

## The effect of computational thinking on cognitive load and problem-solving skills of electrical engineering education students at Universitas Negeri Malang

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Received: 01 Jul 2025; Revised: 02 Oct 2025; Accepted: 12 Oct 2025

 Cite this <https://doi.org/10.24036/jptk.v8i4.47423>

**Abstract:** The rapid development of technology requires prospective teachers to master 21<sup>st</sup> century skills, particularly problem solving. Students in the Bachelor of Electrical Engineering Education program at Universitas Negeri Malang often experience a high cognitive load due to heavy academic demands and limited computational thinking, which hinder their problem-solving abilities. This study investigates the influence of computational thinking on cognitive load and problem-solving skills. Using a quantitative descriptive design with saturated sampling, 116 students from the 2022–2023 cohorts participated by completing a closed-ended questionnaire. Data were analysed through prerequisite tests, descriptive statistics, and hypothesis testing using MANOVA with SPSS 27. Results show that students with higher computational thinking have lower cognitive load ( $M = 44.19$ ) and higher problem-solving skills ( $M = 55.70$ ). Computational thinking significantly affects cognitive load ( $p < 0.001$ ,  $\eta^2 = 0.415$ ) and problem solving ( $p = 0.019$ ,  $\eta^2 = 0.067$ ). However, this study is limited to self-reported questionnaire data from a single institution, which may affect the generalizability of the findings. The novelty of this research lies in its simultaneous examination of computational thinking, cognitive load, and problem-solving skills in engineering education, an area that remains underexplored in the Indonesian higher education context. These findings indicate that computational thinking plays a substantial role in reducing cognitive load and improving problem-solving skills, thereby providing valuable insights for curriculum development and instructional design in higher education.

**Keywords:** computational thinking; cognitive load; problem solving; Electrical Engineering Education

### 1. Introduction

The rapid advancement of technology has profoundly impacted daily life, particularly in education. Appropriate utilization of technology can facilitate human activities and improve efficiency (Khoirunnisa et al., 2025). This transformation requires educational institutions to prepare the younger generation to be adaptive to contemporary challenges, particularly in terms of technological literacy and higher order thinking skills. Prospective teachers, including students of the Bachelor of Electrical Engineering Education, are not only expected to master teaching materials but also to develop essential 21<sup>st</sup> century skills, such as critical thinking, digital literacy, and problem-solving abilities. Higher education curriculum needs to be adapted to address these challenges, including through the integration of technology-based learning and systematic thinking approaches (Ashari Hamzah et al., 2022). Conventional education, which emphasizes theory over technological competence, must transform to prepare students for global challenges. In the 21<sup>st</sup>

century, teachers act as facilitators guiding students to think critically, innovate, and solve problems independently. Graduates are required to possess reflective thinking skills for problem solving and to design technology-based learning experiences. Integrating critical thinking, creativity, communication, and digital literacy into curricula is essential to align education with digital era demands. Interactive and technology-based learning approaches, such as discussions and simulations, can increase student engagement and bridge the gap between theory and practice ([Mukhtoralieva, 2025](#)).

However, many students still encounter difficulties in understanding complex technical materials, which leads to high cognitive load and reduced problem-solving ability. Cognitive load refers to the mental effort required to process information during learning activities ([Sari et al., 2020](#)). If the presented information is overly complex or delivered ineffectively, students' working memory can become overloaded, resulting in difficulties in comprehending the material, particularly in technically intensive courses such as Control Systems and Industrial Automation that require deep understanding ([Sweller, 2022](#)). Heavy academic workloads and ineffective teaching methods further exacerbate cognitive load, while limited computational thinking skills constrain students' ability to manage information and design systematic solutions. The COVID-19 pandemic has intensified these challenges by limiting hands on practice and collaborative learning experiences, reducing opportunities for students to apply computational thinking in real problem-solving contexts. Therefore, effective learning strategies are needed to manage cognitive load while simultaneously enhancing students' problem-solving abilities.

