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Assessing Computational Thinking in Early Childhood: Evidence from Kindergarten Children Aged 5–6 Years in Surakarta, Indonesia

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Abstract
Teachers in kindergartens often lack knowledge on how to assess children's computational thinking abilities, as there is a lack of validated instruments to measure this ability in early childhood. This study aims to analyze children's levels of computational thinking abilities in Kindergarten Surakarta City and identify aspects of computational thinking that are still low, to inform appropriate pedagogical interventions that provide suitable stimulation. The research method employs descriptive quantitative methods, presenting frequency distributions, means, modes, medians, minimums, maximums, ranges, and standard deviations. Data collection techniques through computational thinking tests using instruments that have been validated through expert judgment and pilot testing. The sampling technique used was cluster random sampling, which involved selecting kindergartens in Surakarta City, resulting in 60 respondents aged 5-6 years. Based on the four aspects of computational thinking ability, the algorithm is the most mastered aspect (80%) because teachers often stimulate children through natural daily routines. Pattern recognition (64, 58%) is the ability to identify repetitive patterns, such as those found in color sequences or shapes. Decomposition (54,58%) is challenging because it trains children to break down large problems into smaller parts to make them easier to solve. Debugging (40,41%) is the lowest level because it involves metacognitive aspects in complex problem-solving. This research provides an overview for teachers to be able to implement innovative learning that can stimulate computational thinking. Teachers can actively integrate play-based learning that engages children and collaboration between classmates. In addition, integrating digital technology media can make the learning process more interesting. Given the small sample size in this study, future research should involve a larger group of participants to improve the generalization of results. Future research should use larger sample sizes and encourage collaboration between institutions in different regions so that it can provide further insight into effective learning strategies in stimulating children's computational thinking.

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Introduction
Digitalization has changed the way humans work, communicate, and solve problems. For every child to have an equal opportunity to face these challenges, the education system needs to ensure that computational thinking becomes part of the ability that needs to be integrated into the school curriculum from early childhood education (Kaya et al., 2025). The ability to think computationally is not just a trend but a necessity in the world of modern education. Without adequate computational thinking ability in the field of digital technology, children will face difficulties in competing in an increasingly technology-based world of work (Zourmpakis, 2025). Therefore, the integration of computational thinking in the school curriculum is not just an innovation but a fundamental need in building superior human resources that are adaptive to changing times. Computational thinking can build critical, creative, collaborative, and problem-solving skills that are essential in the 21st century.

The urgency of integrating computational thinking ability in education is increasing along with the development of Industry 4.0 and 5.0, which demands superior human resources with strong digital understanding and ability (Zhang et al., 2025). Strengthening computational thinking ability at various levels of education is needed to prepare human resources who can adapt to technological developments (Yang et al., 2025). The government, schools, industry, and society need to work together in creating an educational ecosystem that is conducive to the development of science so that children are not only users of technology, but can also play the role of innovators who create solutions to challenges in the surrounding environment and producers who can compete at the global level. Computational thinking can equip every child with the ability to contribute to an increasingly digitized world.

Computational thinking, according to Wing, is an attitude and skill that can be applied universally and can be learned and used by everyone who wants to learn and use it (Wing, 2008). Computational thinking is done through decomposition, which is breaking down large problems into small parts that are easier to manage and solve, recognition of patterns or similarities in data or problems so that they can be used to find similar solutions in other situations, abstraction by filtering relevant and important information, and algorithmic thinking by devising logical steps to solve problems (Wing, 2011). Computational thinking is a thinking process that is used to produce solutions with computational steps that can improve analytical skills. The solution can be followed by computational action, such as the use of technology. Computational thinking teaches children to solve problems systematically.

Learning by applying the basic concept of computational thinking aims to develop children's abilities according to their developmental stages. References such as the UNESCO ICT Competency Framework for Teachers (2018) and CSTA K-12 Computer Science Standards (2017) are the basis for learning learning to stimulate computational thinking ability can use various methods, such as problem-based learning, project-based learning, inquiry learning, gamification, and internet-based learning or digital devices development (CSTA, 2017). The learning media used include digital devices such as computers or laptops, digital platforms, interactive modules, and non-digital tools such as cards and boards (Brennan & Resnick, 2012). From the pedagogical side, learning by applying the concept of computational thinking is important as an effort to encourage children to understand, explore, and solve problems through logical, critical, and analytical thinking.

The concept of computational thinking has been applied in various developed countries, with learning being a key aspect. Look at the success of countries such as Singapore, India, China, Australia, and South Korea in integrating learning by applying basic concepts of computational thinking into their education systems (Singhal, 2022; Zeng et al., 2023; An & Shin, 2024). In its implementation, these various countries seek to ensure that support is provided to schools so that they are ready to implement it, for example, by improving teacher competence, supporting facilities and infrastructure, and enhancing children's readiness for learning. Indonesia needs to take strategic steps so as not to be left behind. This effort can be started by providing intensive training for educators; the project-based learning approach that has been applied in various countries can be adopted to develop learning with the concept of computational thinking.

