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COMPUTATIONAL THINKING IN MATHEMATICS EDUCATION: EXAMINING BEBRAS'S USE AS A LEARNING TOOL FOR 2D SHAPES

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Abstract
Educational developments in the 21st century call for the integration of computational thinking into learning to develop students' logical, systematic, and problem-solving skills. However, mathematics instruction on two-dimensional (2D) shapes still tends to be oriented toward a procedural approach, so students' computational thinking skills have not developed optimally. This study aims to analyze the use of Bebras as a learning tool to enhance students' computational thinking skills in the context of two-dimensional shapes. The study employs a quantitative approach with a pretest–posttest design. The research subjects consisted of 32 upper-grade elementary school students. Data collection techniques included tests, observations, and student response questionnaires. Data were analyzed using quantitative descriptive analysis to determine changes in computational thinking skills across the indicators of problem decomposition, pattern recognition, abstraction, and algorithm design. The results indicate that the use of Bebras has a positive impact on improving students' computational thinking skills. The students' average score increased from 61.4 on the pretest to 84.2 on the posttest. Improvements were observed across all computational thinking indicators, with the highest increase in the pattern recognition aspect. In addition, the results of the observations showed an increase in student engagement and learning activity, while the questionnaire results indicated that the majority of students responded positively to the use of Bebras in mathematics instruction. Students found the lessons to be more engaging, interactive, and helpful in gaining a deeper understanding of two-dimensional geometric concepts. Based on the research results, it can be concluded that Bebras is effective as a mathematics learning tool for improving computational thinking skills in two-dimensional plane figures. The integration of Bebras into mathematics instruction has the potential to become a 21st-century learning innovation that supports the development of students' higher-order thinking skills, problem-solving abilities, and understanding of geometric concepts.

Keywords: *Bebras; computational thinking; geometry; mathematics education; two-dimensional shapes*

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Introduction

The development of digital technology in the 21st century requires the education sector to focus not only on mastering academic concepts, but also on higher-order thinking skills relevant to future needs. One such skill that has garnered global attention is computational thinking, the ability to solve problems logically, systematically, and in a structured manner through the processes of decomposition, pattern recognition, abstraction, and algorithm design (Wing, 2006). In the context of mathematics education, computational thinking is closely linked to mathematical reasoning skills, as both emphasize the processes of analysis, problem-solving, and logic-based decision-making.

Computational thinking is an essential skill because it helps students think logically, systematically, and in a structured manner when solving problems. This ability involves breaking down problems, recognizing patterns, abstracting concepts, and developing algorithms that can be applied in various fields, including mathematics, science, and everyday life (R. D. Rahmawati et al., 2024). In the field of education, computational thinking not only supports academic performaance but also enhances creativity, critical thinking, and problem-solving skills needed in the digital age. According to Jeannette Wing, computational thinking is a fundamental skill that every individual should have, not just computer scientists, because it helps people understand and solve complex problems effectively (Wing, 2006). Therefore, integrating computational thinking into mathematics education is a strategic step toward developing students who are adaptable, creative, and capable of meeting the challenges of the digital age (Buitrago-Flórez et al., 2021).

One of the most widely used tools for developing computational thinking is Bebras, as shown by the results of a study conducted by Aji et al. (2024). Bebras is a challenge platform based on contextual problems designed to develop students' computational thinking skills through engaging activities that are relevant to everyday life. Bebras problems do not always require programming skills, but rather emphasize logical and systematic thinking strategies for problem-solving (Nur Marifah et al., 2022). In mathematics education, particularly when teaching two-dimensional shapes (2D shapes), the use of Bebras has the potential to help students understand geometric concepts in a more interactive and meaningful way. Through activities that analyze shapes, patterns, orientation, and spatial relationships, students can develop both conceptual understanding and computational thinking skills in an integrated manner.

However, the implementation of mathematics instruction in schools is still dominated by conventional approaches focused on memorizing formulas and procedural problem-solving (Fitriya & Kurniawan, 2022; Wati et al., 2025). Geometry instruction, particularly regarding two-dimensional plane figures, often focuses solely on shape recognition and simple calculations without providing students with opportunities to explore deeper thinking processes. This situation results in low levels of problem-solving skills, spatial reasoning, and computational thinking among students. Furthermore, the use of the Bebras platform in mathematics education remains relatively limited and is more frequently associated with computer science or information technology (Elfina et al., 2026; Helmi et al., 2025).

