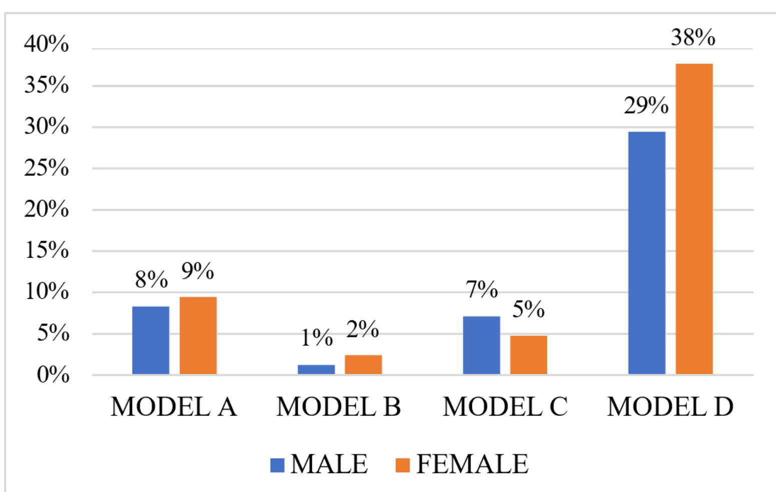

Figure 5.
Percentage of male and female participants in each algorithmic thinking category.

From the bar chart above, it can be seen that the results of the work on the mathematics task given to 85 participants are dominated by model D (as many as 67% or 57 participants). Of the 85 participants, there were 7 males and 8 females whose results of the mathematics task were classified as model A. There was 1 male participant and 2 females whose results of the mathematics task were classified as model B. There were 6 male participants and 4 females whose results of the mathematics task were classified as model C. Also, there were 25 male participants and 32 female participants whose results of the mathematics task were classified as model D (Inappropriate and unsystematic).

The example results of participants whose work is categorized in Model A are presented in Figure 6. Here, Figure 6 is a scan of the original document which is the result of the participant's work in determining the solution to a mathematical task related to the material on linear equation systems in algebra learning.

