Jaya, S. (2025) “Enhancing Problem-Solving Abilities of Teachers and Students through Integrated Computational Thinking Training in the Curriculum”, Sebatik, 29(1).
Submitted: 2025-06-19 Accepted: 2025-06-28 Published: 2025-06-30

Sebatik Vol. 29 No. 1 June 2025
ISSN: 1410-3737(p) 2621-069X(e)

DOI:10.46984/sebatik.v29i1.2606

Enhancing Problem-Solving Abilities of Teachers and Students through Integrated Computational Thinking Training in the Curriculum

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ABSTRACT

Computational Thinking (CT) is a problem-solving approach that utilizes fundamental concepts of computer science. CT involves systematic and logical thinking to break down complex problems into smaller, manageable parts, recognize patterns, perform abstractions, and design algorithmic solutions. This skill is crucial in 21st-century learning as it helps teachers and students develop better problem-solving abilities. A relevant 21st-century curriculum should include skills such as computational thinking, problem-solving, collaboration, and communication. This training aimed to identify teachers' and students' abilities in solving problems using their existing knowledge and skills. The training was conducted using a blended learning method, featuring lectures, exercises, and quizzes. The activity took place at Erenos School in South Tangerang, involving 52 teachers and 184 students from elementary to high school levels. The training, organized by the Bebras Bureau of Universitas Pembangunan Jaya (UPJ), showed an improvement in analysis, synthesis, and evaluation skills among teachers and students who participated in the CT training integrated with the curriculum. The evaluation results revealed a significant increase in students' and teachers' understanding and application of CT concepts in real-life scenarios. Furthermore, teachers reported increased confidence in developing CT-based lesson plans and incorporating computational principles into everyday learning. These findings support the importance of CT integration into the national curriculum to enhance educational quality and equip learners with essential skills for the digital era.

***Keywords**: CT, problem-solving, 21st-century learning, Blended Learning, Curriculum Integration*

1. INTRODUCTION

Education in today's digital age requires students to have strong problem-solving skills to deal with complex and dynamic challenges. Problem-solving skills are one of the most important skills for improving the quality of education and preparing students to compete in the global era. However, many students still have difficulty solving complex problems and need help in developing their problem-solving skills. Low problem-solving skills among students can be attributed to several factors, including a lack of experience in solving complex problems, insufficient analytical and synthesis skills, and inadequate ability to use technology to solve problems.

There are many ways to improve students' problem-solving skills, including: First, using problem-based learning (PBL) methods. This method introduces students to real-life situations, thereby building their analytical and creative problem-solving skills Fahra (Utami, dkk).Thus, students not only learn theory but also apply their knowledge in practical contexts. This approach aligns with educational goals that emphasize the development of critical and creative thinking skills, as well as the ability to collaborate in groups (Ningrum ,dkk). Second, developing critical thinking skills to help students analyze problems and develop effective solutions (Hadi dkk, 2024) third utilizing technology in learning to enable students to become proficient in using software to solve problems, fourth, developing collaboration skills. With these skills, students can be better prepared to face global challenges and create innovative solutions to various complex problems (Rahayu Ala, dkk 2025)

The implementation of CT in the curriculum is regulated in several Minister of Education and Culture Regulations (Permendikbud). Specifically, Permendikbud Numbers 35, 36, and 37 of 2018 regulate the subject of Informatics, which incorporates CT into the 2013 curriculum structure. In this subject, CT is taught as an important thinking skill for problem-solving and designing solutions, not only in the field of ICT but also in various other disciplines. CT is integrated into several subjects, such as Mathematics, Indonesian Language, Natural Sciences (IPA), and Social Sciences (IPS) for elementary education, as well as the Informatics subject for secondary education. This demonstrates the government's seriousness in advancing education in Indonesia and preparing the younger generation to face the digital age (Fenanda,dkk 2024). The implementation of these skills in the curriculum is expected to improve the quality of education, thereby producing graduates who are able to compete at the global level. This policy also presents a challenge for teachers to integrate this approach into the learning process. Therefore, developing teachers' capacity through training and resource support is crucial to ensure the successful implementation of these skills in schools.

The objective of this activity is to develop teachers' and students' problem-solving abilities through CT training integrated with the curriculum. This training is expected to enhance teachers' and students' analytical, synthetic, and evaluative skills in solving problems, as well as improve teachers' ability to develop effective and innovative lesson plans.