Research on the use of Bebras in mathematics education is also still relatively limited. Most previous studies have focused primarily on the development of digital literacy or computer science education (Ayub et al., 2024; Nur Marifah et al., 2022). Research that specifically integrates Bebras with geometry instruction on two-dimensional plane figures remains scarce, particularly in the context of developing students' computational thinking in Indonesia. Consequently, there is a research gap that presents an opportunity for a more in-depth study on the use of Bebras as a mathematics learning tool.

The researchers also conducted a preliminary empirical study at an elementary school in Sawahan Subdistrict, Nganjuk Regency. The researcher found that teachers at the school had already contributed through their creativity in designing lessons. Media and supplementary teaching materials were used to provide meaningful activities. However, instruction on coding or specifically focused on developing computational thinking remains minimal and has not yet been implemented, let alone the integration of mathematics with computational technology. Therefore, the researcher conducted an experiment involving the use of the Bebras platform in instruction. Research specifically examining the use of Bebras as a learning aid for mathematics in the context of two-dimensional plane figures is also still scarce, particularly regarding the integration of geometric concepts and computational thinking.

This study is novel in its effort to integrate Bebras questions and activities into mathematics instruction on two-dimensional plane figures as a means of developing computational thinking. This study does not merely position Bebras as a medium for computer science competitions or practice, but also as a learning tool that supports the contextual and interactive understanding of geometric concepts. Furthermore, this study offers a learning approach that links computational thinking skills with mathematical understanding in basic geometry, thereby contributing to innovations in mathematics education in the digital age. Thus, the objective of this study is to analyze the use of Bebras as a learning tool to enhance students' computational thinking skills in two-dimensional plane figures and to examine how the integration of Bebras into mathematics instruction can support the understanding of geometric concepts in a more effective, creative, and meaningful way.

Methods

This study employs a quantitative approach through empirical research involving tests, observations, and student response surveys. This research method was chosen to explore complex concepts and to identify research findings in depth using statistical analysis. This method involves a systematic research process designed to identify, evaluate, and interpret research findings relevant to a specific topic (Sugiyono, 2013). There are several important aspects to consider in the research data collection process, namely the computational thinking indicators found in the Bebras application, learning activities, and learning outcomes. Specifically, this method is used to describe learning activities that are oriented toward the development of computational thinking and integrated with technology. This method was implemented by adapting a method previously used by Fitriya et al. (2023) which simply draws conclusions from the research findings by combining three data sources.

The study involved a sample of 32 elementary school students, consisting of 12 boys and 20 girls. These students were randomly selected as representatives from the upper grades (grades 4, 5, and 6). A pre-test and post-test design was used to address the research question regarding the effectiveness of Bebras in supporting computational thinking, supplemented by observations and user surveys to address the research question regarding learning activities using Bebras. Using the Minimum Passing Score or in bahasa we call **KKM** as a standard for mathematics in elementary school, which is 70, it can be concluded that students have met the standard if their pre-test and post-test scores are above 70, including those who have exceeded the computational thinking category.

Result and Discussion

This study was conducted with 32 upper-grade students to analyze the use of Bebras as a learning tool to improve computational thinking skills in the context of two-dimensional (2D) shapes. The study was conducted over four sessions using a challenge-based learning approach by integrating Bebras questions into mathematics learning activities. The research instruments included pretest and posttest assessments, student activity observation sheets, and a student questionnaire regarding their responses to the use of Bebras in learning.

Before the intervention was implemented, the students first took a pretest to assess their initial computational thinking skills regarding two-dimensional plane figures. After the learning process using Bebras was completed, the students took a posttest using the same assessment indicators. The analysis results showed a significant improvement in computational thinking skills following the implementation of Bebras in mathematics instruction. The results of the pretest and posttest are presented in Table 1.