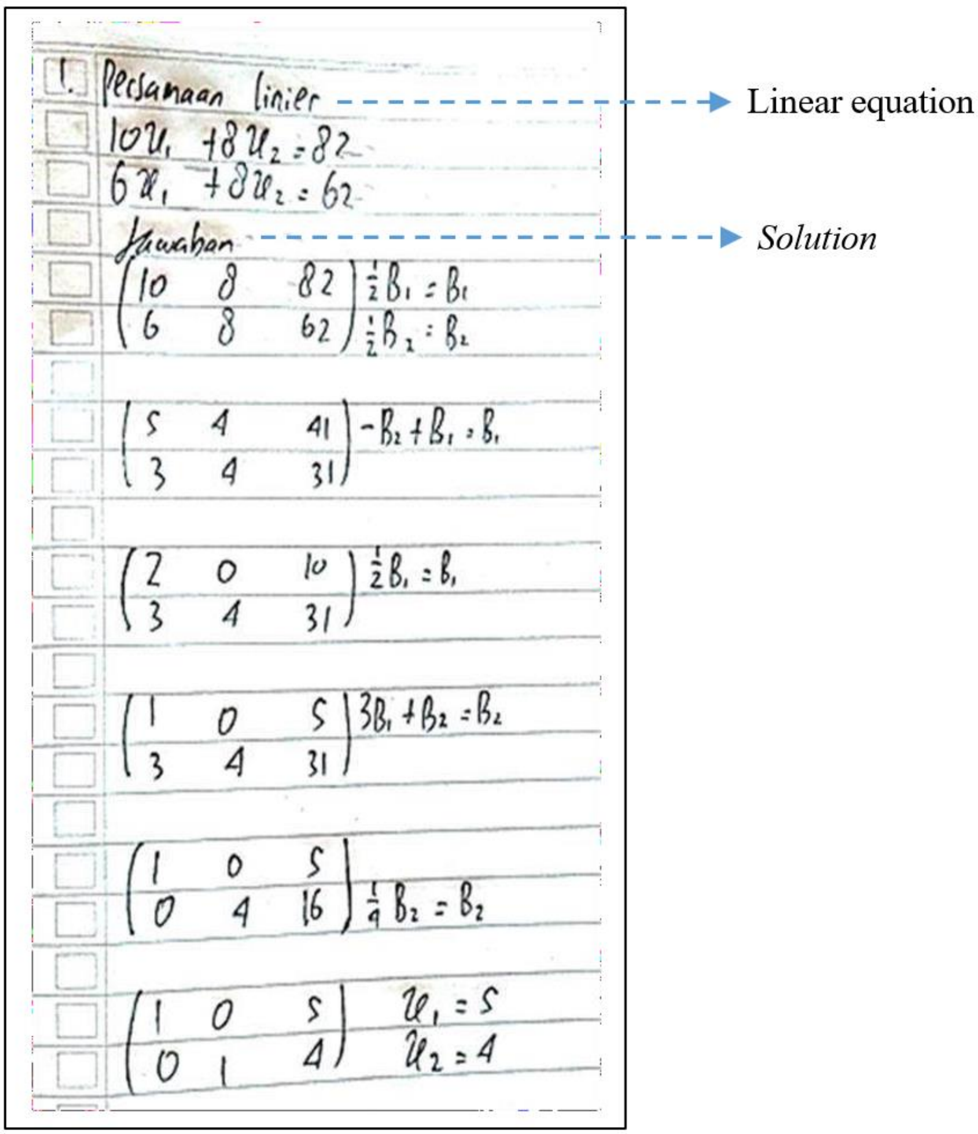

Figure 6.
An example of a participant's result also categorized in model A.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 1307-1319, 2025
DOI: 10.55214/25768484.v9i6.8103

The steps of the elimination procedure using elementary row operations in Figure 6 use elementary row operations, including "row addition with multiples of other rows", so it requires several steps to get the "primary 1" in the first row of the expansion matrix, to produce a row echelon form. This step is different from the alternative solutions presented in Figure 4. However, the steps presented in Figure 6 are still considered correct and systematic. Therefore, we categorize the results of the participant's work such as Figure 6 into the Model A category.

The participants also can write the augmented matrix form for a system of linear equations correctly, i.e.

$$\begin{bmatrix} 10 & 8 & 82 \\ 6 & 8 & 62 \end{bmatrix}$$

Next, the participant is precise in reducing the augmented matrix to row echelon form, i.e.

$$\begin{bmatrix} 1 & 0 & 5 \\ 0 & 1 & 4 \end{bmatrix}$$

This process uses "elementary row operating procedures appropriately and systematically. The solution obtained for the system of linear equations is also correct, i.e.: $x_1 = 5$ and $x_2 = 4$. Based on Figure 6, the participant formed an augmented matrix of the system of linear equations, reduced the augmented matrix into row echelon form, and expressed the solution of the linear equations system accurately and systematically.

The results of the participant's work in completing the mathematical task presented in Figure 7 are included in the category of model B (appropriate and unsystematic). We decided this because the participant was not systematic in completing her task, namely, she did not present a solution for x_1 and x_2. She stopped at the stage of producing a row echelon matrix.