One approach to address these challenges is computational thinking. Computational thinking is a logical and systematic way of thinking derived from computer science principles that can be applied to solve various types of problems ([McClelland and Grata, 2018](#)). According to Wing ([Pirzado et al., 2025](#)), computational thinking encompasses decomposition, abstraction, algorithmic thinking, and solution evaluation. This approach has been shown to effectively help students simplify problems, identify patterns, organize solution steps, and evaluate the effectiveness of solutions. Integrating computational thinking into engineering education, it is expected that students' cognitive load can be reduced and their problem-solving abilities significantly improved. Previous studies have indicated that computational thinking positively influences problem solving skills and cognitive load management; nevertheless, its implementation in higher education, particularly at Universitas Negeri Malang, remains underexplored. Therefore, it is important to further investigate the effect of computational thinking on students' cognitive load and problem-solving abilities. Based on this background, the present study focuses on examining whether computational thinking has a significant effect on students' cognitive load and whether it also influences their problem-solving skills. In addition, this study aims to investigate whether computational thinking simultaneously affects both cognitive load and problem-solving abilities. Accordingly, the objectives of this research are to analyse the influence of computational thinking on the cognitive load of Bachelor of Electrical Engineering Education students at Universitas Negeri Malang, as well as on their problem-solving abilities. Moreover, this study seeks to examine the simultaneous effect of computational thinking on both variables to provide a more comprehensive understanding of its role in engineering education.

## 2. Methods

### 2.1 Research design

The research used descriptive quantitative analysis method to analyze the effect of computational thinking on cognitive load and problem-solving skills. The research was conducted in the Bachelor of Electrical Engineering Education program at Universitas Negeri Malang. The Data were

collected through a structured, closed-ended questionnaire designed to measure computational thinking, cognitive load, and problem-solving skills among students.

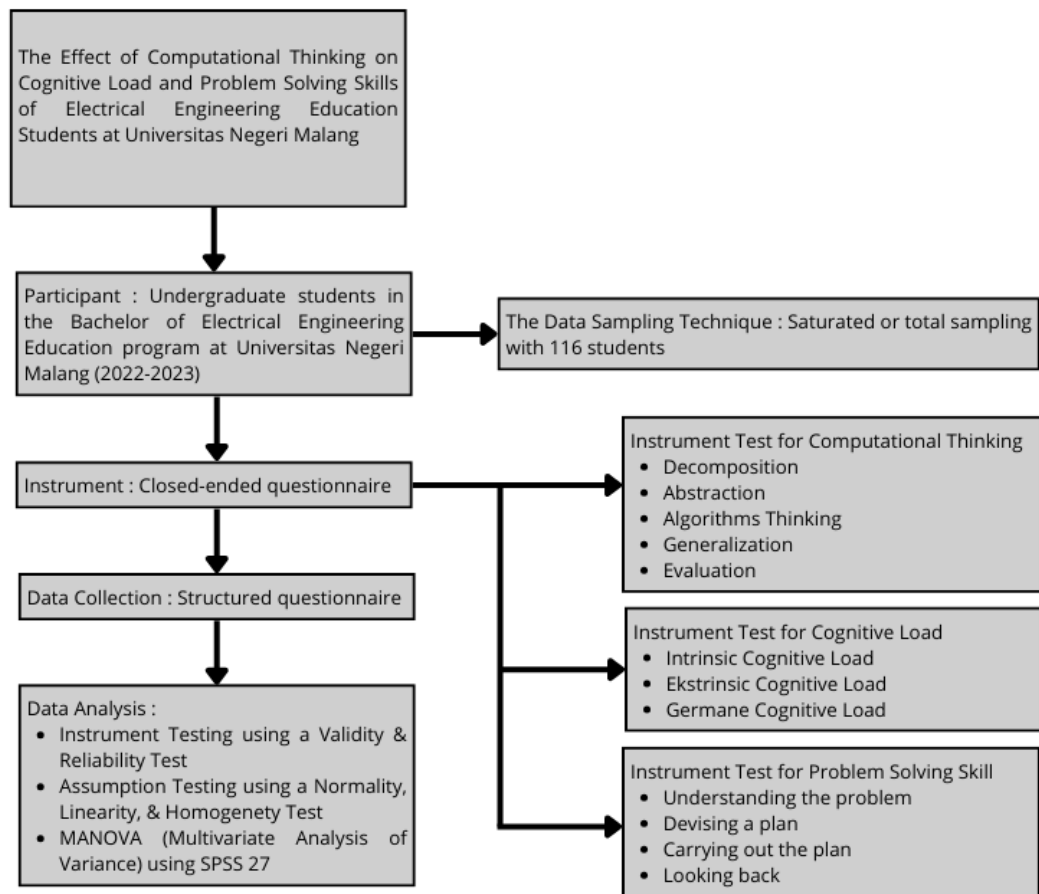


Figure 1. Research design

## 2.2 Participants

The population of this study consisted of all undergraduate students in the Bachelor of Electrical Engineering Education program at Universitas Negeri Malang from the 2022 and 2023 cohorts. The data sampling technique used was total or saturated sampling. A saturated sampling technique was employed, whereby all members of the population were included as research participants. The total number of respondents was 116 students, as presented in Table 1.

