

How to Cite (APA Style):

Ardiansyah, R., Atmojo, IRW, Subandi, IW, Matsuri, Adi, FP, & Saputri, DY (2026). Case-based learning practices for enhancing cognitive learning outcomes and computational thinking in teacher education. *Jurnal Ilmiah Pendidikan Dasar*, 13 (1), 212-225. <http://dx.doi.org/10.30659/pendas.13.1.212-225>



Case-based learning practices for enhancing cognitive learning outcomes and computational thinking in teacher education

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Submitted: August 20th, 2025

DOI: 10.30659/pendas.13.1.212-225

Revised: January 28th, 2026

Accepted: January 31st, 2026

Keywords:	Abstract
case-based learning; computational thinking; cognitive learning outcomes	<i>The objective of this research is to determine the effect of the case-based learning model on students' cognitive learning outcomes and computational thinking skills. This is a quantitative study. The sample was selected using cluster random sampling techniques. Data collection was carried out using essay tests to measure cognitive learning outcomes and computational thinking, as well as scales to assess students' enjoyment of learning. Validity and Data analysis were performed using PLS-SEM. The results of this study are as follows. The findings indicate a positive effect of the case-based learning model on the cognitive learning outcomes of PGSD UNS students. There is a significant effect of students' computational thinking on their cognitive learning outcomes. Based on these results, it can be concluded that the case-based learning model affects students' cognitive learning outcomes. Then there is a significant effect of case-based learning on computational thinking. The results of this research can be used as a reference for further research.</i>

INTRODUCTION

Background of the Study

The 21st century is known as the century of information technology, globalisation, and the industrial revolution 4.0, which brings changes in all aspects of

Jurnal Ilmiah Pendidikan Dasar Vol. XIII, no. 1, January, 2026, Page. 212-225

doi: 10.30659/pendas.13.1.212-225

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life, especially in education. The learning process involves students being active throughout the learning process. Active student learning emphasises memory, cognitive flexibility, and self-control so that students can be active during the learning process (Kongthanajindasiri et al., [2024](#)). 21st-century education requires students to have higher-order thinking skills, namely computational thinking (Pratamasari et al., [2025](#)). Computational thinking (CT) is considered an important element of 21st-century skills related to general problem solving, along with other fundamental elements such as communication, digital literacy, critical thinking, and creativity (Tsarava et al., [2022](#)). Computational thinking was first used to solve cognitive processes by applying computer programming rules. Computational thinking is considered an important tool for disseminating computer science or programming education because the scale of CT's perception and topics are related to computing, computer science, programming, and digital literacy (Mumcu et al., [2025](#)). Computational thinking skills have an essential position alongside other important skills, such as reading, writing, and arithmetic. At an early age, teaching children should prioritise computational thinking skills such as abstraction, logical reasoning, sequencing, and algorithms, in addition to literacy skills such as reading, writing, and mathematics that children already acquire.

Computational thinking plays a crucial role in supporting problem-solving in learning, including in the humanities, mathematics, and science. Computational thinking is one of the competencies expected to be mastered by elementary school students in this independent curriculum (Masitoh et al., [2025](#)). Computational thinking is expected to be implemented in the educational curriculum, thereby improving skills, particularly in science and mathematics, in the PISA (Azizia et al., [2023](#)).

Juldial and Haryadi ([2024](#)) stated that computational thinking skills are considered basic skills in writing, reading, and mathematics that are needed by everyone, not only for professionals in the field of information technology. Computational thinking is an approach to solving problems that is carried out like computation on a computer to obtain effective, efficient, and optimal solutions. Computational thinking is the ability to think about processes in solving problems factually, that lead to high-level thinking skills to obtain effective, efficient, optimal, and fast solutions. Computational thinking is a skill needed to equip children with analytical thinking, creativity, and problem-solving (Agustin et al, [2025](#)). Simply put, computational thinking is a thought process for solving complex problems into

simpler problems with simple methods. Computational thinking trains the skill of breaking down problems into smaller parts or into simpler sub-problems (Juldial and Haryadi, [2024](#)). Based on the explanation, it can be concluded that computational thinking is an approach to the thinking process in solving complex problems into simple ones to obtain effective, efficient and optimal learning solutions.