In addition, this activity is also expected to provide benefits for teachers and students, including: improving the problem-solving abilities of teachers and students, improving the analytical, synthesis, and evaluation abilities of teachers and students in solving problems, improving teachers' abilities to develop effective and innovative lesson plans, and preparing students to face challenges in the digital age.

Moreover, the integration of CT into the education system aligns with global trends in educational transformation, where digital competencies are becoming essential pillars of student success. Countries such as Finland, Singapore, and the United Kingdom have embedded CT into their national curricula, not just within informatics or ICT subjects, but across disciplines, to foster interdisciplinary thinking and equip learners with future-ready skills. These international practices provide valuable references and justification for the Indonesian education system to intensify the integration of CT, especially in preparing students to thrive in the Fourth Industrial Revolution (4IR) era.

The relevance of CT goes beyond the classroom; it is widely acknowledged as a foundation for workforce readiness. According to the World Economic Forum (2023), problem-solving, critical thinking, and digital literacy are among the top skills required by employers in the next decade. Thus, embedding CT into early education is not only an academic concern but also a socioeconomic imperative. Students who are trained in CT from an early age are more likely to become adaptable, innovative, and solution-oriented individuals capable of contributing to society's development and resilience in times of crisis, such as during pandemics or rapid technological disruptions.

In the context of Indonesia, several challenges hinder the optimal integration of CT in the learning process. These include the uneven distribution of trained informatics teachers, limited access to digital resources in remote areas, and a general lack of awareness regarding the importance of computational skills outside of computer science. Furthermore, many educators are still unfamiliar with the pedagogical approaches required to teach CT effectively. These systemic issues necessitate a structured intervention through training programs that not only build teacher capacity but also raise awareness among stakeholders about the long-term benefits of CT-based education.

Another important aspect is the need for contextualization. CT training in Indonesia must take into account the diversity of cultural, linguistic, and technological backgrounds among students. This means that training materials, lesson plans, and assessment tools must be adaptable and sensitive to local educational contexts. For example, CT examples based on real-life problems in agriculture, environment, or community development are more likely to engage students in rural areas, while urban students may benefit from CT applications in digital media or entrepreneurship.

Research has also shown that CT can support inclusive education. Students with different learning styles or disabilities can benefit from CT's emphasis on step-by-step logic, visualization, and algorithmic thinking. With proper scaffolding and assistive technologies, CT has the potential to bridge learning gaps and promote equity in educational outcomes. Therefore, embedding CT into curriculum design can be a key strategy to advance the Sustainable Development Goals (SDG 4: Quality Education).

Several recent studies have highlighted the positive impact of Computational Thinking (CT) integration in education, particularly in improving students' problem-solving skills and digital literacy. Weng,dkk (2022) conducted a study in Taiwan and found that CT-based learning modules significantly enhanced students' logical reasoning and performance in mathematics. Similarly, research by Lye and Koh (2020) showed that incorporating CT in primary education not only improved programming proficiency but also increased metacognitive awareness among students. In the Indonesian context, a study by Putri and Sutopo (2021) demonstrated that CT-based problem-based learning models were effective in fostering collaboration and creativity in junior high school students. Another study by Hidayati and Prasetyo (2023) reported that the integration of CT into science lessons resulted in higher-order thinking skills and better learning outcomes. Furthermore, Yuliana,dkk (2024) found that CT training for teachers in rural areas led to increased confidence and pedagogical adaptability, indicating the potential scalability of CT initiatives across diverse educational settings in Indonesia. These studies affirm the importance of CT as a cross-disciplinary skill and support the need for structured training programs targeting both students and educators.

Based on these considerations, this study aims not only to explore the effectiveness of CT training but also to contribute to the broader discourse on educational innovation in Indonesia. By analyzing the implementation and outcomes of integrated CT training among teachers and students, the study provides insights into best practices, challenges, and policy implications. This contribution is expected to assist educational institutions, curriculum developers, and policymakers in designing more effective CT programs that respond to the dynamic needs of the digital era.