Computational thinking ability not only opens up great opportunities for children to prepare essential abilities in the 21st century but also presents challenges related to the availability of resources, an appropriate curriculum, and teachers' readiness to teach computational thinking concepts effectively (Masarwa et al., 2024). Most existing learning curricula provide only basic concepts of computational thinking. The existing curriculum is mostly adapted from Western contexts and has not provided a valid instrument for assessing computational thinking ability that aligns with the cultural characteristics and developmental needs of children in Indonesia. In addition, the challenge facing teachers today is the lack of valid assessment instruments to assess children's computational thinking ability. Findings in the field show that several schools in Surakarta City have also implemented learning basic concepts of computational thinking, but teachers have not been able to assess children's computational thinking ability due to the lack of valid assessment instruments and the absence of contextually valid assessment tools for early childhood in Indonesia. Based on the findings in the field, this study is one of the efforts to validate the instrument for assessing computational thinking ability for early childhood in Indonesia. This study prepares an assessment instrument according to local contextualization by adapting the concept of global computational thinking ability into the early childhood education system in Indonesia. Based on these problems, the purpose of this study is to develop an assessment instrument that has construct validity and reliability according to the academic requirements of early childhood education to assess the level of computational thinking ability, especially for children aged 5-6 years, so that it can provide complete and accurate information for teachers in kindergarten to assess children's computational thinking ability.

Several studies related to computational thinking ability have been conducted in Indonesia. Research on systematic review research on computational thinking in early childhood (Kumala et al., 2023), coding games to stimulate computational thinking ability in early childhood (Hardiyanti et al., 2025), and research on the influence of early childhood education teachers' understanding on early childhood coding learning (Setianingrum & Hidayana, 2025). Some previous research has focused on instructional interventions, activity stimulation, and teachers' understanding of the implementation of learning activities to stimulate children's computational thinking skills. However, the problem of measuring valid standards according to the characteristics of early childhood development has not been solved methodologically. Some of these studies explore the basic concepts of computational thinking learning in general; there has been no research on standardized measurement tools that provide valid assessment instruments to measure early childhood computational thinking ability in Indonesia. This research was conducted to make a theoretical and practical contribution in the form of the development of computational thinking ability assessment instruments in children aged 5-6 years. Theoretically, this research is useful as a contribution to developing existing assessment methodologies to produce new concepts in the field of early childhood education in Indonesia. Practically, the results of this study are useful for teachers in kindergartens to measure the computational thinking ability of children aged 5-6 years, and the results can be useful as a basis for evaluating educational services.

Methods

Research Design

This study uses a descriptive quantitative approach. Quantitative descriptive is a research approach that uses numerical data to describe, summarize, or analyze the characteristics of a phenomenon systematically and accurately, as it is, without manipulating variables or testing the hypothesis of cause-and-effect relationships (Creswell & Creswell, 2018). The design of the descriptive quantitative approach method analyzes the data that has been collected using descriptive statistical techniques to summarize and understand the data. This study aims to descriptively analyze the data from the assessment of computational thinking ability of children aged 5-6 years through a performance test that measures four aspects, namely algorithms, debugging, decomposition, and pattern recognition.

In the process of developing instruments, the main steps focus on the process of making instruments, starting from literature studies to concept identification (determining the constructs to be measured), arranging items (making grids and formulating statements based on literature). Instrument validation focuses on expert logical validity tests (material or constructs) to check the suitability of items and empirical validity (field tests) to calculate score correlations and reliability tests. Data analysis uses a quantitative approach of statistical techniques to prove the feasibility of the instrument. The researcher ensures that the developed instrument meets strict validity and reliability criteria before being used for the collection of key research data.

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Instrument Development and Validation

This study aims to provide an assessment instrument to measure the computational thinking ability of children aged 5-6 years through a performance test that measures four aspects, namely algorithms, debugging, decomposition, and pattern recognition. The research instrument for the assessment of computational thinking ability of children aged 5-6 years is declared feasible to use if it has gone through the validity stage. Before use, the instrument is tested for validity first. The validity test of this instrument was validated by experts, and the results were analyzed using the Aiken item validity index formula. The researcher set a p-value of 0.05, allowing a 5% chance of error. Aiken's V formula is as follows:

$$V = S / [n(c-1)]$$

Explanation:
V: Rater agreement index
S: The score assigned by each rater minus the lowest score
n: Number of raters
c: Multiple categories

The validity test of this instrument has been validated by experts and analyzed using the Aiken validity index. The observation instrument for assessing children's computational thinking was validated by five experts. The experts include two experts from early childhood academics and three experts from kindergarten practitioners.

Based on Table 2 Aiken's V validity coefficients by involving five validators with a rating scale of 1-5 on each item, the rater agreement index is 0.80. Instrument items with a value greater than 0.80 are declared valid. The results of Aiken's V calculation range from 0 to 1, with a minimum threshold of 0.80 indicating high validity.

Table 2. Instrument Validity Coefficient

No of Raters (n)	Number of Rating Categories (c) 5	
	v	p
5	.80	.040

Source: (Aiken, 1985)

Table 3. Aiken's Index V Analysis Results from Five Raters

No	Dimension	Rater					n(c-1)	V	Conclusion
		I	II	III	IV	V			
1.	Algortihms	5	5	5	5	5	20	1	Valid
2.	Debugging	5	5	5	5	4	20	0.95	Valid
3.	Decomposition	5	5	5	4	4	20	0.90	Valid
4.	Pattern Recognition	5	5	4	4	4	20	0.85	Valid
Total		20	20	19	18	17	80	0.925	Valid

The instrument is declared valid because the average item of the instrument has met the value of Aiken's V index greater than 0.80, which is indicated by an average of 0.925. After the instrument is declared valid (0.925 > 0.80) based on calculations using Aiken's index formula V, the instrument will be tested empirically before being used to collect research data. Empirical testing of the instrument was carried out with 30 subjects outside the main sample with characteristics of children aged 5-6 years (group B). A grid of research instruments to measure the computational thinking ability of children aged 5-6 years can be seen in Table 4.