Table 1. Table of population and sample size of the research

No	Offering	Year of entry	Total students
1	S1 PTE-A	2022	23
2	S1 PTE-B	2022	24
3	S1 PTE-A	2023	36
4	S1 PTE-B	2023	33
Total			116

## 2.3 Instruments

Research instruments were used in a closed-ended questionnaire developed to measure three research variables: computational thinking, cognitive load, and problem-solving skills. Each questionnaire employed a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). All items were reviewed by experts to ensure content validity and were pilot tested to confirm the validity and reliability of the instruments.

## 2.4 Data collection

The data sources used in this research are the primary data obtained from undergraduate students in the Bachelor of Electrical Engineering Education program at Universitas Negeri Malang. The data were collected through a structured questionnaire designed to measure computational thinking, cognitive load, and problem-solving skills.

## 2.5 Data analysis technique

The data analysis techniques used are in three stages: instrument testing, assumption testing, and hypothesis testing.

- Instrument test. Instrument testing was performed to ensure that the questionnaire items measuring computational thinking, cognitive load, and problem-solving skills were valid and reliable. Content validity was examined through expert judgment, and the reliability of the instruments was assessed using Cronbach's Alpha.
- Assumption Test. Before hypothesis testing, assumption checks were conducted to confirm that the data met the requirements for parametric statistics. These included tests of normality, linearity, and homogeneity.
- Hypothesis Test. After all assumptions were satisfied, hypothesis testing was performed using Multivariate Analysis of Variance (MANOVA) with the assistance of SPSS version 27. This analysis aimed to determine the effect of computational thinking on cognitive load and problem-solving skills. The level of significance was set at 0.05, and using Partial Eta Squared ( $\eta^2$ ) to determine the strength of the relationships.

## 3. Results

This section presents the findings from the analysis of data collected through a closed-ended questionnaire on computational thinking, cognitive load, and problem-solving skills. The data was analyzed using Multivariate Analysis of Variance (MANOVA) with the help of SPSS 27. The results demonstrate the significant effect of computational thinking on both cognitive load and problem-solving skills among Electrical Engineering Education students at Universitas Negeri Malang.

### 3.1 Descriptive statistics

The descriptive analysis revealed that students with high levels of computational thinking achieved lower scores on cognitive load and higher scores on problem-solving skills than those with moderate or low computational thinking. The data shows the mean and standard deviation for each variable, categorized by the level of computational thinking among the students. Table 2 presents the mean and standard deviation for each group.



The results of the hypothesis testing are as follows:

- a. Based on Table 3, the significance value for the cognitive load variable is  $p < 0.001$ , which is less than 0.05, indicating a significant effect of computational thinking on cognitive load. The Partial Eta Squared value of 0.415 indicates that 41.5% of the variance in cognitive load is explained by computational thinking, with the remaining 59.5% influenced by external factors. Therefore, the first hypothesis is accepted, showing that computational thinking significantly affects students' cognitive load.
- b. Based on the hypothesis testing results presented in Table 3, it shows that the significance value for the cognitive load variable is 0.019, which is less than 0.05, indicating that the significance level is lower than 0.05. This suggests a significant effect of computational thinking on problem-solving ability. Furthermore, Table 2 reveals a Partial Eta Squared value of 0.067. This result indicates that 6.7% of the variance in problem-solving ability is explained by computational thinking, with the remaining effect influenced by other factors outside of computational thinking. Therefore, the second hypothesis is accepted, indicating that computational thinking significantly impacts students' problem-solving ability.

## 4. Discussion

### 4.1 The effect computational thinking on cognitive load

The results of the hypothesis testing indicate that computational thinking has a significant effect on students' cognitive load, with a significance value of  $p < 0.001 < 0.05$ . Descriptive statistics further show that the highest average cognitive load occurs among students with moderate computational thinking, whereas the lowest average cognitive load is observed among students with high computational thinking. These findings suggest that an increase in computational thinking is associated with a decrease in students' cognitive load. Moreover, the Partial Eta Squared value of 0.415 indicates that 41.5% of the variation in cognitive load is influenced by differences in computational thinking levels, while the remaining 59.5% is affected by other factors beyond this variable. Universitas Negeri Jakarta was conducted.