In addition to the aforementioned studies, recent research has explored the long-term benefits of integrating CT in teacher professional development. A study by

Rahman,dkk. (2020) found that continuous CT training helped teachers build adaptive teaching strategies and encouraged the use of real-world problems in class. Meanwhile, Lim and Chai (2021) examined the relationship between CT-based pedagogies and students' engagement, finding that active learning strategies grounded in CT principles increased motivation and improved collaboration in problem-solving. These findings are consistent with the shift in education toward learner-centered approaches that emphasize agency, inquiry, and the use of digital tools. Together, these studies reinforce the critical need to embed CT within curriculum design, teacher training, and school-wide instructional practices to support 21st-century learning goals.

2. FOCUS AND SCOPE

The scope of CT training activities applies engineering process practices in the learning process and principles of computer science by integrating the following:

1. Computational thinking
   Problem-solving skills through modeling and simulation to produce effective, efficient, and optimal solutions that can be implemented by humans or machines, including logical, critical, and creative reasoning based on data, either independently or collaboratively
2. Digital literacy enriched with concepts of information and communication technology, computing systems, computer networks and the internet, as well as the social impact of informatics on individuals and society as a life skill in the digital age
3. Data analysis, which is data processing focused on computational data analysis
4. Algorithms and programming to create digital creative works or programs to help solve individual or community problems.

The four elements of the Informatics subject are interconnected, designed for all Indonesian citizens attending school under diverse geographical conditions and facilities. The Informatics subject curriculum framework is designed to be easily implemented innovatively and adaptable to the evolving times and digital technologies that can be leveraged for the learning process.

3. MATERIALS AND METHODS

This training activity is conducted using blended learning, which is a learning approach that combines traditional (face-to-face) learning methods with online or digital learning. In blended learning, participants can learn directly in the classroom and also access learning materials, resources, or activities through a digital platform. The goal of blended learning is to increase the flexibility, efficiency, and effectiveness of learning, with the following details:

3.1 Preparation Stage

At this stage, the person in charge of the activity conducts a Forum Group Discussion (FGD) with the school to formulate activity targets, schedules, evaluation models, and follow-up actions as a form of continuity for the training and mentoring program for teachers and students. This is followed by a socialization session as an initial educational activity for all teachers and students regarding the importance of understanding and mastering problem-solving skills through CT/Informatics training. The importance of improving digital skills, as well as the informatics learning targets that students need to achieve, is expected to enable every teacher to enhance the quality of teaching and learning.

3.2 Implementation Stage

This stage consists of training and guidance on materials in line with the learning objectives, namely computational thinking, digital literacy, data analysis, and programming algorithms.

3.3 Evaluation Stage

At this stage, the person in charge of the activity, the school, and the teachers involved in the training and mentoring activities evaluate the implementation, materials, and achievement of learning targets. Any unsatisfactory results will be followed up as a form of quality assurance for the Informatics learning process.

4. RESULTS AND DISCUSSION

Training and mentoring activities show that trainees are able to apply effective and efficient thinking processes to solve problems related to information technology using structured data. They can determine logical steps to process interactive instructions and data that can be executed by humans or automated systems. Participants also demonstrated the ability to utilize available tools and digital facilities optimally, including the use of internet-based data to support decision-making and task execution.

In addition to technical skills, trainees effectively collaborated and communicated within group tasks, showing improved teamwork, adaptability, and problem-solving in dynamic digital environments. The program also fostered ethical awareness, as participants were guided to create and interact responsibly in the digital world respecting privacy, intellectual property, and appropriate online behavior.

Furthermore, the training encouraged creative thinking through tasks that involved designing solutions or digital products with real-world relevance. These competencies align with the goals of 21st-century education, where digital fluency, critical thinking, collaboration, and ethical responsibility are essential. The specific learning outcomes achieved for each competency element are presented in Table 1.

ISSN: 1410-3737(p) 2621-069X(e)

