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Exploration of Prospective Mathematics Teachers' Computational Thinking Abilities in Solving Quadratic Equation and Function Problems Based on Learning Styles

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Abstract

Teachers must be capable of shaping individuals who can adapt to computational thinking skills. Learning styles impact students' performance and learning outcomes. This study examine the computational thinking abilities of prospective mathematics teachers from the perspective of visual, auditory, kinesthetic learning styles. A qualitative approach was used in this study, specifically a case study research design. The subjects of this study were first-semester students in the Mathematics Education program enrolled in the Basic Mathematics course. Research instruments: written tests, learning style questionnaires, interviews. The test questions were validated by three mathematics education experts and piloted with four students. Based on the research findings, it was concluded that learning style influenced students' computational thinking skills. Kinesthetic students demonstrated proficiency across all indicators of computational thinking ability. Visual and auditory students struggled with algorithmic thinking and pattern recognition. However, visual and auditory students, like kinesthetic students, performed well in abstraction and decomposition.

Keywords: *computational thinking, learning style, mathematics, quadratic function*

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INTRODUCTION

Continuous development and transformation have occurred significantly over the past several years in fields such as technology, education, economics, science, and others. In line with this phenomenon, various skills are needed to keep adapting to these changes, known as 21st-century skills. Teachers play an essential role in educating individuals who can adapt to the rapid advancements of this era (Özer & Kuloğlu, 2023). Computational thinking aligns with various skills, such as problem-solving, creativity, and critical thinking, which are key aspects of 21st-century skills (Lye et al., 2014). Furthermore, Juškevičienė & Dagienė (2018) argue that computational thinking skills enable students to learn how to face diverse challenges and build understanding through problem-solving. Therefore, it is crucial for teachers and prospective teachers to possess computational thinking skills in the 21st century to shape individuals capable of adapting to the times equipped with computational thinking.

Computational thinking is a skill based on fundamental computational concepts, such as problem-solving, designing systems, and understanding the mind and human behavior (Wing, 2006). This skill is not only useful for computer science experts but has also become a skill that everyone needs to learn (Aminah et al., 2022). Computational thinking becomes a thought process in formulating a problem that will produce a solution that can be presented in computational steps and algorithms (Aho, 2012).

According to Bhagat & Dasgupta (2021), there are four main indicators of computational thinking: abstraction, decomposition, pattern recognition, and algorithms. Abstraction is a process that makes problems easier to understand by setting aside elements that are less relevant to the current issue (Csizmadia et al, 2015). Decomposition is the ability to help in the problem-solving process by breaking down and separating the problem into smaller sub-parts, making it a strategy for problem-solving (Rich et al, 2019). Pattern recognition is the ability to apply an approach to finding solutions by extracting and then analyzing to recognize patterns in objects (Asht & Dass, 2018). An algorithm is a series of sequential steps in computation that can transform an input into an output.

Aminah et al. (2022) presented findings showing that computational thinking contributes to students and can also develop teachers' professional levels regarding the integration of computational thinking in learning. Similarly, computational thinking for prospective mathematics teachers can help determine appropriate strategies for problem-solving by using the correct algorithms. Furthermore, computational thinking skills can be used to improve the quality of education for prospective mathematics teachers in areas like problem-solving skills, critical thinking, the learning process, and more (Zeybek, 2022).

Based on how individuals receive and process information, mathematics learning with visual, auditory, and kinesthetic learning styles affects an individual’s mathematical problem-solving abilities (Permana et al., 2013). The appropriate application of learning methods and techniques tailored to each individual's learning style—visual, auditory, or kinesthetic—impacts learning outcomes, particularly cognitive outcomes in mathematics (Palobo et al., 2020).

Learning style refers to how each individual concentrates, retains, and absorbs new or challenging information or skills. Emotional, physical, environmental, psychological, and sociological factors impact learning styles, allowing individuals to receive and apply their knowledge (Dunn, 1983). The most widely used framework for categorizing different types of learning styles is Fleming's VARK model, often simplified as VAK, representing visual (V), auditory (A), and kinesthetic (K), which groups learning styles based on the sensory modalities students use to receive information (Sreenidhi & Helena, 2017).