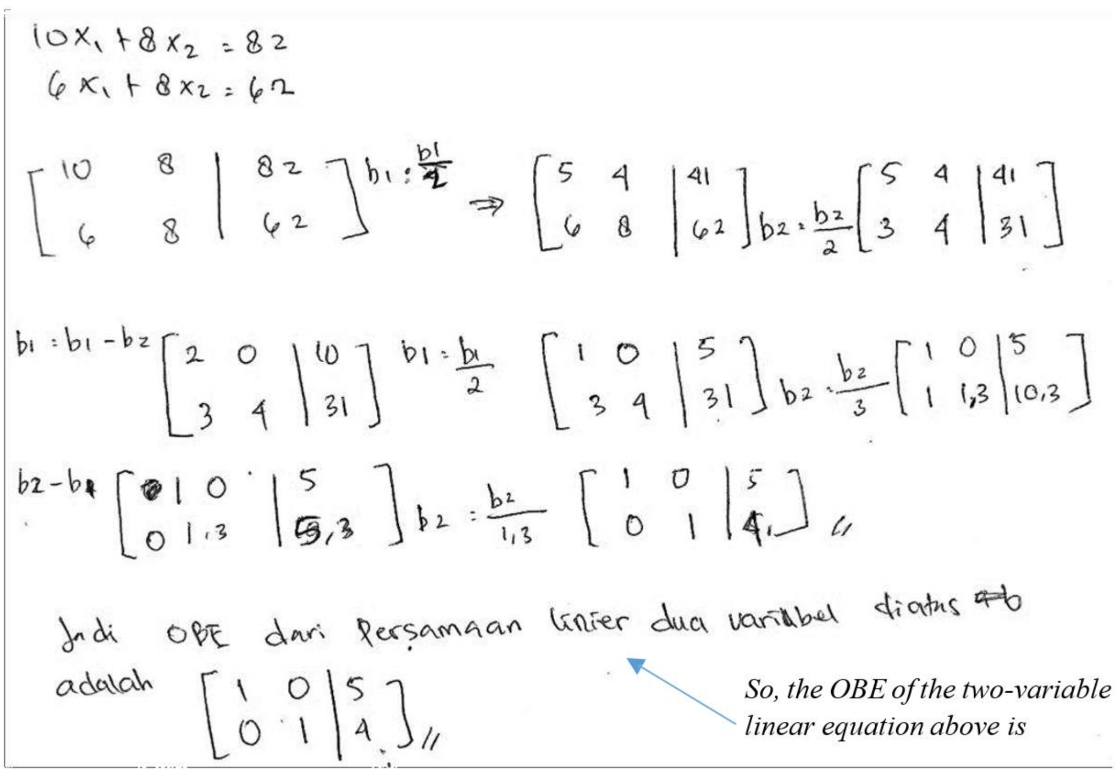

Figure 7.
Example of the participant's work that categorized in model B.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 1307-1319, 2025
DOI: 10.55214/25768484.v9i6.8103

Here, Figure 8 presents the participant's work in solving mathematical tasks categorized in the C model (Inappropriate and systematic). The result as Figure 8 could be more precise in presenting elementary row elimination procedures but still classified as systematic in carrying out procedures for solving systems of linear equations and reducing the augmented matrix to echelon form.

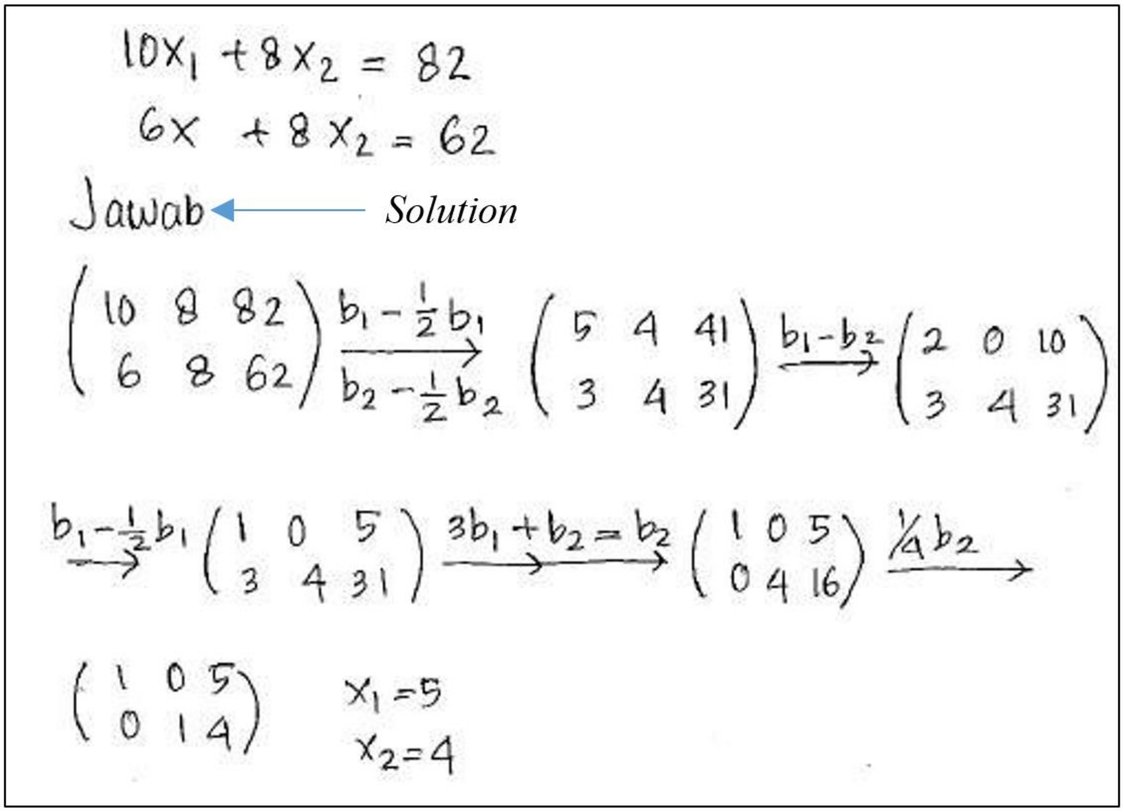

Figure 8.
Example of Participant's work categorized in model C.