Table 1. Learning Outcomes for Each Element

Element	Result
Computational Thinking	Training participants will be able to: 1. understand the concept of structured data sets in everyday life, understand the concept of data processing worksheets, and apply CT knowledge and skills in solving problems involving simple structured data sets with small volumes, and dispose of the necessary CT in various fields 2. write a set of instructions using a limited set of vocabulary or symbols in pseudocode format
Digital Literacy	Training participants will be able to: 1. understand how search engines work and how to use them on the internet 2. recognize the credibility of digital information sources and understand the digital media ecosystem 3. distinguish between facts and opinions 4. understand how to use digital technology tools to create reports, presentations, and data analysis and interpretation 5. describe the components, functions, and workings of computers 6. understand the concepts and applications of local network and internet connectivity, both wired and wireless 7. Knowing the types of virtual public spaces; understanding the use of digital media for content production and dissemination 8. Understanding the importance of maintaining a digital footprint, practicing tolerance and empathy in the digital world 9. Understanding the impact of cyberbullying, creating secure passwords 10. Understanding device security from various types of malware, distinguishing between private and public information
Data Analysis	Training participants will be able to: 1. utilize open, reliable, and legal data sources to process data for effective, efficient, and optimal decision-making and prediction with or without a computer
Algorithms and Programming	Training participants will be able to: 1. understand the concept of algorithmic strategies, develop structured computer programs in algorithmic notation or other notation based on appropriate algorithmic strategies 2. develop, maintain, and refine standard algorithms into program source code with attention to quality 3. design and implement a program that uses complex and appropriate data structures using available libraries or tools

In addition to the quantitative outcomes, qualitative feedback from both teachers and students highlighted increased engagement, motivation, and collaboration during the training. Teachers noted that students were more enthusiastic in solving computational puzzles and real-life problem simulations. Many students expressed a newfound interest in informatics and digital problem-solving, indicating that CT-based approaches resonated well with their learning styles. Moreover, participants demonstrated significant improvement in understanding abstract concepts through visual and interactive activities, such as pseudocode writing, flowchart design, and simulation tasks. The program also fostered peer-to-peer learning, especially in group-based problem-solving exercises. This social learning element not only enhanced collaboration skills but also built a stronger learning community among participants, fostering a sense of shared purpose and mutual support.

Post-training observations further revealed that the use of CT strategies encouraged students to ask more questions, think critically, and approach challenges with greater confidence. Teachers reported a noticeable shift in classroom dynamics, where students took more initiative, demonstrated persistence in problem-solving, and were more engaged in reflective thinking. This transformation was particularly evident in open-ended tasks and project-based learning activities, where students applied CT skills to analyze situations, generate hypotheses, test solutions, and iterate on their ideas. Additionally, several educators shared that the training helped them move beyond traditional didactic methods and instead adopt a more student-centered, inquiry-driven pedagogy that empowered learners to take ownership of their learning journeys.

Based on post-training interviews, teachers stated that integrating CT into lesson plans across various subjects including Mathematics, Science, Social Studies, and even Indonesian became more intuitive and meaningful. The integration allowed students to make interdisciplinary connections, contextualize theoretical knowledge, and engage in higher-order thinking. For instance, in Science classes, students used decomposition and abstraction to understand complex systems, while in Social Studies, CT facilitated the analysis of cause-and-effect relationships and decision-making scenarios. These interdisciplinary applications made learning more relevant and authentic, and helped students see the broader applicability of CT beyond computing or informatics.

Moreover, the program created opportunities for professional growth among teachers, as many reported an increased sense of confidence and competence in using CT tools and strategies in the classroom. The collaborative nature of the training encouraged teachers to co-develop lesson plans, share best practices, and support one another through peer mentoring. This culture of continuous learning is essential in sustaining educational innovation and ensuring that CT is not treated as a one-time initiative, but as an integral part of ongoing curriculum development. Participants also recommended the establishment of follow-up sessions, teacher learning communities, and access to open-source digital teaching materials to maintain the momentum built during the training.

These findings underscore the importance of comprehensive and sustained professional development in CT for educators, supported by institutional policies that prioritize curriculum innovation and digital pedagogy. There is a clear need for structured implementation frameworks, supported by school leadership, to ensure CT integration becomes embedded in teaching practices rather than remaining as an optional enrichment activity. Furthermore, involving stakeholders such as parents, school administrators, curriculum developers, and policymakers in CT-related initiatives can foster a more holistic educational ecosystem that supports innovation from multiple levels.

Finally, to further strengthen the evidence base, future research should investigate the long-term impact of CT-based instruction on students' academic achievement, creativity, collaboration, digital citizenship, and readiness for 21st-century careers. Studies may also explore the role of CT in inclusive education settings, its application in vocational and community-based learning, and how it can address diverse learning needs and socio-cultural contexts. By continuing to invest in CT integration and aligning it with broader educational goals, schools will be better equipped to prepare students for complex societal challenges and ensure they are empowered to thrive in a rapidly evolving digital world. The potential of CT to transform not just learning outcomes, but also mindsets and future competencies, makes it a strategic priority in building a responsive and future-ready education system.