Research on computational thinking from the perspective of visual, auditory, and kinesthetic learning styles was conducted by Veronica et al. (2022), who found differences in thinking styles based on each learning style. However, that study was only conducted with elementary school students. Further research by Maharani et al. (2021) Maharani et al. (2021) examined computational thinking skills among prospective mathematics teachers in the context of geometry. This study, therefore, aims to examine computational thinking abilities among prospective mathematics teachers, viewed from the perspective of visual, auditory, and kinesthetic learning styles, specifically in the subject of equations and quadratic functions. This study focuses on undergraduate students in the Mathematics Education program.

RESEARCH METHODOLOGY

A qualitative approach was used in this study, specifically a case study research design. This research design is appropriate because the researcher aims to explore the computational thinking abilities of subjects according to their VAK learning styles. Furthermore, two students from each learning style category were selected based on the highest scores in computational thinking test performance.

The study was conducted at a private university in the city of Surakarta. The research subjects were all first-semester students in the Mathematics Education program taking the Basic Mathematics course, totaling 42 students. These subjects were chosen based on the course material that would be included in the test questions, covering topics from the Basic Mathematics course in the first semester. Based on the computational thinking test results, the researcher then conducted interviews with six students—two from each VAK learning style category—to gain deeper insights into their computational thinking abilities.

The research used instruments including written tests, a learning style questionnaire, and interviews. The researcher developed test questions by adapting five items from the Ministry of Education and Culture's Minimum Competency Assessment. These five questions were then validated by three mathematics education experts. Based on the experts' validation, the researcher refined the instruments, particularly focusing on clarifying the key concepts essential for assessing computational thinking. The test was then piloted with four first-semester Mathematics Education students. Based on the pilot results, the researcher selected three questions to use for data collection, considering a time limit of 60 minutes for students to complete the questions. The three computational thinking test questions included items on finding the maximum or minimum value of a quadratic function, graphing a quadratic function, and applying quadratic equations, as shown in Table 1.

Table 1. Computational Thinking Test Questions

No.	Question
1.	SOAP FACTORY A soap-making home business records each product they produce. The business keeps daily production cost records, then compiles these into weekly cost records. Analysis of the graph derived from these records shows that the daily production cost forms a quadratic function as follows: $B(x) = 2x^2 - 800x + 105.000$ where B(x) represents the daily production cost in hundreds of rupiahs, and x is the number of soap units produced that day. What is the minimum daily production cost, and how many units of soap are produced at this minimum cost?
2.	An art gallery has a wall carved with an arch represented by the quadratic function $f(x) = -x^2 - 4x + 12$, where x is in feet. Create a graph of the quadratic function representing the arch in the gallery, and determine the width of each arch at floor level.
3.	A picture frame has a length and width of 45 cm and 36 cm, respectively. If the area of the photo within the frame is 1,036 cm² and the distance between the edge of the photo and the frame is uniform, determine the width of this distance!

Subjects were chosen based on a questionnaire that grouped students by learning style. The learning style questionnaire was adapted from O'Brien's (2015) learning style questionnaire. Based on the results, the number of students in each learning style category is presented in Table 2.

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Table 2. Classification of Students' Learning Styles

Type	Number of Students
Visual	11
Auditory	9
Kinesthetic	16
Auditory and Kinesthetic	5
Auditory and Visual	1

Table 2 shows that out of 42 mathematics education students, only 9 had an auditory learning style. Most students, totaling 16, had a kinesthetic learning style. Additionally, there were 11 students with a visual learning style, while the remaining students had dual learning styles, such as auditory-kinesthetic and auditory-visual. However, this study focused only on analyzing computational thinking abilities in students with a single learning style. The researcher then selected two students from each VAK learning style category with the highest computational thinking test scores for further exploration of their computational thinking processes through interviews.

The data obtained from students' responses to the computational thinking test were analyzed by the researcher using the scoring rubric presented in Table 3.