Computational thinking is an important pillar in preparing students to face the complexities of modern life (Rohmah et al., [2025](#)). Computational thinking can complement mathematical and engineering skills because it focuses on designing systems that help solve complex problems in everyday life (Istiqomah & Hestiningtyas, [2025](#)). Computational literacy is useful in analysing and considering the possibilities, strengths, and limitations in computation-centred mathematics education (Muhammad et al., [2024](#)). Kristiandari et al. ([2023](#)) found that low computational thinking skills correlate with low cognitive learning outcomes in various fields of study.

Cognitive learning outcomes are an important indicator in evaluating the effectiveness of the classroom learning process. These learning outcomes include students' ability to understand, remember, analyse, and apply the information they have learned. Learning quality can be improved by conducting meaningful learning if the learning can facilitate learning activities that provide opportunities for students to discover something through the learning activities undertaken. Meaningful means if children directly experience what they are learning by activating more of their senses rather than simply listening to someone/the teacher explain the learning material (Iwani, [2022](#)). One learning model that can be used as an alternative is Case-Based Learning. In the case-based learning model, the teacher presents a case or problem so that students can more easily understand the concepts of the material being taught. This model emphasises the process of solving the case faced scientifically, placing the case or problem as the key to the learning process. In case-based learning, educators must be able to provide appropriate feedback so that it can guide students to solve the case.

Case-based learning offers students the opportunity to gain experience in connecting and applying concepts comprehensively. Researchers have explored case-based learning in general and found that it can be an effective learning method for developing problem-solving skills. Case-based learning offers students the opportunity to consider problems similar to those they will face and encounter in

everyday life and make connections between the problems presented and their existing knowledge.

The case-based learning model uses a constructivist approach, thus requiring active participation from students in constructing their own knowledge. This model presents case-based problems in the form of real-life scenarios related to the material being taught. Students are required to integrate various sources of information within the context to help solve the case based on their prior knowledge and experience. In the case-based learning model, students can effectively engage in the learning process and thus construct their own knowledge.

The Problem of The Study

World Bank data, education in Indonesia only reaches lower levels of cognitive thinking, namely knowledge, understanding, and application, while higher levels of thinking, such as analysis, evaluation, and creativity, are still very low (Maryamah et al., [2024](#)). Referring to the results of the 2022 PISA, it shows that students in Indonesia scored below the OECD average in mathematics, reading, and science. The 2022 PISA results are among the lowest ever measured by PISA in three subjects; the observed results are equivalent to the results obtained in 2003 in reading and mathematics, and in 2006 in science. It is important to apply computational thinking to improve skills in mathematics and science. Indonesia will achieve an increase in scores and an increase in ranking in PISA 2021, and this improvement can be achieved by equipping Indonesian students with the abilities that will be measured in PISA 2021, especially computational thinking.

Field findings in 2023 showed that only 0.09% of PGSD students studying in their fourth semester of Applied Science achieved a pass rate on the final semester exam (UAS) for the physics sub-topic. This led researchers to examine students' cognitive abilities in Applied Science. The study focused more on examining learning outcomes in the cognitive domain, which relates to intellectual aspects. Cognitive learning outcomes can measure an individual's depth of understanding and mastery of a subject.

Research's State of the Art

Researchers chose the case-based learning model over other learning models because it helps students connect theory directly to practical situations. According to Reyes ([2025](#)), real-world cases provide a direct context for the application of learned concepts, thereby deepening students' understanding. Case-based learning allows students to apply learned theoretical concepts directly to practical situations. The

case studies used in this model are based on real-life situations or simulations that reflect real-world challenges. This facilitates a deeper and more concrete understanding of the subject matter, allowing students to immediately see the relevance and application of the knowledge they have acquired (Mendrofa, [2024](#)). Case-based learning emphasises in-depth analysis and critical discussion of given cases. This process helps students develop strong analytical skills, the ability to break down complex problems into manageable parts, and structured problem-solving skills. Students learn to evaluate multiple perspectives, consider implications, and formulate evidence-based solutions.

This research differs from previous studies. The topic was chosen based on the belief that to welcome the era of Society 5.0, education must be able to contribute and adapt to changes in human civilisation. Therefore, education must be able to develop the necessary skills, one of which is computational thinking. Computational thinking is seen as a skill that supports many dimensions of 21st-century education. Computational thinking is a fundamental skill, along with reading, writing, speaking, and performing mathematical operations. Teachers need to consider learning models that can be practically applied in everyday life, so that students can immediately see the relevance and application of the knowledge they gain through case-based learning (Mendrofa, [2024](#)). Therefore, the integration of computational thinking skills and case-based learning models is expected to have a positive impact on students' cognitive learning outcomes.