Figure 1. Sample CT Questions for Elementary School Level

Figure 2. Sample CT Questions for Junior High School Level

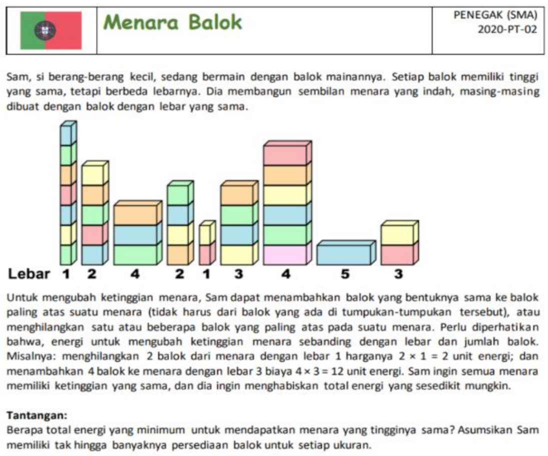

Figure 3. Sample CT Questions for High School Level

Figure 4. CT Training with Teachers (Offline)

Figure 5. CT Training with Students (Online)

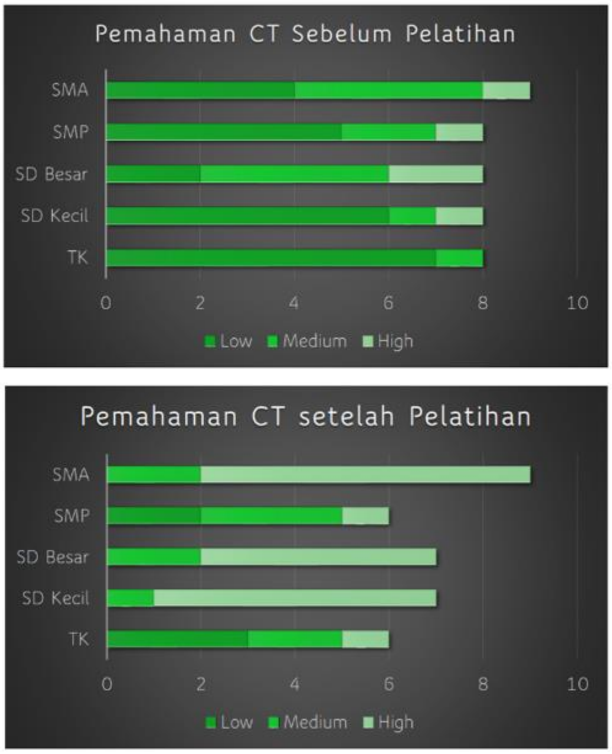

Figure 6. CT Comprehension Evaluation Results

5. CONCLUSIONS

CT training activities integrated with the curriculum have successfully improved the problem-solving abilities of teachers and students. Through this training, teachers and students can understand the basic concepts of CT and apply them in solving complex problems. The results of the activities show that teachers have improved their ability to design CT-based learning, students have improved their problem-solving skills and can apply CT concepts in solving problems, and there has been a significant improvement in the ability of teachers and students to analyze, synthesize, and evaluate problems. Thus, CT training integrated with the curriculum can be one solution to improve the problem-solving skills of teachers and students and prepare them to face the challenges of the 21st century.

6. SUGGESTIONS

Learning activities can be adapted using case studies related to Computational Thinking (CT) to enhance students' problem-solving skills. Integrating CT into core subjects such as Mathematics, Indonesian Language, Science, and Social Studies can help students tackle more complex problems. CT training that is embedded within the curriculum has the potential to create a broader and more sustainable impact for both teachers and students.

To expand the impact, CT training programs should be scaled across various regions, especially in under-resourced schools. Ensuring equitable access to digital infrastructure and learning materials is essential so that all students can benefit equally. Curriculum developers are encouraged to integrate CT into a wider range of subjects through collaboration between CT specialists and subject teachers to create contextual learning experiences.

Long-term professional development for educators should focus on both CT content and effective teaching strategies. Further research is also needed to assess the long-term impact of CT training on students' academic achievement, creativity, and digital citizenship. Future studies could also explore CT's role in inclusive education and its adaptability in vocational or community-based learning environments.

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