He was inappropriate in using elementary row operations. He wrote $b_1 - \frac{1}{2}\,b_1$. The correct one should be $b_1 = \frac{1}{2}\,b_1$. The same thing also happens in using elementary row operations for the second row. He wrote "$b_2 - \frac{1}{2}\,b_2$", it should be "$b_2 = \frac{1}{2}\,b_2$". Even so, He can apply the steps to solving a system of linear equations systematically.

ISSN: 2576-8484
Vol. 9, No. 6: 1307-1319, 2025
DOI: 10.55214/25768484.v9i6.8103

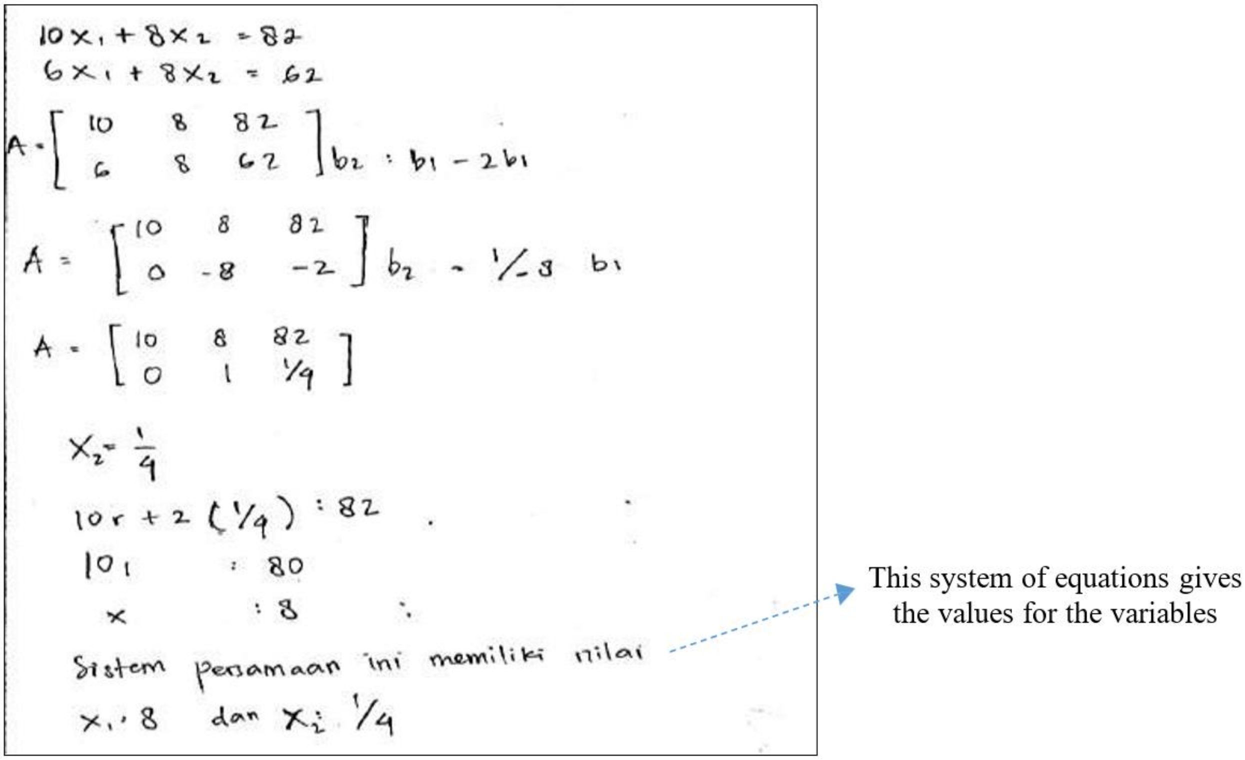

Figure 9.
Example of participant's work categorized in model D.