Table 4. Assessment Instrument of Computational Thinking Ability

Dimension	Indicator	Performance Test	Number of Items
Algorithms	Ability to follow a series of sequential steps to solve problems	Compile an algorithm sequence using the direction of the arrows as a guide from start to finish	1
Debugging	Ability to solve problems by finding a solution	Compile 20 jigsaw puzzle pieces into a whole picture	1

Dimension	Indicator	Performance Test	Number of Items
Decomposition	Ability to divide complex tasks into simpler ones	Dividing the composition geometric shapes matches the picture	1
Pattern recognition	The ability to repeat patterns in doing the same task	Repeat the pattern according to the color pattern and arrow direction instructions	1
Total of items			4

After conducting empirical tests on 30 samples outside the research sample, the next stage is to test the validity and reliability of the instrument. The validity test was conducted using the Pearson Correlation moment product with the help of IBM SPSS Statistics version 27. The results of the instrument validity test can be seen in Table 5.

Table 5. Pearson Correlation Product-Moment Validity Test

No	Dimension	r calculated	r table (α = 0.05 ; n = 30)	Conclusion
1.	Algorithms	0.927	0.361	Valid
2.	Debugging	0.927	0.361	Valid
3.	Decomposition	0,866	0.361	Valid
4.	Pattern recognition	0.833	0.361	Valid

The basis for making a decision is a validity test. If the value of r is calculated > r of the table, then the item is declared valid. Based on the validity test of product-moment correlation with the help of IBM SPSS Statistics version 27, all four items were declared valid (r > 0,361 at α = 0.05, n = 30). After all items are declared valid, the next stage is to conduct a reliability test. The reliability test in this research instrument used Cronbach's Alpha with the help of IBM SPSS Statistics version 27. The results of the instrument reliability test are in Table 6.

Table 6. Cronbach's Alpha Reliability Test

No	Dimension	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Cronbach's Alpha Deleted
1.	Algorithms	6.57	5.495	.868	.857
2.	Debugging	6.50	5.362	.865	.857
3.	Decomposition	6.27	5.582	.756	.896
4.	Pattern Recognition	6.57	5.702	.698	.917
Total (Average)					0.909

The basis for deciding on the reliability test is that if Cronbach's Alpha value > 0.70, then the item is declared reliable (George & Mallery, 2019). Table 6 provides an overview of the statistical values for each item. In the Cronbach's Alpha column, if the item deleted is known, the Cronbach's Alpha value for the four items (algorithms, debugging, decomposition, pattern recognition) is > 0.70, so it can be concluded that all items are reliable. The reliability value (α = 0.909) indicates excellent internal consistency. This decision refers to the α ≥ 0.9 = Excellent reliability (George & Mallery, 2019). It can be concluded that all four items are reliable. The instrument is declared reliable as a data collection tool in research. After the instrument is declared valid and reliable, it is ready to be used to collect research data.

Participants

The sampling technique in this study uses cluster random sampling. The cluster random sampling technique is used to determine a sample when the object to be studied or the data source is very broad (Creswell & Creswell, 2018). Cluster sampling is taken by group, for example, region or institution. Cluster sampling is efficient if the population is geographically large or difficult to reach individually. Sampling units are groups (not individuals) (Creswell & Guetterman, 2019). The population is divided into clusters, then several clusters are randomly selected, and all cluster members are sampled. The population of Surakarta City has five sub-districts; two sub-districts are randomly selected, then one kindergarten institution is randomly selected in each selected sub-district, and then all children in the school are researched. The selected research sample was children aged 5-6 years (group B). This study has obtained consent obtained from parents to protect the confidentiality of children's data and guarantee that participation is voluntary and does not pose a danger to the study subject participants.

Table 7. Participants of the Research Subject

School Name	District	Number of Children
Aisyiyah XI Kindergarten	Jebres	30
Islam Terpadu Nur Hidayah Kindergarten	Laweyan	30
Total		60

The selection of a sample limited to two kindergartens with 60 respondents was a contextual and exploratory research approach. The focus of the research is not on generalizing the results to the entire population, but rather on an in-depth understanding of specific phenomena in a specific environment. As an exploratory study, this study aims to identify new themes and provide an in-depth picture that can be used as a foundation for large-scale quantitative research in the future. The small sample size allows researchers to obtain more detailed and accurate data related to the computational thinking skills of children aged 5-6 years in the city of Surakarta.

Data Collection Procedures

The data collection uses the form of a performance test. Performance testing is the process of collecting data by means of systematic observation to make decisions about individuals. A performance test refers to a standard that is to be achieved, or that is set as the minimum limit that a child must meet. Therefore, the standards to be achieved must be set first (Creswell & Creswell, 2018). Triana et al. (2020) A stated performance test is a method of assessment by observing and assessing children's activities that show certain performance. This study uses a performance test to measure aspects of the computational thinking ability of children aged 5-6 years.

Data Analysis

The data analysis in this study uses descriptive statistics. Descriptive statistics are used to analyze data by describing the data that has been collected as it is. Descriptive statistics include the presentation of data through tables, graphs, pie charts, mode calculations, medians, means, and data distribution through averages and standard deviations (Creswell & Guetterman, 2019). The results of the descriptive data analysis presented in this study are frequency distribution, mean, mode, median, minimum, maximum, and standard deviation. The descriptive statistical analysis technique of this study was used to describe the results of the assessment of computational thinking ability of children aged 5-6 years, which were divided into three categories, namely high, medium, and low, based on the classification of the average score range.

Result

Data on the computational thinking ability of children aged 5-6 years was obtained by assessing performance tests. The assessment of computational thinking ability of children aged 5-6 years consisted of four indicator items with a total of 60 respondents. The frequency data on the computational thinking ability in Table 7.