Table 3. Computational Thinking Skills Test Scoring Rubric

Indicator	Description	Score
Abstraction	The student can identify essential information given and asked in the problem and can accurately represent mathematical concepts using symbols or mathematical language.	3
	The student can correctly identify essential information given and asked in the problem but only partially represents the mathematical concepts with symbols or mathematical language. Or, the student can correctly represent the mathematical concepts with symbols or language but only partially identifies essential information.	2
	The student has some difficulty identifying essential information and representing mathematical concepts using symbols or mathematical language for the given problem.	1
	The student cannot identify essential information or represent mathematical concepts using symbols or mathematical language for the given problem.	0
Algorithm	The student can organize the steps for solving the problem logically and accurately.	3
	The student can organize most of the problem-solving steps logically and accurately.	2
	The student has some difficulty organizing the steps for solving the problem.	1
	The student cannot organize the problem-solving steps logically or accurately.	0
Pattern Recognition	The student can recognize patterns and solve the problem accurately.	3
	The student can recognize patterns and accurately solve part of the problem.	2
	The student has some difficulty recognizing patterns and solving the problem.	1

Indicator	Description	Score
	The student cannot recognize patterns or solve the problem.	0
Decomposition	The student can understand the problem by breaking it down into simpler, more manageable parts that can be solved accurately.	3
	The student can break down most of the problem into simpler parts that can be solved accurately.	2
	The student has some difficulty breaking down the problem into simpler parts for solution.	1
	The student cannot break down the problem into simpler, solvable parts.	0

The researcher's analysis involved data collection, data selection, data presentation, and drawing conclusions (Miles & Huberman, 1992). Based on the analysis using the scoring rubric, the researcher assessed each student's computational thinking skills for each indicator, including abstraction, algorithms, pattern recognition, and decomposition. Data presentation in this study is in descriptive analysis form.

To gain deeper insights into computational thinking skills, the researcher conducted interviews to explore the computational thinking processes related to the computational thinking indicators. Finally, based on the analysis of responses and interviews with selected subjects, the researcher drew conclusions regarding students' computational thinking abilities.

RESULTS AND DISCUSSION

This section discusses the results of each student's work based on their computational thinking abilities. Here, visual learners will be denoted as V1 and V2, auditory learners as A1 and A2, and kinesthetic learners as K1 and K2. The discussion presented in this section focuses on questions 1 and 2.

Abstraction

Based on the analysis of the test responses, all subjects with visual, auditory, and kinesthetic learning styles were able to accurately identify the essential information given and asked in the questions. Additionally, all six students correctly represented the mathematical concepts in symbolic or mathematical language for the given problem. This is evident from an example of V1's work and the interview conducted while solving question 1, shown in Figure 1.

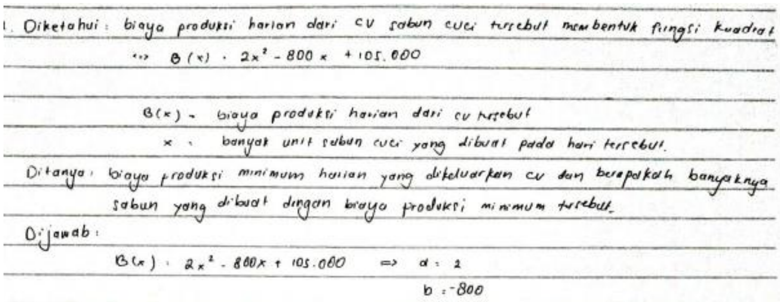
1. Diketahui : biaya produksi harian dari CV sabun cuci tersebut membentuk fungsi kuadrat
<=> B(x) = 2x² - 800x + 105.000
B(x) = biaya produksi harian dari CV tersebut
x = banyak unit sabun cuci yang dibuat pada hari tersebut.
Ditanya : biaya produksi minimum harian yang dikeluarkan CV dan berapakah banyaknya sabun yang dibuat dengan biaya produksi minimum tersebut.
Dijawab :
B(x) = 2x² - 800x + 105.000 => a = 2
b = -800

Figure 1. Answer to Question 1 by V1 for the Abstraction Indicator

Interviewer : "Could you explain again what is given and what is asked in the question?"

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V1 : "The given information is the production cost of soap represented as a quadratic function B(x), where B(x) is the daily production cost of the CV (company), and x is the number of soap units produced by the CV. The question asks for the minimum daily production cost and the number of soap units produced that day."

Interviewer : "Based on the quadratic function equation in the question, can you determine the values of a, b, and c?"

V1 : "The value of a is 2, b is -800, and c is 105,000."