The importance of this research is to determine the positive interaction between students' cognitive learning outcomes and computational thinking using the case-based learning model. A comprehensive and fundamental assessment model that measures computational thinking skills effectively and efficiently is needed. The results can be used as a reference for assessment in various disciplines that specifically study computational thinking skills, especially when linked to problem-solving skills.

Novelty, Research Gap, & Objective

This research is novel in its integration of the Case-Based Learning (CBL) model with measurements of computational thinking skills and student learning outcomes. Most previous studies examining CBL tend to focus solely on problem-solving or critical thinking skills, without linking them to the computational thinking aspect, which is an essential competency in the digital age.

The research gap lies in the lack of studies directly linking the CBL model to improved cognitive and computational thinking learning outcomes. Several previous studies have demonstrated the success of CBL in encouraging active student engagement, but its impact on thinking components such as decomposition, pattern recognition, abstraction, and algorithmic thinking has not been studied in depth. On the other hand, computational thinking studies in higher education often focus on technology-based learning or programming, rather than on case-based learning designs. The main objective of this study is to analyse the influence of the Case-Based Learning model on cognitive learning outcomes and computational thinking skills.

METHOD

Type and Design

The type of research used by the researcher was quantitative. The choice of quantitative research methods was based on the researcher's reasons for studying samples from a specific population, the use of research instruments in data collection, quantitative data analysis, and testing the hypotheses (Kotronoulas et al., [2023](#)). The researcher used a factorial design. Factorial designs are used to evaluate the impact of two or more treatments on related variables.

Factorial design is a form of experimental design adapted to the use of moderator variables that can influence the treatment of the independent variable on the dependent variable (Kotronoulas et al., [2023](#)). This is evident in the research objectives, namely, to determine the effect of computational thinking and cognitive learning outcomes and to observe the interaction of the application of the case-based learning model. All groups used as samples were selected randomly with a pretest; groups with the same pretest results were eligible to be used as research samples (Kotronoulas et al., [2023](#)).

Data and Data Sources

This research was conducted in the Elementary School Teacher Education Study Program at UNS Surakarta. The population consisted of 198 students from the Class of 2022. Thirty-two students were recruited from the control class and 32 from the experimental class.

Data Collection Technique

Kotronoulas et al. ([2023](#)) explained that the quality of research data is influenced by the quality of data collection (related to the methods used in the data collection process), as well as the quality of the data instruments used (related to the

validity and reliability of the data instruments that have been created). Damayanti et al. ([2024](#)) explained that data collection techniques are divided into two, namely test techniques (using test instruments, which include oral tests, written tests, and computer-based tests/CBT) and non-test techniques (not using test instruments which include documentation, observation, interviews, and questionnaires). The techniques used in collecting research data, researchers use instruments in the form of test questions and observations.

Data Analysis

Data analysis is the process of collecting all data from respondents through a series of steps. These steps include grouping data based on respondent type and variables, tabulating data based on variables from all respondents, presenting data from each research variable, and performing calculations. These calculations are performed to answer the predetermined research questions and test the validity of the hypotheses (Kotronoulas et al., [2023](#)).

Mudiono et al. ([2023](#)) researched factors influencing student learning behaviour using the PLS-SEM approach. The results showed that student learning behaviour is influenced by the family environment, campus environment, and student learning motivation. PLS-SEM is a technique in Structural Equation Modelling based on an iterative approach that maximises the explained variance of each endogenous variable. PLS-SEM has several advantages compared to covariance-based SEM methods. PLS-SEM can be used to analyse data that cannot meet the assumption of normality, or research data that is small.

RESULTS

Statistical analysis using PLS-SEM with the help of *SmartPLS* software is presented in Figure 1.