Table 8. Data Frequency Distribution

Skor	Frequency	Percent (%)
44	4	6.7%
50	15	25.0%
56	16	26.7%
63	9	15.0%
69	7	11.7%
75	4	6.7%
81	2	3.3%

Skor	Frequency	Percent (%)
88	3	5.0%
Total	60	100.0

Based on the data in Table 8, the results of computational thinking ability for children aged 5-6 years are between 44 and 88, with a maximum ideal score of 100. The most frequent score obtained by children was a score of 56, which amounted to 16 children or 26.7%. Score 50, there were 15 children or 25%. Score 63, there were 9 children, or 15%. Score 69, there were 7 children or 11.7%. Score 75, there are 4 children or 6.7%. The score of 81 was 2 children or 3.3%. The lowest score of 44 was achieved by 4 children or 6.7%, while the highest score achieved by children was 88, amounting to 3 children or 5%. Based on the score obtained by the child, no child obtained a perfect maximum score of 100, the highest score that a child was able to achieve was 88. In addition to analyzing frequency distribution data that shows the results of the achievement of computational thinking ability, data concentration measures in the form of mean, mode, median, minimum, maximum, range, and standard deviation will be presented, which are shown in Table 9.

Table 9. Data Central Tendency

N	60
Mean	59.97
Median	56.00
Mode	56
Std. Deviation	11.321
Range	44
Minimum	44
Maximum	88

Based on table 9, it can be seen that the mean value of computational thinking ability is 59.97. This figure shows that, in general, the level of children's ability is in the medium category. This average provides an overview of the extent to which children can apply a logical and systematic mindset in solving problems. In addition, the median value of this data is 56. This means that half of the total number of children have a score below 56, and the other half above. The mode or value that appears most often is 56. The standard deviation value is 11.321, this figure shows how far the spread of the value is from the average. The greater the standard deviation, the greater the variation in grades among children. It can be seen that children's computational thinking abilities are quite diverse. The grades obtained by children are not uniform and show significant differences between individuals. The range between the highest and lowest values is 44, with a minimum value of 44 and a maximum of 88. To clarify the interpretation of the data from the results, an assessment criterion is needed that classifies the results of the achievement of computational thinking ability of children aged 5-6 years, which are categorized into three, namely high (very well developed), medium (developing as expected), and low (starting to develop). The data is converted to a scale of 100 to make it easier to determine the development categories statistically. The criteria for assessing the computational thinking ability can be seen in Table 10.

Table 10. Assessment Category

Score Interval	Score Category	Development Category
72 – 100	High	Very well developed
50 – 71	Medium	Developing as expected
25 – 49	Low	Starting to develop

Based on the assessment categories in Table 9, it is used as a guideline to assess the results of the achievement of computational thinking ability of children aged 5-6 years. The categories of achievement results for the computational thinking ability assessment of children aged 5-6 years are presented in a bar diagram in Figure 1.

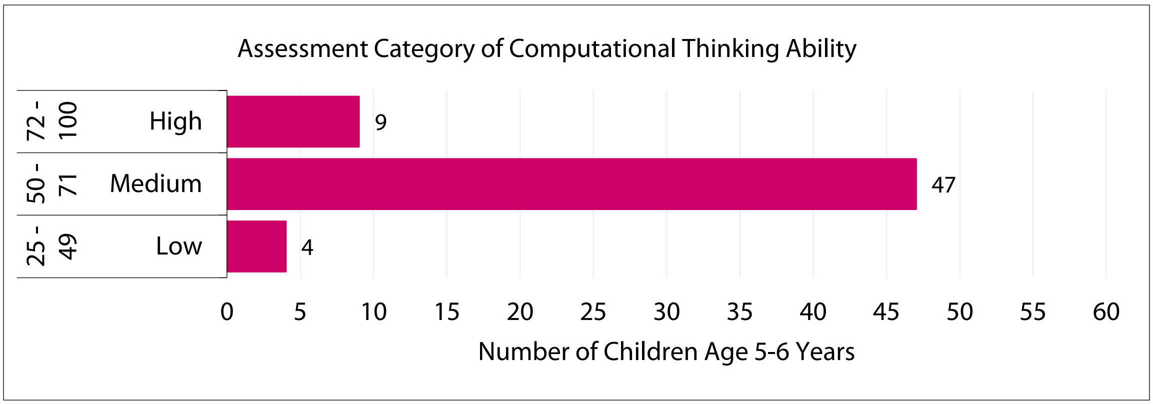

Figure 1. Diagram of assessment of computational thinking ability in children 5-6 years

Based on Figure 1, it shows that out of the total number of 60 children, the majority obtained a score of 50-71, which is included in the medium category, and there are as many as 47 children. Children who obtained the low category with a score of 25-49 were 4 children. As for the high category with a score interval of 72-100, 9 children were obtained. Data shows that the results of the achievement of computational thinking obtained by the majority of children are still in the medium category. This needs to be a concern for teachers in providing learning activities that can help stimulate the development of children's computational thinking ability.

Based on data obtained from 60 children, the high category includes children with a score range between 72 and 100. In the high category, 9 children have superior abilities to those in the medium and low categories. Based on the results of observation notes, children who belong to the high category group have distinctive characteristics of being able to show structured and logical thinking ability. Children in the high category can show behavior in accordance with indicator aspects such as algorithms, debugging, decomposition, and pattern recognition independently. Children are able to formulate solutions logically by taking solution steps, understanding complex problem-solving, and improving solutions effectively and efficiently. The child can understand that understand what is meant by a mistake, and then try to fix it. Children tend to be independent in thinking and are ready to be given more difficult challenges to continue to develop computational thinking.