V1 accurately identified and wrote down the essential information given and asked in the question. To explore V1's abstraction ability further, an interview was conducted, revealing that V1 could accurately determine the values of a, b, and c in the quadratic function equation. This shows that the subject could represent the mathematical concepts in symbolic form, including the values of a, b, and c accurately. Thus, it can be concluded that the visual, auditory, and kinesthetic subjects demonstrated computational thinking skills in the abstraction indicator.

Algorithm

For the algorithm indicator, students with kinesthetic learning styles were able to organize the steps to solve the given problem systematically and accurately. This is shown in K1's answers and interview regarding their solution for question 2 in Figure 2.

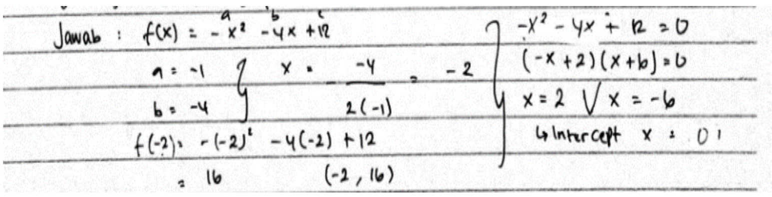

Figure 2. Answer to Question 2 by K1 for the Algorithm Indicator

From the interview, it is evident that K1 could organize the solution steps accurately and effectively, enabling them to draw the quadratic function graph correctly. Therefore, K1 demonstrated strong algorithmic ability.

Interviewer : "Can you explain the sequence of steps you took to create the graph?"

K1 : "Using the formula $x = \frac{-b}{2a}$ to find the y-coordinate of the vertex, then using $f(x) = 0$ for the y-intercept, and factoring $0 = -x^2 - 4x + 12$ to find the x-intercepts."

There was a slight difference in the algorithm indicator for auditory and visual students, who could only organize some of the solution steps for question 2. This is shown in A2's answers and interview conducted to explore their algorithm skills for question 2 in Figure 3.

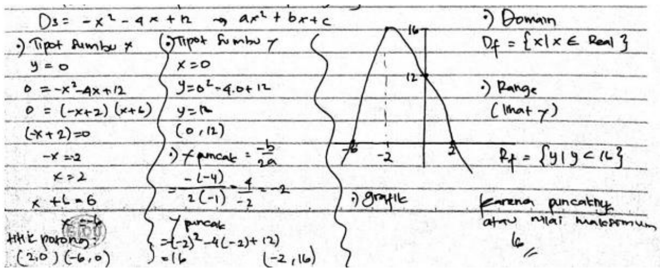

Figure 3. Answer to Question 2 by A2 for the Algorithm Indicator

Interviewer : "Can you explain the sequence of steps you took to create the graph?"

A2 : "Starting from the x-intercepts where $y = 0$ by factoring, then the y-intercept where $x = 0$, then the vertex using $x = \frac{-b}{2a}$, the y-coordinate of the vertex by substituting x back into the quadratic function, and finding the domain and range."

Through this interview, it became clear that A2 could not organize the solution steps effectively, as there were some unnecessary steps in their sequence. Although the graph was correct, the presented steps were not efficient, indicating A2's algorithm skills were lacking. In conclusion, the kinesthetic learner demonstrated computational thinking skills in the algorithm indicator, while the visual and auditory learners did not fully display effective computational thinking skills in this area.

Pattern Recognition

Based on the analysis of test answers, kinesthetic learners were able to recognize patterns and accurately solve the problem. This is illustrated by K2's answer to question 2, as shown in Figure 4.

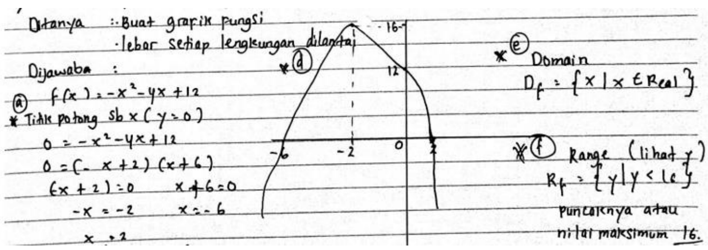

Figure 4. Answer to Question 2 by K1 for the Pattern Recognition Indicator

In Figure 4, K1 accurately and clearly drew the quadratic function graph. K1 identified key points, including the vertex at $(-2, 16)$,, x-intercepts at $(-6, 0)$ and $(2, 0)$, and the y-intercept at $(0, 12)$. The student calculated the vertex using the formula $x = \frac{-b}{2a}$ and then substituted this value to find the y-coordinate. K1 found the x-intercepts by setting $y = 0$ and factoring the quadratic equation, and determined the y-intercept by substituting $x = 0$ into the function. Additionally, K1 correctly calculated the width of the curve by taking the absolute difference between the x-intercepts, -6 and 2, as confirmed in the interview:

Interviewer	: "How did you determine the width of the curve?"
K1	: "By taking the absolute value of 2−(−6)2 - (-6)2−(−6) from the x-intercepts."