Figure 9 presents examples of the answers categorized into model D (Inappropriate and unsystematic). The authors categorize the participant' works such as Figure 9 into the model D category (Inappropriate and unsystematic) for several reasons as follows: (a) inappropriate in determining the solution; (b) inappropriate in reducing augmented matrices to row echelon form.

(c) Inappropriate in performing elimination procedures, using elementary row operations; and

(d) Unsystematic in reducing augmented matrices to row echelon form.

Based on Figure 9, the participant was not appropriate in reducing augmented matrices to row echelon form. She also was not reducing augmented matrices to row echelon form systematically. At the end of the reduction process, she presented the matrix as follows.

$$\begin{bmatrix} 10 & 8 & 82 \\ 0 & 1 & \frac{1}{4} \end{bmatrix}$$

Which is not a row echelon matrix. As a result, the solution provided by her is not correct. It indicates that She has not been able to complete this math assignment accurately and systematically.

Figures 6 to 9 show the order of solving algebraic mathematical problems carried out by participants in this study, which represent each category of models A, B, C, and D. The results of the participants' work in Figure 6 use the ability to solve mathematical problems/tasks according to algorithms or systematic steps according to the sequence in Figure 3. Therefore, we classify this work into model A. As we know, algorithmic thinking is the ability of students to work with algorithms and understand systematic steps or strategies for solving problems.

4.2. Discussion

The results of the participants' answers in solving mathematical tasks (categorized model A) imply that the participants were involved in an algorithmic thinking process in completing the task. It means that algorithmic thinking is needed to solve problems by applying a systematic and accurate sequence of steps to get the right solution. It is in line with Dogan [27] said that algorithmic thinking is a way to find solutions by clearly defining steps [27]. Based on the analysis of participants' work results, 59% of works are categorized in model D. In this case, many participants failed to determine the correct sequence of steps. As expressed by Kovalchuk, et al. [28] the concept of algorithmic thinking relates to several skills analyzing initial data and determining the result; finding the sequence of actions necessary to solve the problem; grouping several simpler tasks in a general task; solving the problem in large blocks with more detailed elaboration; writing an algorithm for solving the problem [28]. This is an empirical finding indicating that the ability of algorithmic thinking has not been optimally used by students in completing the tasks at hand. This empirical finding aligns with Bilbao et al, where most students failed in algorithmic thinking [29].

Related to learning activities of mathematics and informatics materials, algorithmic thinking is also needed because several mathematics and informatics problems require the ability to think logically, precisely, and systematically. For example, in solving algebraic problems (mathematics) or compiling programming algorithms (ICT). When prospective ICT teachers study applied mathematics, they need to master the main numerical methods and algorithms for solving mathematical problems. This follows what was expressed by Gavrishina and Zaharov [30] that when students study the field of applied mathematics, they must have an overview of the available applied program packages, know how to use numerical methods in solving applied problems using modern computer technology, develop numerical methods and algorithms, and implement algorithms in high-level programming languages [30, 31]. In line with Dogan [27] study, participants reported that teachers with well-developed algorithmic thinking skills tend to teach in stages, following a process that facilitates learning, encourages students to plan nicely and neatly, and helps them develop/improve their algorithmic thinking skills [27].

On the other hand, algorithmic thinking skills can also increase the algorithm's efficiency. In line with Futschek [32] algorithmic thinking is a collection of abilities connected with building and understanding algorithms, including the ability to increase the efficiency of an algorithm [32]. Given how important it is for students to have good algorithmic thinking skills, educators must try to improve their algorithmic thinking skills. By strengthening algorithmic thinking, we can also enhance problem-solving skills, learning, and understanding of ICT or computer science, especially related to programming/algorithms, and also improve thinking systematically and logically in solving mathematical tasks.

5. Conclusion

Algorithmic thinking is a system of ways of thinking with a systematic construction sequence of actions to find solutions/achieve goals. Based on the research data provides information that the ability to solve mathematical problems systematically and appropriately is still very lacking. This is indicated by as many as 67% of participants are not accurate and not systematic in completing algebraic mathematics tasks. These empirical findings indicate that most students or prospective ICT teachers still need to improve their algorithmic thinking skills when compiling and producing solutions in solving mathematical problems.