Data on the achievement of computational thinking ability showed that the majority of children were in the medium category, developing as expected, with a score interval of 50-71, as many as 47 children. Based on the results of observation notes, children in the medium category show typical characteristics and begin to understand basic concepts of computational thinking, such as recognizing patterns and solving problems with guidance. Children have been able to understand patterns and solve simple problems. Children have begun to show the ability to think logically and in a structured way, although they are not yet completely consistent.

The low category includes children with scores of 25-49 who describe limitations in the ability to analyze problems logically and systematically. In the low category, starting to develop, there are 4 children who generally still have difficulty understanding patterns, solving problems step by step, and developing structured thinking strategies. Based on the results of observation notes, children need more intensive guidance to develop basic computational thinking ability, and need stimulation in the form of simpler learning to develop basic computational thinking.

After analyzing the results of the achievement of computational thinking ability, which are divided into high, medium, and low categories. This study also analyzed the percentages for each aspect, calculated based on the average score per indicator. The results of this calculation aim to find out which aspects have developed optimally and which aspects need to be further developed. This is important because teachers need to pay attention to the aspect of computational thinking ability in developing learning plans. The results of the research on the achievement of each aspect of computational thinking ability of children aged 5-6 years are shown in Figure 2.

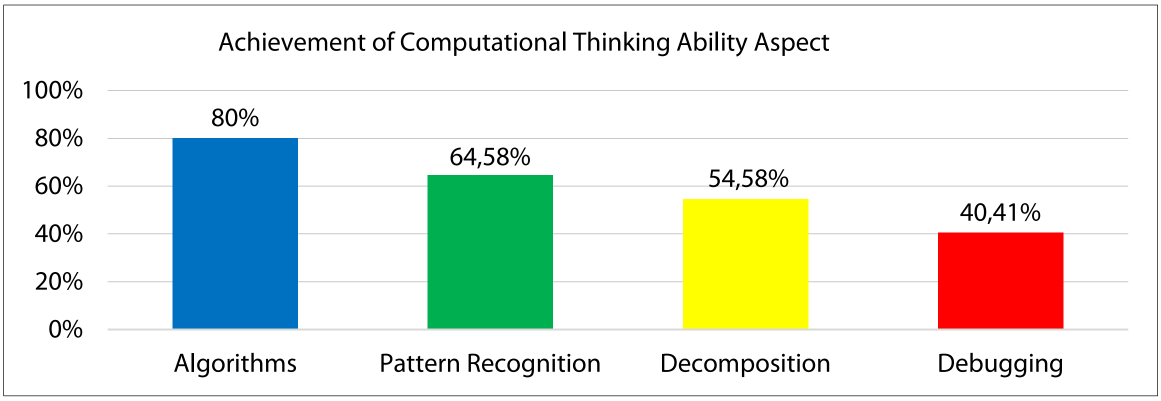

Figure 2. Diagram of the achievement of the computational thinking ability aspect

Based on the results of computational thinking ability shown in Figure 2, the algorithm aspect received the highest score, followed by pattern recognition, decomposition, and debugging. The algorithmic aspect scored the highest of 80%, which is supported by the results of observation notes that the majority of children are able to follow a series of sequential steps to solve problems. Followed by the next highest aspect is pattern recognition, which scored 64.58% in children, and is a fundamental cognitive ability to identify and create repetitive patterns. The decomposition aspect obtained an average score of 54.58% is challenging because it trains children to break down large problems into smaller parts to make them easier to solve. In addition to the challenging aspect of decomposition, there is another aspect that is very challenging for children, namely, debugging. The debugging aspect, achieving an average score of 40.41%, is the weakest compared to the other three aspects. The debugging aspect requires understanding that a problem, understanding what an error means, and then trying to fix it. Children must learn to repeatedly try to find solutions to problems. This aspect is challenging for children because it is cognitively demanding, which involves error correction, abstract reasoning, and reflection. The metacognitive abilities and self-reflection of children aged 5-6 years are still limited because they are still in the developmental stage.

Discussion

Based on the results of the study, the researcher examined the computational thinking ability of children aged 5-6 years referring to the indicators : (1) ability to follow a series of sequential steps to solve problems (algorithms); (2) ability to repeat patterns in doing the same task (pattern recognition); (3) ability to divide complex tasks into simpler ones (decomposition); (4) ability to solve problems by finding a solution (debugging). The four indicators of computational thinking can be achieved in kindergartens through unplugged coding learning activities based on daily life.

The algorithm aspect is the ability to follow directions and instructions according to what is ordered by the teacher in the form of one-step or multi-step instructions. Children can understand a concept because they find the value of daily life, such as ordering activities from waking up to going to school, ordering prayer movements, and ordering objects in order. Providing simple instructions that children encounter in daily conversations is also one of the self-help skills that can be applied in learning unplugged coding based on daily activities. Even though some children experience obstacles, learning continues to run according to the learning objectives, especially in providing an understanding of algorithm concepts to children. Algorithms have a close relationship with the child's ability to logically sequence steps, commands, or instructions (Terroba et al., 2021; Terroba et al., 2022). In essence, children who have an understanding related to the concept of algorithms will also know the concept of the sequence and steps that must be taken in achieving a goal, so this indicator can be used as a reference for teachers in assessing children's development in the form of understanding algorithm concepts. The algorithmic aspect scored highest compared to the other aspects because the teacher often stimulates through the child's daily routine, which naturally involves sequential actions.