On the other hand, analysis showed that visual and auditory learners recognized patterns but were only able to solve part of the problem accurately. This is seen in V2's response to question 2, shown in Figure 5.

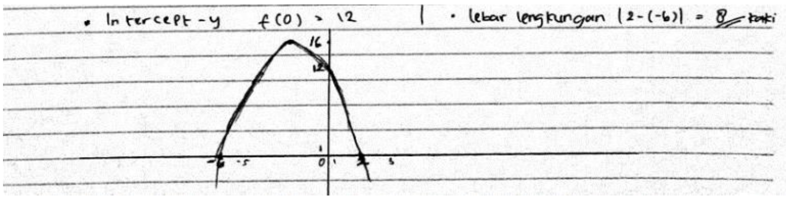

Figure 5. Answer to Question 2 by V2 for the Pattern Recognition Indicator

In Figure 5, V2 also accurately drew the quadratic function graph, identifying the vertex (-2,16), x-intercepts (-6,0) and (2,0), and y-intercept (0,12). However, V2 was unable to correctly determine the width of the curve as asked in the question. During the interview, V2 explained their approach:

Interviewer	: "How did you find the width of the curve on the floor?"
V2	: "Using the range, which is 16."

This interview revealed a misconception; V2 identified the curve's width as the range, which they calculated as 16. However, this range represents the height of the curve, not the width as required in the question. This indicates that V2 was unable to solve for the width of the quadratic graph accurately. In conclusion, kinesthetic learners demonstrated computational thinking skills in the pattern recognition indicator, while visual and auditory learners did not fully exhibit effective computational thinking in this area.

Decomposition

Based on the analysis of computational thinking test answers, all subjects with visual, auditory, and kinesthetic learning styles were able to break down complex problems into simpler, manageable parts for effective resolution across all three questions. This is illustrated by K2's response to question 2, shown in Figure 6.

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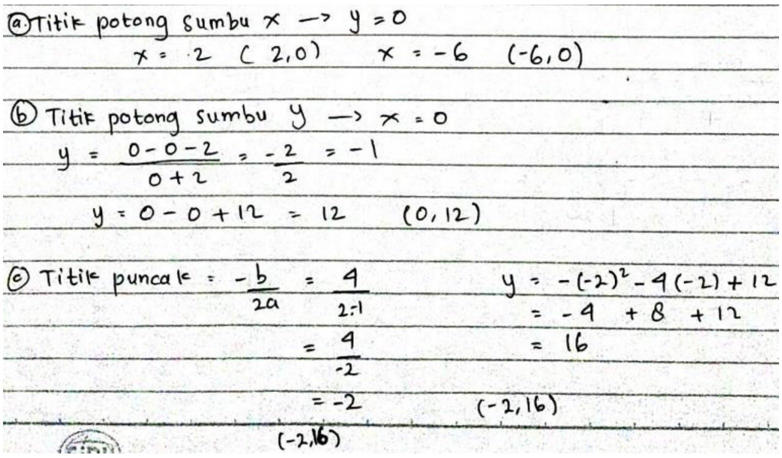

Figure 6. Answer to Question 2 by K2 for the Decomposition Indicator

In Figure 6, K2 created a graph of the quadratic function by first finding the x-intercepts where $y = 0$, the y-intercept where $x = 0$, and then calculating the vertex. This approach allowed K2 to simplify the complex problem, making it easier to understand and solve by breaking down the larger problem into solvable components. This is further supported by the interview:

Interviewer	: "In drawing this graph, what do you need to find?"
K2	: "To create the graph, I need to find the x-intercepts where $\mathrm{y} = 0$, then the y-intercept where $\mathrm{x} = 0$, and finally the vertex using the formula $\frac{-b}{2a}$."