This relationship can be explained by the notion that students with strong computational thinking skills are more capable of understanding complex materials efficiently. Such skills allow students to reduce cognitive load by processing, storing, and representing complex information commonly encountered in technical courses. This finding aligns with John Sweller's cognitive load theory, which posits that cognitive load can be minimized when individuals employ efficient thinking strategies to manage information within working memory. In this context, computational thinking serves as an effective strategy that enables students to solve problems systematically, thereby enhancing both problem-solving skills and cognitive load management. These findings are consistent with previous research. (Gupta & Zheng, 2020) indicated that cognitive load during learning is influenced by task complexity, instructions provided, and students' thinking strategies. Students with prior understanding and strategic approaches, such as computational thinking, tend to experience lower cognitive load as they can filter relevant information and simplify reasoning processes in simulation-based and analytical tasks (Hakim, 2024) . These results demonstrate that integrating computational thinking into learning activities with high difficulty levels has the potential to reduce cognitive load and improve learning efficiency in the program.

#### 4.2 The effect of computational thinking on problem solving skills

The results also show that computational thinking significantly influences students' problem-solving abilities, with a significance value of  $0.047 < 0.05$ . Descriptive statistics indicate that the highest average problem-solving ability is found in students with moderate computational thinking, while the lowest is observed in students with high computational thinking. This suggests that an increase in computational thinking corresponds with an improvement in students' problem-solving skills. The Partial Eta Squared value of 0.067 indicates that 6.7% of the variation in problem-solving ability is explained by differences in computational thinking, while the remaining 93.3% is affected by external factors unrelated to this variable.

These findings reinforce the view that computational thinking including decomposition, abstraction, algorithmic thinking, generalization, and evaluation plays an essential role in helping students solve problems effectively and efficiently. Students accustomed to applying computational thinking are better trained to break down problems into simpler components, design logical solutions, and identify optimal strategies for resolution. This aligns with Polya's problem-solving framework, which emphasizes understanding the problem, devising a plan, implementing the solution, and evaluating the results (Lisnawita et al., 2021). Computational thinking strengthens each of these stages, particularly in planning solutions and performing systematic analyses. The results are further supported by previous studies (Fei et al., 2025) found that students with high computational thinking skills tend to solve problems more effectively, as structured computational thinking strategies help them understand core issues, avoid confusion, and design more strategic and efficient solutions. In conclusion, computational thinking has a significant impact on the problem-solving abilities of Electrical Engineering Education students at Universitas Negeri Malang. Enhancing computational thinking can serve as a key strategy for improving students' problem-solving skills, aligning with the demands of 21<sup>st</sup> century competencies that emphasize critical thinking, problem-solving, and innovation.

### 5. Conclusion

The result of the study, based on research conducted on undergraduate students of the Electrical Engineering Education program at Universitas Negeri Malang it can be concluded that computational thinking has a significant effect on both cognitive load and problem-solving skills among undergraduate students in the Bachelor of Electrical Engineering Education program at Universitas Negeri Malang. Students with higher levels of computational thinking experience lower cognitive load and exhibit stronger problem-solving abilities during academic activities. These results underscore the importance of incorporating computational thinking into instructional approaches to assist students in managing cognitive challenges and improving their problem-solving capacity. Future research is encouraged to examine instructional models and targeted interventions that enhance computational thinking as a means of fostering deeper and more sustainable learning outcomes.

### Author's declaration

#### Author contribution

**Yuni Rahmawati** contributed to the conceptualization, methodology design, refined the discussion and conclusion, and writing -review & editing. **Alfiana Sari** contributed to data collection, developed the research methodology, conducted the literature review, analysed the findings, and writing -review & editing.

### Funding statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

### Acknowledgements

The authors gratefully acknowledge to Universitas Negeri Malang for providing institutional support and access to research participants during the data collection process. We also extend our appreciation to the students from various faculties who participated in this study and contributed valuable insights through their responses. Special thanks are due to the academic and administrative staff of Department Electrical and Information Engineering, Faculty of Engineering, for their guidance and encouragement throughout the research process. Additionally, we acknowledge the constructive feedback provided by peer reviewers and colleagues, which significantly helped improve the quality and clarity of this article.

### Conflict of interest

The authors declare that there are no competing interests related to the research or publication of this article.

### Ethical clearance

This research was conducted in accordance with the ethical standards of academic research involving human participants. All participants were informed about the purpose of the study, and their informed consent was obtained voluntarily. Participation was anonymous, and all responses were treated with strict confidentiality. No sensitive personal data were collected, and respondents were free to withdraw from the study at any stage without penalty.

### Data availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

### AI statement

This article is the original work of the author without using AI tools for writing sentences and/or creating/editing tables and figures in this manuscript.

### Publisher's and Journal's note

Universitas Negeri Padang as the publisher, and the Editor of Jurnal Pendidikan Teknologi Kejuruan state that there is no conflict of interest towards this article publication.

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