Algorithmic thinking is required to solve problems by involving a systematic and accurate sequence of steps to get the right solution. However, we can use algorithmic thinking to increase the efficiency of problem-solving algorithms. Therefore, algorithmic thinking includes more than abilities to solve problems systematically, building and understanding the algorithm. It connects to the ability to increase the efficiency of the problem-solving algorithm. Because many aspects or dimensions influence algorithmic thinking skills, there are many opportunities for future research. How the process of algorithmic thinking is a mental activity, what kind of mental activity component of algorithmic thinking, and how to increase the algorithmic thinking skill is something interesting to study in future research.

Acknowledgments:
The author would like to Universitas Negeri Surabaya and Universitas Trunojoyo Madura for supporting this research activity. This paper is part of my study work in the doctoral program at Universitas Negeri Surabaya. Therefore, I thank my mathematics education doctoral program supervisors at Universitas Negeri Surabaya. Also, thank you to the Informatics Education Department at Universitas Trunojoyo Madura, Indonesia.

Conflicts of Interest:
The authors declare no conflict of interest.

Funding:
This research was not funded

Transparency:
The authors confirm that the manuscript is an honest, accurate, and transparent account of the Study; that no vital features of the study have been omitted; and that any discrepancies from The study as planned has been explained. This study followed all ethical practices during writing.

References
[1] S. A. Rogozin, V. V. Kudinov, V. D. Meshkov, and M. E. Senkin, "Development of digital literacy of a future teacher during the first year of university studies," *Perspektivy Nauki i Obrazovaniya*, vol. 66, no. 6, pp. 67–88, 2023. https://doi.org/10.32744/pse.2023.6.4

[2] M. S. Tsvetkova and V. M. Kiryukhin, "Algorithmic thinking and new digital literacy," *Olympiads in Informatics*, vol. 15, pp. 105-118, 2021.

[3] J. Fraillon and M. Rozman, *Assessment framework*. Paris: UNESCO Publishing, 2023.

[4] J. Hromkovič, T. Kohn, D. Komm, and G. Serafini, "Examples of algorithmic thinking in programming education," *Olympiads in Informatics*, vol. 10, no. 1-2, pp. 111-124, 2016. https://doi.org/10.15388/ioi.2016.08

[5] V. Yustitia, V. S. Murti, D. Kusmaharti, and L. Faridah, "Enhancing students' critical thinking in numeracy problem-solving through a field-independent learning style and high self-efficacy," *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, vol. 9, no. 1, pp. 119-129, 2025. https://doi.org/10.22437/jiituj.v9i1.36525

[6] N. Aminah, Y. L. Sukestiyarno, A. N. Cahyono, and S. M. Maat, "Student activities in solving mathematics problems with a computational thinking using Scratch," *International Journal of Evaluation and Research in Education*, vol. 12, no. 2, pp. 613-621, 2023. https://doi.org/10.11591/ijere.v12i2.23308

[7] L. Zsakó and P. Szlávi, "ICT competence: Algorithmic thinking," *Acta Didactica Napocensia*, vol. 5, no. 2, pp. 49–58, 2012.

[8] O. Sadykova and G. Il'bahtin, "The definition of algorithmic thinking," presented at the International Session on Factors of Regional Extensive Development (FRED 2019), 2020.

[9] M. Stephens and D. M. Kadijevich, *Computational/algorithmic thinking* (Encyclopedia of mathematics education). London, 2019.

[10] A. G. Gejn and N. A. Junerman, *Practicum skills to use mathematical methods and computer in informatics and information technologies [Workshop technology to solve educational mathematical problems: Problem book on computer science and IT]*. Moskva: Prosveshhenie, 2003.

[11] T. V. Nikolaeva, "The importance of algorithms in our lives. In Pedagog. today: Problems and solutions," in *Proceedings of the VI International Scientific Conference (St. Petersburg, April 2020). St. Petersburg: Svoe Izd*, 2020, pp. 56–57.

[12] C. Selby, "Computational thinking: The developing definition," in *Proceedings of the ITiCSE Conference 2013*, 2013.

[13] A. A. Temerbekova, N. G. Kudryavtsev, V. Y. Safonova, and I. S. Leushina, "Algorithmic thinking as one of the factors determining the quality of the educational process in the field of mathematics, computer science, and project activities," in *CEUR Workshop Proceedings*, 2021, pp. 425-435.