Thus, it can be concluded that the visual, auditory, and kinesthetic subjects demonstrated computational thinking abilities on the decomposition indicator. Table 4 summarizes the similarities and differences in computational thinking abilities across each learning style for each indicator.

Table 4. Summary of Similarities and Differences in Computational Thinking Indicators

Indicator	Visual	Auditory	Kinesthetic
Abstraction	Able to determine key information in the problem and accurately represent mathematical concepts using symbols or math language.	Able to determine key information in the problem and accurately represent mathematical concepts using symbols or math language.	Able to determine key information in the problem and accurately represent mathematical concepts using symbols or math language.
Algorithm	Less able to structure problem-solving steps sequentially and accurately.	Less able to structure problem-solving steps sequentially and accurately.	Able to structure problem-solving steps sequentially and accurately.
Pattern Recognition	Less able to recognize patterns and solve problems accurately.	Less able to recognize patterns and solve problems accurately.	Able to recognize patterns and solve problems accurately.

Indicator	Visual	Auditory	Kinesthetic
Decomposition	Able to break down complex problems into simpler parts that can be accurately solved.	Able to break down complex problems into simpler parts that can be accurately solved.	Able to break down complex problems into simpler parts that can be accurately solved.

A comparison of computational thinking abilities based on specific indicators among students with visual, auditory, and kinesthetic learning styles is presented in Table 4. The table shows that all students could accurately identify key information known and asked within the given problems. This indicates that all subjects have strong abstraction skills in problem-solving. Research by Arifah et al. (2022) similarly found that students with visual, auditory, and kinesthetic learning styles excel in identifying known information and understanding the questions that need to be solved. Analysis in this study also found no significant differences across learning styles in abstracting information from the given problems. Maharani et al. (2021) also noted that pre-service math teachers effectively discern key information needed for problem-solving.

On the algorithm indicator, students with kinesthetic learning styles could organize problem-solving steps in a sequential and accurate manner, producing correct answers. This aligns with Domu (2023), who found that kinesthetic learners tend to organize solution steps well, as they grasp the problem effectively. Understanding an algorithm in a math problem means that students can grasp the concept and apply the appropriate mathematical methods to solve it (Kusuma & Masduki, 2016). On the other hand, visual and auditory learners were less adept at structuring solution steps precisely. The test results and interview responses show that these students included unnecessary steps, resulting in less efficient solutions. A good algorithmic ability involves structuring and solving problems with efficiency, precision, and accuracy (Novalina Samosir et al., 2019). Thus, the visual and auditory learners in this study struggled to structure problem-solving steps effectively.

For the pattern recognition indicator, students with kinesthetic learning styles could recognize patterns and solve problems accurately. They could draw graphs correctly based on given points and recognize patterns to solve for the graph's width in the problem. Strong pattern recognition skills are an effective strategy for solving mathematical problems (Masduki et al., 2019). This finding supports Indraswari et al. (2018), who noted that kinesthetic learners are capable of identifying rules or patterns within problems and using them accurately. In contrast, visual and auditory learners experienced misconceptions in pattern recognition, leading to inaccurate solutions.

Finally, on the decomposition indicator, students of all three learning styles—visual, auditory, and kinesthetic—could break down complex problems into simpler, manageable parts. The analysis revealed no significant differences in decomposition skills across learning styles. Therefore, it can be inferred that students with visual, auditory, and kinesthetic learning styles exhibited strong decomposition skills. Good decomposition skills, as found by Tyminski et al. (2014), can support pre-service teachers' development in areas such as planning and instruction.

In conclusion, kinesthetic students met all computational thinking indicators, while auditory and visual students struggled with the algorithm and pattern recognition indicators. This study thus shows that computational thinking abilities vary across visual, auditory, and kinesthetic learning styles, particularly in the algorithm and pattern recognition indicators when solving equations and quadratic functions. This study also demonstrates that computational thinking is effective for math problem-solving, suggesting its applicability beyond information technology (Maharani et al., 2019).