The findings of this study show that the learning implemented by teachers to children that can provide stimulation for children in understanding the concept of algorithms are activities that contain instructions or involve logical sequencing tasks for children. This is in line with research that states that activities that contain instructions can be strengthened by bringing the theme of other activities that are indeed familiar with the child's world, so that children's understanding related to the concept of algorithms can be conveyed (Clarke-Midura et al., 2023). An example of giving these tasks is a task that requires a series of work in the form of brushing teeth, sequencing the process of metamorphosis, sorting objects into small and large categories, making cardboard blocks that have been numbered, and then asking children to arrange the blocks according to the order of numbers. In addition, algorithmic activities can be honed with a series of activities that are repeated every day; daily activities can be the key to children's success in understanding algorithm concepts. The concept of algorithms in kindergarten can also be honed in recalling activities when children and teachers discuss activities from the beginning of departure to when they leave school, as well as the procedures for playing in daily activities. The findings are in line with previous research that children aged five to six can follow multi-step instructions and can recount activities or experiences in the correct order (Sharma et al., 2019). With learning activities that contain a sequence make early childhood accustomed to doing actions regularly based on the rules of the system, so that children can solve problems in a systematic order.

The pattern recognition aspect is the ability to repeat patterns while doing the same task. Pattern recognition in children is a fundamental cognitive ability to identify, understand, and create repetitive patterns, such as in a sequence of colors or shapes. Teachers can stimulate learning activities by inviting children to arrange blocks with certain patterns, such as red, blue, red, blue, and ask children, "What will come after blue blocks?" This helps children understand patterns and make predictions. In addition, activities such as making accessories out of beads can also stimulate pattern recognition. Pattern recognition in practice is to show a combination of movements of the same pattern that is executed several times, repeating according to the set number or until it reaches the requirements. Teachers can stimulate through unplugged coding loops of operation, asking children to work on board games that start from the start line to the finish line to understand the repetitive activities in reaching the finish line. The stimulation of this loop operation allows the child to understand the repetition or activity of commands. In addition to board games, children are also guided to make projects so that they are able to know the operation of loops, namely, making a house building with lines of paper pasted to form a wall. Sticking colorful paper to a wall is one of the activities that can introduce children to the concept of loops because of the repetition of patterns in activities carried out by children. The results of this study are in line with previous research that stated that children aged five to six years can compose a pattern repetition to imitate the pattern and predict the next sequence (Pratiwi, 2017). Recent research has also proven that children aged five to six years can group similar objects by shape, size, and color, and can make simple patterns (Singhal, 2022).

The decomposition aspect is the child's ability to divide tasks into small parts. Children learn that complex problems will be easier if they are divided into several parts, so that problems will be solved faster if children manage one small part that has been solved. Besides that, children will easily analyze problems in more detail and detail. The decomposition aspect can also be stimulated through the activity of making a building using blocks and legos. This activity is related to project-based learning, namely, children make a project or product. The implementation of the project-based learning model is carried out together; children have their own division of tasks in completing a project being done. The implementation of this ability to divide tasks involves the teacher first giving directions on what goals and projects to be done. After the child is given a briefing, the activity is handed over to the child, the child determines the task of the part to be done, and the child also determines the creativity of the project to be created. The decomposition aspect can be stimulated through task-sharing activities such as inviting children to make sandwiches. The steps can be broken down into finding ingredients, preparing the bread, adding the filling, and then closing it. Children can also work together in a team so that the complex tasks given can be completed more easily and quickly. This result is in line with previous research, where teachers integrated aspects of computational thinking skills in the curriculum to teach geometric shapes and colors (Bers et al., 2019). These findings are relevant, suggesting that computational thinking skills can be integrated into the kindergarten curriculum according to the stages of early childhood development. The decomposition aspect is challenging because it trains children to break down large problems into smaller parts to make them easier to solve.

The findings of this study show that the debugging aspect shows the lowest results compared to the other three aspects of computational thinking. This is because debugging is a metacognitive ability that involves complex thinking analysis, such as error correction, abstract reasoning, and reflection. The debugging aspect is a complex thought process that requires children to understand that a problem can have multiple solutions, understand what the error means, and then try to fix it. Debugging steps include identifying problems, looking for solution ideas, choosing one of the ideas, developing the idea, and testing solutions. Debugging teaches children to be consistent and never give up until they find the right solution. This is in line with research that debugging leads to complex processes, involves diligence, and has a strong relationship with several aspects of executive functioning, such as self-control, planning, and organization (Guss et al., 2024). Children aged five to six years are still at a basic level of computational thinking, so to understand the debugging aspect, they need help from teachers. Teachers can stimulate the debugging aspect through problem-based learning, such as puzzles. This is in line with previous research that putting together puzzle pieces can develop computational thinking aspects of debugging. Children learn to think about strategizing how to solve the puzzle correctly, so that they can see the whole picture (Mutoharoh et al., 2021). The results of recent research have also proven that puzzles are one of the play activities that apply the concept of unplugged coding to stimulate problem-solving, where children identify the cause of the problem, name several solutions, try to practice solutions to solve problems, find the best solutions, and give reasons why the solution was chosen (Ubaidillah et al., 2025). This puzzle piece is one of the implementations of unplugged coding activities to stimulate computational thinking.