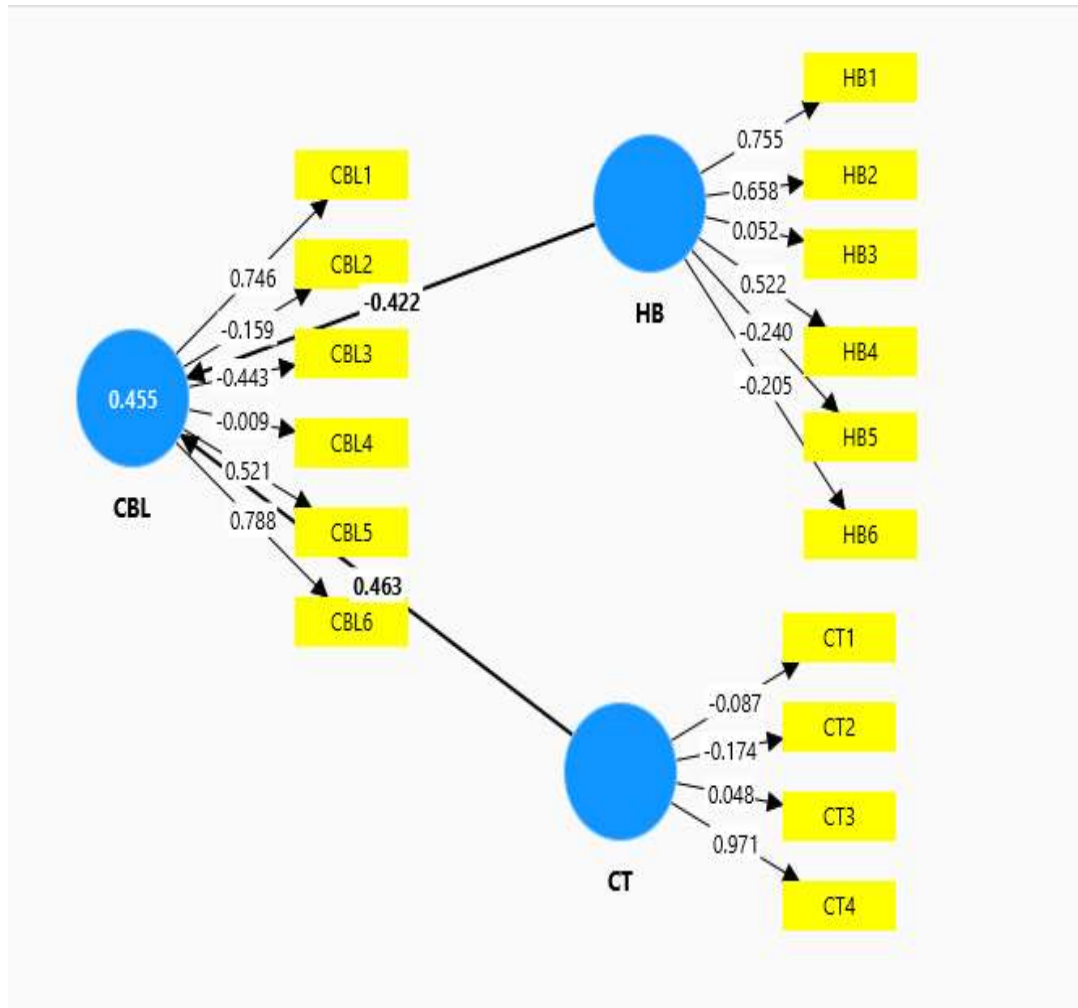


Figure 1 Outer loading graph of each indicator

The analysis of the diagram shown in Figure 1 will be explained in detail in Table 1.

Table 1 Outer loading values for each indicator

Construction	Indicator	Outer value	loading	Conclusion
Learning outcomes	HB 1	0.720		Significant
	HB 2	0.729		Significant
	HB 3	0.760		Significant
	HB 4	0.730		Significant
	HB 5	0.765		Significant
	HB 6	0.769		Significant
Computational Thinking	CT 1	0.756		Significant
	CT 2	0.785		Significant

Case-Based Learning	CT 3	0.728	Significant
	CT 4	0.968	Significant
	CBL 1	0.775	Significant
	CBL 2	0.742	Significant
	CBL 3	0.785	Significant
	CBL 4	0.825	Significant
	CBL 5	0.765	Significant
	CBL 6	0.724	Significant

Each construct in this study is composed of several question indicators. The question indicators must be valid. The validity test of the PLS-SEM model was conducted by comparing the calculated t-values of the outer loading values of each indicator. A correlation of more than 0.70 is considered high. Based on the categorization results in Table 1, all indicators in the construct are valid.

Construct reliability testing was conducted by examining the composite reliability value of each construct. A construct is considered reliable if its composite reliability value is above 0.7. Table 2 provides information on the composite reliability values for each construct. Based on Table 2, it can be concluded that all constructs used in this study have good reliability.

Table 2 Composite reliability values for each construct

Construction	Composite Reliability
Learning outcomes	0.750
Computational Thinking	0.825
Case-Based Learning	0.860

The structural model in this study explains the relationships between constructs consisting of learning outcome variables, computational thinking, and case-based learning. The results of the structural model testing and their significance values are presented in Table 3.