Table 1. Students' Pre-test and Post-test Results on Computational Thinking

No	Computational Thinking Indicator	Pre-test score Average	Post-test Average	Improvement
1	Problem decomposition	63,1	84,5	21,4
2	Pattern recognition	60,7	86,3	25,6
3	Abstraction	59,8	82,4	22,6
4	Algorithm	62,0	83,7	21,7
	Overall average	**61,4**	**84,2**	**22,8**

Based on Table 1, it is evident that all computational thinking indicators showed improvement following the use of Bebras in the learning process. The greatest improvement occurred in the pattern recognition indicator, with an increase of 25.6 points. This indicates that Bebras activities, which heavily utilize the visualization of shapes, patterns, and spatial relationships, are effective in helping students recognize the characteristics of two-dimensional shapes more effectively. Meanwhile, the indicators of abstraction and strategy formulation also showed a significant increase because students became accustomed to simplifying problems and determining solution steps systematically.

These findings indicate that Bebras-based learning activities can help students understand geometric concepts while developing their systematic and logical thinking skills. In the theory of computational thinking, Jeannette Wing states that computational thinking is a problem-solving process that employs a logical and structured approach involving decomposition, pattern recognition, abstraction, and algorithms (Wing, 2006). Bebras activities, which take the form of visual challenges and contextual problem-solving, have been shown to effectively facilitate these four components in the mathematics learning process.

The greatest improvement in this study was observed in the pattern recognition indicator. This is because most of the Bebras questions require students to visually identify shape patterns, spatial relationships, and object characteristics. In the subject of two-dimensional plane figures, the ability to recognize patterns is crucial because students must understand the similarities and differences in characteristics between figures, such as the number of sides, angle sizes, symmetry, and shape orientation (Oktaviana, 2016; Purnomo et al., 2025; Zemon et al., 2023). These findings are consistent with Jean Piaget's constructivist theory, which posits that knowledge is actively constructed through an individual's experiences and interactions with the learning environment. The use of Bebras provides students with the opportunity to explore geometric concepts through hands-on experience in solving visual challenges, making their conceptual understanding more meaningful than learning that is purely procedural (Masgumelar & Mustafa, 2021; Piaget, 2000).

In addition, improvements in abstract thinking and strategy formulation indicate that students are beginning to be able to simplify problems and determine solution steps systematically. In learning with Bebras, students are not only asked to find answers but also to analyze information, choose strategies, and explain the reasoning behind the solutions they use. This process aligns with Polya's problem-solving theory, which explains that solving mathematical problems involves four stages: understanding the problem, planning a strategy, implementing the strategy, and evaluating the solution (Daulay & Ruhaimah, 2019; Fitriya & Kurniawan, 2022). Bebras activities indirectly train students through these stages because each challenge requires different analytical and strategic thinking. Thus, Bebras not only helps improve math learning outcomes but also develops higher-order thinking skills (Fitriya, Kurniawan, et al., 2023).

In addition to test results, this study also observed students' learning activities throughout the learning process. The observations were conducted to determine the level of student engagement during Bebras-based learning.

Table 2. Observations Results of Student Activities

Observed Aspects	**Percentage**
Actively participates in group discussions	88%
Able to identify geometric patterns	84%
Proposes problem-solving strategies	79%
Participates enthusiastically in lessons	91%
Completes Bebras challenges independently	76%
Connects geometric concepts to problems	82%

The results of the observations in Table 2 show that using Bebras in the classroom increases students' active engagement. A total of 91% of students demonstrated high enthusiasm throughout the lesson. Students appeared more interested when presented with visual challenges than with conventional, procedural exercises. Group discussions were also more active as students tried various strategies to find the right solutions to the Bebras problems.

During the learning process, students focus not only on the final answer but also on the thought processes used to solve problems. For example, in an activity involving the identification of two-dimensional shapes based on visual patterns, students are asked to identify different shapes by analyzing the characteristics of angles, symmetry, and the orientation of objects. This activity encourages students to use decomposition and abstraction skills simultaneously. Teachers also provide opportunities for students to explain the problem-solving strategies they used, thereby further developing their mathematical communication and logical thinking skills.