Based on the results of the research and discussion above, it shows that the computational thinking ability of children aged 5-6 years in the city of Surakarta can be stimulated by implementing unplugged coding activities based on daily activities. Various activities have been carried out to develop computational thinking that can be implemented in early childhood, namely sequence operations (executing instructions one by one according to the predetermined sequence until the end) and loops (showing the combination of movements of the same pattern that are carried out several times until reaching a goal). Unplugged coding activities have advantages that are in accordance with the characteristics of early childhood and teachers in Indonesia, considering that the distribution of facilities and infrastructure, such as digital technology media, has not been evenly distributed. This is evidenced by the results of observations in the Surakarta city kindergarten, where some of the teachers still have problems with the availability of digital technology media, such as computers or laptops. So, in the implementation of daily learning, teachers find it difficult to implement plugged coding. Therefore, using unplugged coding for teachers has easy access and understanding according to the characteristics and needs of teachers and early childhood in kindergarten. Computational thinking is very flexible to be applied in early childhood learning through coding activities. This is in line with the latest research, which states that there are two types of coding activities, namely plugged (using digital media) and unplugged (without digital media). The implementation of coding activities that are in accordance with the stages of children's development can help develop computational thinking (Hardiyanti et al., 2025).

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One of the learning activities in kindergarten that can develop early childhood computational thinking ability is the practice of unplugged coding. Unplugged coding is a coding activity without digital technology media. The unplugged coding learning method is new in the 21st century. Even in some countries, coding learning is a core subject and must be studied by students because, according to the results of research that has been carried out, unplugged coding activities can develop computational thinking in early childhood (Singhal, 2022). Integrating unplugged coding learning with daily activities is an effective strategy so that messages can be easily captured by early childhood. Applying learning that is relevant to daily activities will provide a deeper experience and understanding of early childhood memory (Çiftçi & Topçu, 2023). Recent evidence suggests that children will have the opportunity to practice coding concepts and engage with the environment in a meaningful and engaging way when connected to the concepts of everyday activities in children's real lives (Zurnacı & Turan, 2024). The findings of this study are in line with several previous studies that provide information on the integration of unplugged coding based on daily activities that can help develop early childhood computational thinking in kindergarten.

This study contributes to the global literature by providing empirical evidence from a Global South context, which remains underrepresented in research on early childhood computational thinking. The findings highlight how locally relevant, low-resource pedagogical strategies can effectively support the development of computational thinking in young learners. Therefore, this research not only enriches international scholarship but also offers a scalable and adaptable model for integrating computational thinking into early childhood education systems across diverse socio-economic contexts.

Conclusion

This study examined the achievement of early childhood computational reasoning and identified dimensions that require targeted pedagogical support in kindergarten learning. The findings indicate that the algorithmic aspect achieved the highest level of performance, while debugging emerged as the most challenging dimension for children aged five to six years. Strong performance in algorithms, pattern recognition, and decomposition suggests that these foundational components of Computational Thinking can be effectively developed through structured activities grounded in children's daily experiences. However, the lower achievement in debugging highlights the complexity of metacognitive processes involved in identifying errors, evaluating alternative solutions, and reflecting on problem-solving strategies. These results underline the importance of integrating problem-based and inquiry-oriented learning approaches in kindergarten to strengthen children's higher-order reasoning abilities. Both digital coding activities and Unplugged Coding approaches provide flexible and developmentally appropriate pathways for introducing computational thinking in early childhood education.

The study contributes to the growing global discussion on early childhood STEM education by demonstrating that computational thinking can be cultivated through contextualized and resource-sensitive pedagogical strategies. This finding is particularly relevant for educational settings where access to digital infrastructure remains limited, as unplugged coding enables teachers to embed computational concepts into play-based and routine classroom activities. Nevertheless, this study is limited by its localized sample and contextual scope. Future research should involve larger and more diverse samples across different regions and educational contexts to enhance the generalizability of the findings. Longitudinal and intervention-based studies are also recommended to examine the long-term development of children's computational reasoning and to identify the most effective instructional strategies for fostering computational thinking in early childhood education.

Declarations

Author Contribution Statement

Widya Dwi Hardiyanti: Conceptualization and Writing original draft. Prayitno: Methodology, Formal Analysis and Supervision. Nur Hayati: Validation and Resources. Puteri Annisa Tsamrotul Fuadah: Investigation and Writing-Review & Editing.

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Data Availability Statement

The datasets generated and/or analyzed during this study are available from the corresponding author upon reasonable request.

Declaration of Interests Statement

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Additional Information

No additional information is available for this paper at this time.

References

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement, 45*(1), 131–142. https://doi.org/10.1177/0013164485451012

An, M. Y., & Shin, K. S. (2024). Effects of teachers' media utilization and computational thinking on sustainable development in early childhood education. *Sustainability, 16*(13), Article 5773. https://doi.org/10.3390/su16135773

Bers, M. U., González-González, C., & Armas-Torres, M. B. (2019). Coding as a playground: Promoting positive learning experiences in childhood classrooms. *Computers & Education, 138*, 130–145. https://doi.org/10.1016/j.compedu.2019.04.013

Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. In *Proceedings of the 2012 Annual Meeting of the American Educational Research Association* (pp. 1–25). http://scratched.gse.harvard.edu/ct/files/AERA2012.pdf

Çiftçi, A., & Topçu, M. S. (2023). Improving early childhood pre-service teachers' computational thinking skills through the unplugged computational thinking integrated STEM approach. *Thinking Skills and Creativity, 49*, Article 101337. https://doi.org/10.1016/j.tsc.2023.101337

Clarke-Midura, J., Lee, V. R., Shumway, J. F., Silvis, D., Kozlowski, J. S., & Peterson, R. (2023). Designing formative assessments of early childhood computational thinking. *Early Childhood Research Quarterly, 65*, 68–80. https://doi.org/10.1016/j.ecresq.2023.05.013

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE.

Creswell, J. W., & Guetterman, T. C. (2019). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (6th ed.). Pearson.