Learning style differences can influence the development of computational thinking indicators in students. Consistent with Rahmah & Masduki (2023), the way individuals absorb information can create differences in mathematical problem-solving approaches due to variations in thinking styles. Kinesthetic learners were able to fulfill all four computational thinking indicators, while visual and auditory learners demonstrated strengths only in abstraction and decomposition. These differences in problem-solving strategies align with Rosida (2023), who noted that learning styles impact problem-solving strategies in math. However, the differences among learning styles were not highly significant, as this study focused on students with high computational thinking scores. The findings reveal that kinesthetic learners performed best. Differences from prior research, such as that by Veronica et al. (2022), may be attributed to the subject matter, as this study focused on equations and quadratic functions using a geometric approach. With geometry-related content like parabolic graphs, kinesthetic learners performed particularly well (Zales & Vasquez, 2022).

CONCLUSION AND SUGGESTIONS

Based on the findings of this study, data analysis reveals that different learning styles can lead to variations in computational thinking abilities among prospective mathematics teachers when solving mathematical problems. Students with a kinesthetic learning style demonstrate strong computational thinking skills, particularly in the indicators of abstraction, algorithms, pattern recognition, and decomposition. On the other hand, students with visual and auditory learning styles show less capability in meeting the algorithm and pattern recognition indicators of computational thinking. Nevertheless, students with visual and auditory learning styles perform well in abstraction and decomposition, similar to kinesthetic learners. Additionally, this study reveals that using a geometric approach to address topics in equations and quadratic functions, kinesthetic learners display the best problem-solving abilities compared to visual and auditory learners. Through this research, the researcher hopes to demonstrate, based on the analysis, that individual learning style differences—particularly the visual, auditory, and kinesthetic styles in this study—can create cognitive skill differences among students in solving mathematical problems across various indicators of computational thinking ability. Future research could explore computational thinking skills in other subjects, such as calculus, statistics, and geometry.

REFERENCES

Aho, A. V. (2012). Computation and computational thinking. *Computer Journal*, *55*(7), 833–835. https://doi.org/10.1093/comjnl/bxs074

Aminah, N., Leonardus, Y. S., Wardono, & Cahyono, A. N. (2022). Computational thinking process of prospective mathematics teacher in solving diophantine linear equation problems. *European Journal of Educational Research*, *11*(3), 1495–1507. https://eric.ed.gov/?id=EJ1353043

Arifah, U., Suyitno, H., & Dewi, N. R. (2022). Mathematics critical thinking skills based on learning styles and genders on brain-based learning assisted by mind-mapping. *Unnes Journal of Mathematics Education Research*, *11*(1), 27–34.

Asht, S., & Dass, R. (2012). Pattern recognition techniques: a review. *International Journal of Computer Science and Telecommunications*, *3*(8), 25-29. https://www.ijcst.org/Volume3/Issue8.html

Bhagat, K. K., & Dasgupta, C. (2021). *Computational Thinking for Teachers*. Canada: Commonwealth of Learning (COL)

Csizmadia, A., Curzon, P., Dorling, M., Humphreys, S., Ng, T., Selby, C., & Woollard, J. (2015). *Computational thinking: a guide for teachers*. UK: Computing At School (CAS)

Domu, I. (2023). Student learning styles in solving math story problems on the material of two-variable linear equation systems. *Journal on Education*, *6*(1), 2072–2082. https://doi.org/10.31004/joe.v6i1.3200

Dunn, R. (1983). Learning style and its selation to exceptionality at both ends of the spectrum. *SageJournals*, 49(6). https://doi.org/10.1177/001440298304900602

Indraswari, N. F., Budayasa, I. K., & Ekawati, R. (2018). Algebraic reasoning in solving mathematical problem based on learning style. *Journal of Physics: Conference Series*, 947. https://doi.org/10.1088/1742-6596/947/1/012061

Juškevičienė, A., & Dagienė, V. (2018). Computational thinking relationship with digital competence. *Informatics In Education*, *17*(2), 265–284. https://doi.org/10.15388/infedu.2018.14

Kusuma, H., & Masduki. (2016). How students solve the logarithm? conceptual and procedural understanding. *Journal of Research and Advances in Mathematics Education*, *1*(1), 56–68.