Students' engagement appears more active when they discuss, express their opinions, and try various problem-solving strategies. This indicates that Bebras-based learning is capable of creating a more interactive and student-centered learning environment. According to Lev Vygotsky's theory of social constructivism, learning occurs most effectively when students are actively engaged in social interaction and collaboration with their surroundings. Group discussions in Bebras activities help students build shared understanding through the exchange of ideas and the process of negotiating meaning (F. A. Rahmawati & Purwaningrum, 2022; Suoth et al., 2022). Thus, the use of Bebras not only impacts students' cognitive development but also their communication and collaboration skills.

In addition to observations, this study also measured students' responses to the use of Bebras through a Likert-scale questionnaire as a survey of learning activities. The survey results are presented in Table 3.

Table 3. Results of the Student Response Survey on Learning

Statements	Percentage Agree
Learning is more interesting and fun	87%
Bebras helps me understand two-dimensional shapes	84%
Bebras exercises help develop logical thinking	89%
Learning makes me more active	81%
I find it easier to understand patterns and shapes	85%
I want to use Bebras in other subjects	83%

According to Table 3, the majority of students responded positively to the use of Bebras in mathematics instruction. A total of 89% of students stated that Bebras problems helped them think more logically and systematically when solving problems. Additionally, 85% of students found it easier to understand patterns and shapes of two-dimensional figures through the visual activities included in the Bebras problems. These results indicate that the integration of Bebras not only enhances computational thinking skills but also boosts students' motivation and interest in learning mathematics.

The students' positive response to the use of Bebras also indicates that interactive, challenge-based learning media can boost motivation to learn mathematics. Most students felt that learning became more enjoyable, engaging, and less monotonous. This aligns with learning motivation theory, which states that the use of media and challenging activities can increase students' interest and engagement in the learning process (Fitriya et al., 2022; Jamilah et al., 2025). The Bebras questions, which take the form of logic and visualization games, challenge students to find solutions, so that learning mathematics is no longer seen as a difficult and boring activity. This finding is also supported by research by Valentina Dagienė, who states that Bebras is designed to develop computational thinking through activities that are fun, contextual, and easy to understand for students at various educational levels (Dagiene & Stupuriene, 2016).

Empirically, improvements in student learning outcomes and engagement indicate that the use of Bebras in mathematics instruction fosters a learning process that is more interactive, contextual, and student-centered. Challenge-based learning provides students with opportunities to explore various problem-solving strategies, thereby promoting the optimal development of higher-order thinking skills. The findings of this study also reinforce Jeannette Wing's view that computational thinking can be developed through problem-solving activities involving logic, pattern analysis, and systematic strategy formulation. Thus, the research results indicate that the use of Bebras as a mathematics learning tool for two-dimensional plane figures is effective in enhancing students' computational thinking skills. The integration of Bebras into instruction also has a positive impact on student engagement, motivation, and understanding of geometric concepts, making it a viable innovative alternative for 21st-century mathematics education.

Conslusion

Based on the results of the research conducted, it can be concluded that the use of Bebras as a learning tool in the teaching of two-dimensional shapes has a positive impact on improving students' computational thinking skills. Integrating Bebras activities and problems into mathematics instruction helps students develop problem decomposition skills, pattern recognition, abstraction, and the ability to formulate logical and systematic problem-solving strategies. This improvement is evident from the pretest and posttest results, which show an increase in students' computational thinking skills following Bebras-based instruction.

In addition to enhancing computational thinking skills, the use of Bebras also has a positive impact on the overall mathematics learning process. Students become more active in discussions, more enthusiastic about learning, and more interested in solving visual and logic-based challenges. Learning, which previously tended to be procedural and teacher-centered, has shifted toward being more interactive, contextual, and student-centered. Bebras activities help students understand two-dimensional geometric concepts more concretely through pattern recognition, spatial relationships, and shape analysis linked to real-world problem-solving situations.

The results of this study also indicate that integrating computational thinking into mathematics education can serve as a relevant educational innovation in response to the demands of 21st-century education. Bebras not only functions as a medium for computer science challenges but can also be utilized as a pedagogical tool to enhance students' higher-order thinking skills. Thus, the use of Bebras in mathematics education can serve as an effective alternative learning strategy to support the development of logical, critical, creative, and systematic thinking skills required by students in the digital age. This study is expected to serve as a reference for teachers and researchers in developing more innovative, engaging, and meaningful computational thinking-based mathematics education.

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