[14] J. Blannin and D. Symons, *Algorithmic thinking in primary schools. In Encyclopedia of education and information technologies*. Cham: Springer International Publishing, 2020.

[15] M. Kallia, S. P. van Borkulo, P. Drijvers, E. Barendsen, and J. Tolboom, "Characterising computational thinking in mathematics education: A literature-informed Delphi study," *Research in Mathematics Education*, vol. 23, no. 2, pp. 159-187, 2021. https://doi.org/10.1080/14794802.2020.1852104

[16] J. M. Smith and C. Angeli, *Computational Thinking: Activities* (Handbook of Research on Tools for Teaching Computational Thinking in P-12 Education). Springer Nature Switzerland. https://doi.org/10.1007/978-3-319-60013-0_4-1, 2020.

[17] R. A. Cahdriyana and R. Richardo, "Computational thinking in mathematics learning," *Literasi: Jurnal Ilmu Pendidikan*, vol. 11, no. 1, pp. 50-56, 2020. https://doi.org/10.21927/literasi.2020.11(1).50-56

[18] M. Figueiredo *et al*., "Algorithmic thinking in early childhood education: Opportunities and supports in the Portuguese context," in *EDULEARN21 Proceedings*, 2021: IATED, pp. 9339-9348.

[19] M. G. Supiarmo and E. Susanti, "Students' computational thinking process in solving PISA questions on change and relationship content based on self-regulated learning," *Numeracy*, vol. 8, no. 1, pp. 58-72, 2021. https://doi.org/10.46244/numeracy.v8i1.1378

[20] H. Y. Mumcu and S. Yıldız, "The investigation of algorithmic thinking skills of 5th and 6th graders according to different variables," *MATDER Matematik Eğitimi Dergisi*, vol. 3, no. 2, pp. 18-26, 2018.

[21] G. Polya, *Mathematical discovery on understanding, learning, and teaching problem solving*. United States of America: John Wiley & Sons, 1981.

[22] K. Henra, I. Budayasa, and M. L. Ismail, "What is the room for guessing in metacognition? Findings in mathematics problem solving based on gender differences," *Perspektivy Nauki i Obrazovaniya*, vol. 69, no. 3, pp. 469–482, 2024. https://doi.org/10.32744/pse.2024.3.28

[23] Z. Szabó, "Problem solving and interrelation of concepts in teaching algorithmic thinking and programming," in *CEUR Workshop Proceedings*, 2020, pp. 318-327.

[24] T. Y. E. Siswono, *Paradigm of educational research: development of theory and application of mathematics education*, 1st ed. Bandung: PT Remaja Rosdakarya, 2019.

[25] J. Creswell, *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*, 5th ed. United States of America: Pearson Education, 2015.

[26] H. Anton and C. Rorres, *Elementary linier algebra - application version*, 11th ed. United States of America: John Wiley & Sons, 2014.

[27] A. Dogan, "Algorithmic thinking in primary education," *International Journal of Progressive Education*, vol. 16, no. 4, pp. 286-301, 2020.

[28] M. Kovalchuk, A. Voievoda, and E. Prozor, "Algorithmic thinking as the meaningful component of cognitive competencies of the future engineer," *Universal Journal of Educational Research*, vol. 8, no. 11B, pp. 6248-6255, 2021. https://doi.org/10.13189/ujer.2020.082263

[29] J. Bilbao, E. Bravo, O. García, C. Rebollar, and C. Varela, "Study to find out the perception that first year students in engineering have about the Computational Thinking skills, and to identify possible factors related to the ability of Abstraction," *Heliyon*, vol. 7, no. 2, p. e06135, 2021. https://doi.org/10.1016/j.heliyon.2021.e06135

[30] O. Gavrishina and Y. Zaharov, "Competency-based approach in training mathematicians: Challenges of time," *Procedia-Social and Behavioral Sciences*, vol. 214, pp. 212-221, 2015. https://doi.org/10.1016/j.sbspro.2015.11.665

[31] J. Shara, "Using the algorithmisation in mathematics teaching," *International Journal of Engineering and Science*, vol. 9, no. 12, pp. 9–12, 2020.

[32] G. Futschek, "Algorithmic thinking: The key for understanding computer science," presented at the International Conference on Informatics in Secondary Schools-Evolution and Perspectives. Berlin, Heidelberg: Springer Berlin Heidelberg, 2006.