Lye, S. Y., Hwee, J., & Koh, L. (2014). Review on teaching and learning of computational thinking through programming: what is next for K-12? *Computers in Human Behavior*, *41*, 51–61. https://doi.org/10.1016/j.chb.2014.09.012

Maharani, S., Agustina, Z. F., & Kholid, M. N. (2021). Exploring the prospective mathematics teachers computational thinking in solving pattern geometry problem. *Al-Ishlah: Jurnal Pendidikan*, *9490*(3), 1757–1767. https://doi.org/10.35445/alishlah.v13i3.1181

Maharani, S., Kholid, M. N., NicoPradana, L., & Nusantara, T. (2019). Problem solving in the context of computational thinking. *Infinty: Journal of Mathematics Education*, *8*(2), 109–116. https://doi.org/10.22460/infinity.v8i2.p109-116

Masduki, M., Suwarsono, S., & Budiarto, M. T. (2019). Teacher’s strategies to promote student’s mathematical competencies in algebra: a case study. *Journal of Physics: Conference Series*, *1265*(2019), 1–10. https://doi.org/10.1088/1742-6596/1265/1/012016

Miles, M. B., & Huberman, A. M. (1992). *Analisis data kualitatif: buku sumber tentang metode-metode baru*. Jakarta: UI Press.

Novalina Samosir, R., Siagian, P., & Banjarnahor, H. (2019). Differences in the ability to understand mathematical concepts of students taught by using guided discovery learning and contextual teaching and learning models assisted by autograph software viewed from student learning styles. *American Journal of Educational Research*, *7*(11), 830–836. https://doi.org/10.12691/education-7-11-12

Özer, M., & Kuloğlu, A. (2023). The relationship between primary school teachers ’ perceptions of 21st century skills and digital literacy level. *Malaysian Online Journal of Educational Technology*, *11*(3), 173–183. https://doi.org/10.52380/mojet.2023.11.3.429

Palobo, M., Pagiling, S. L., & Nur’aini, K. D. (2020). Analysis of effect of learning style on mathematics learning outcomes. *Advances in Social Science, Education and Humanities Research*, *473*, 484–488.

Permana, R. I., Amry, Z., & Mulyono. (2013). Pengaruh gaya belajar visual, auditori, kinestetik Terhadap kemampuan pemecahan masalah matematis berbantuan e-learning di smp negeri 1 binjai. *Paradikma Jurnal Pendidikan Matematika*, *12*(1), 1–9. DOI: 10.24114/paradikma.v11i2.22893

Rahmah, N. H., & Masduki, M. (2023). Pre-service mathematics teachers’ algebraic thinking in solving mathematics problems based on adversity quotient. *Prima: Jurnal Pendidikan Matematika*, *7*(2), 172. https://doi.org/10.31000/prima.v7i2.8714

Rich, P., Rich, P. J., Egan, G., & Ellsworth, J. (2019). A framework for decomposition in computational thinking. *In Innovation and Technology in Computer Science Education*. https://doi.org/10.1145/3304221.3319793

Rosida, A. (2023). Exploring student algebraic thinking in solving math problems in terms of kolb ' s learning style. *Jurnal Pendidikan Matematika (JUPITEK)*, *6*(1), 62–72. https://doi.org/10.30598/jupitekvol6iss1pp62-72

Sreenidhi, S. K., & Helena, T. C. (2017). Styles of learning based on the research of fernald, keller, orton, gillingham, stillman, montessori and neil d fleming. *International Journal For Innovative Research In Multidisciplinary Field*, *3*(4), 17–25.

Tyminski, A. M., Zambak, V. S., Drake, C., & Land, T. J. (2014). Using representations , decomposition , and approximations of practices to support prospective elementary mathematics teachers ' practice of organizing discussions. *J Math Teacher Education*, 463–487. https://doi.org/10.1007/s10857-013-9261-4

Veronica, A. R., Siswono, T. Y. E., & Wiryanto, W. (2022). Primary school students' computational thinking in solving mathematics problems based on learning style. *Eduma : Mathematics Education Learning and Teaching*, *11*(1), 84-96. https://doi.org/10.24235/eduma.v11i1.10378

Wing. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33–35. https://doi.org/10.1201/b16812-43

Zales, J. P., & Vasquez, R. S. (2022). Learning styles and achievement in geometry. *South Florida Journal of Development*, *3*(4), 5542–5548. https://doi.org/10.46932/sfjdv3n4-117

Zeybek, G. (2022). The relationship between pre-service teachers' computational thinking skill levels and online self-regulated learning levels. *Critical Questions in Education*, *13*(3), 264–288.