Computer Science Teachers Association. (2017). *CSTA K–12 computer science standards: Revised 2017*. https://csteachers.org/k12standards/

George, D., & Mallery, P. (2016). *IBM SPSS Statistics 23 step by step: A simple guide and reference* (14th ed.). Routledge. https://doi.org/10.4324/9781315545899

Guss, S. S., Clements, D. H., Sharifnia, E., Sarama, J., Holland, A., Lim, C.-I., & Vinh, M. (2024). Designing inclusive computational thinking learning trajectories for the youngest learners. *Education Sciences, 14*(7), Article 733. https://doi.org/10.3390/educsci14070733

Hardiyanti, W. D., Prayitno, Christianti, M., Rambe, A., & Ulfiyani. (2025). Coding games to stimulate computational thinking ability in early childhood. *Journal for Lesson and Learning Studies, 8*(2), 243–256. https://doi.org/10.23887/jlls.v8i2.92569

Kaya, D., Yaşar, A. Ö., Çetin, İ., & Kutluca, T. (2025). The relationship between the 21st-century skills and computational thinking skills of prospective mathematics and science teachers. *Journal of Pedagogical Research, 9*(1), 73–95. https://doi.org/10.33902/JPR.202531498

Masarwa, B., Hel-Or, H., & Levy, S. T. (2024). Kindergarten children's learning of computational thinking with the "sorting like a computer" learning unit. *Journal of Research in Childhood Education, 38*(2), 165–188. https://doi.org/10.1080/02568543.2023.2221319

Mutoharoh, Hufad, A., Fathurrohman, M., & Rusdiyani, I. (2021). Unplugged coding activities for early childhood problem-solving skills. *JPUD: Jurnal Pendidikan Usia Dini, 15*(1), 121–140. https://doi.org/10.21009/jpud.151.07

Pratiwi, M. I. (2017). Study on the ability to recognize the ABCD-ABCD pattern in group B children in kindergarten in Group 3 of Kasihan Sub-district. *Journal of Early Childhood Education, 6*(1), 56–64. https://journal.student.uny.ac.id/pgpaud/article/view/6800

Setianingrum, I., & Hidayana, A. F. (2025). The effect of early childhood teachers' understanding on early childhood coding learning. *Journal of Care (Children Advisory Research and Education), 13*(1), 90–100. https://doi.org/10.25273/jcare.v13i1.22004

Sharma, K., Papavlasopoulou, S., & Giannakos, M. (2019). Coding games and robots to enhance computational thinking: How collaboration and engagement moderate children's attitudes? *International Journal of Child-Computer Interaction, 21*, 65–76. https://doi.org/10.1016/j.ijcci.2019.04.004

Singhal, V. (2022). Precoding skills: Teaching computational thinking to preschoolers in Singapore using unplugged activities. *Proceedings of the International Conference on Computational Thinking Education*, 86–87. https://doi.org/10.34641/ctestem.2022.452

Terroba, M., Ribera, J. M., Lapresa, D., & Anguera, M. T. (2021). Observational analysis of the development of computational thinking in early childhood education (3 years old) through a proposal for solving problems with a ground robot with programmed directionality. *Revista de Educación a Distancia, 21*(68), 1–20. https://doi.org/10.6018/red.480411

Terroba, M., Ribera, J. M., Lapresa, D., & Anguera, M. T. (2022). Observational analysis of the development of computational thinking in early childhood education (5 years old) through an intervention proposal with a ground robot with programmed directionality. *European Early Childhood Education Research Journal, 30*(3), 437–455. https://doi.org/10.1080/1350293X.2022.2055102

Triana, D. D., Sabarini, S. S., & Yudha, R. P. (2020). *Web-based motion literacy learning and assessment*. CV Budi Utama.

Ubaidillah, Setiarini, N., Budiarti, I., & Windarty, K. (2025). The effect of game coding on early childhood problem-solving skills. *Jurnal Ar-Raihanah: Early Childhood Islamic Education, 5*(1), 17–23. https://doi.org/10.53398/arraihanah.v5i1.632

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366*(1881), 3717–3725. https://doi.org/10.1098/rsta.2008.0118

Wing, J. M. (2011). Research notebook: Computational thinking. What and why? *The Link Magazine, 6*, 20–23. http://www.cs.cmu.edu/link/research-notebook-computational-thinking-what-and-why

Yang, Z., Blake-West, J., Yang, D., & Bers, M. U. (2025). The impact of a block-based visual programming curriculum: Untangling coding skills and computational thinking. *Learning and Instruction, 95*, Article 102041. https://doi.org/10.1016/j.learninstruc.2024.102041

Zeng, Y., Yang, W., & Bautista, A. (2023). Teaching programming and computational thinking in early childhood education: A case study of content knowledge and pedagogical knowledge. *Frontiers in Psychology, 14*, Article 1252718. https://doi.org/10.3389/fpsyg.2023.1252718

Zhang, X., Chen, Y., Hu, L., Hwang, G.-J., & Tu, Y.-F. (2025). Developing preschool children's computational thinking and executive functions: Unplugged vs. robot programming activities. *International Journal of STEM Education, 12*, Article 10. https://doi.org/10.1186/s40594-024-00525-z

Zourmpakis, A. I. (2025). Developing computational thinking in early childhood education: Long-term impacts on CT skills and motivation using the CAL approach, ScratchJr, and gamification. *Advances in Mobile Learning Educational Research, 5*(2), 1536–1547. https://doi.org/10.25082/AMLER.2025.02.009

Zurnacı, B., & Turan, Z. (2024). Educational robotics or unplugged coding activities in kindergartens? Comparison of the effects on pre-school children's computational thinking and executive function skills. *Thinking Skills and Creativity, 53*, Article 101576. https://doi.org/10.1016/j.tsc.2024.101576