Table 3 Coefficient values and significance of the structural model

Relationship between constructs	Coefficient	T statistic	Significance
CBL -> HB	0.063	2,486	0.003
CBL -> CT	0.066	2,725	0.000

Based on Table 3, information is obtained that the two variables have a significant relationship if the resulting significance value is less than 0.05. Based on Table 3, the CBL and HB variables have a significant relationship, as do the CBL and CT variables.

DISCUSSIONS

Based on the SEM-PLS test results, the relationship between CBL and learning outcomes obtained a significance value of 0.003, meaning there is an influence of the *case-based learning model* on cognitive learning outcomes. Providing appropriate and effective learning methods during the learning process makes students more creative and motivated to learn. The use of student-centred and highly effective learning methods can motivate students to learn and achieve good results. This can be supported by Varma et al. ([2025](#)), who stated that students feel satisfied because *Case-Based Learning* is an effective and student-centred learning method, as it involves and motivates students, especially improving students' knowledge and thinking skills in solving problems. *The Case Based Learning (CBL)* model is a learning model based on cases that are complex problems based on real conditions to stimulate class discussions and collaborative analysis. Case learning is a method that involves factual learning and investigation of up-to-date issues in everyday life (Novani & Yulanda, [2022](#)). Case learning involves interactive conditions, student exploration of realistic and specific situations. In this case, case-based learning emphasizes approaches in solving problems frequently encountered in everyday life. The advantages of *Case Based Learning* are, (1) it can develop analytical skills, (2) it can develop the ability to apply context (theory) and reality in the field, (3) independence in finding and solving tasks through problem-solving training, (4) increasing self-confidence, enthusiasm and cooperation in groups, good oral (presentation) skills. Students using the *Case Based Learning Model* will easily use their basic skills in solving cases given in learning (Irwanto et al., [2024](#)). The *Case Based Learning Model* has also been implemented by Dewi et al. ([2022](#)) in Chemistry learning at the 10th grade level. The results show that the *Case Based Learning model* has an effect on the generic science skills and conceptual understanding of 10th grade students on petroleum material.

The syntax of the *Case Based Learning (CBL)* learning model according to Azzahra in (Wu et al., [2023](#)): 1) Determine cases, where cases are selected according to the material, the aim is to develop students' inquiry and discussion skills; 2)

Analyze cases, cases are discussed in groups, students formulate problems by optimizing their initial knowledge by recalling initial knowledge and related concepts; 3) Find information, data, and literature independently to solve problems; 4) Students determine the steps to solve the case; 4) Draw conclusions from the discussion answers and put them on a poster; 5) Group presentations and continued with question and answer discussions; 6) Correction of inappropriate answers and adjusted to understanding during group discussions.

Based on the SEM-PLS results, the relationship between computational thinking and the case-based learning model has a high significance level of 0.00. The results of this study indicate that the application of the *case-based learning* (CBL) learning model has a significant effect on improving students' *computational thinking* (CT) skills. This finding is in line with the view that CBL is a learning approach that places students in case-based situations, thus encouraging them to analyze problems, identify relevant information, design solutions, and evaluate alternative solutions. The CBL model can improve the main components of CT, namely problem decomposition, abstraction, pattern recognition, and algorithmic design.

CBL provides opportunities for students to practice solving complex problems in contexts that resemble real-world situations. Through group discussions and case analysis, students develop higher-order thinking skills, which are a key component of CT. Previous research has shown that CBL can significantly improve critical thinking skills, which are one of the supporting skills of CT (Fembriani et al., 2025). The positive influence of CBL on CT can be explained through the theory of social constructivism, where knowledge is actively constructed by students through interactions with meaningful problems. Students not only remember information but also process it, connect it with prior knowledge, and apply it to new situations.

CONCLUSION

The conclusions of this study are based on the problem statement, then formulated based on the problem formulation, theoretical review, and data analysis described in the previous chapter. The results of this study indicate that the *case-based learning model* has an effect on students' cognitive learning outcomes. This is evidenced by the SEM-PLS test results, which showed a significance of 0.003. The case-based learning model also has a positive effect on computational thinking skills, as evidenced by the results of the SEM-PLS test showing a significance level of 0.000.

The case-based learning model can be an alternative model used by educators in implementing classroom learning and can increase student activity.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.