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COGNITIVE EXPLORATION PROCESS CHILDREN IN COMPLETING REPEATING PATTERNS

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ABSTRAK. Pembelajaran pola berulang menjadi dasar bagi anak untuk memahami konsep matematika selanjutnya. Akan tetapi, penelitian terdahulu mengungkapkan bahwa masih terdapat anak usia 5-6 tahun yang mengalami kesulitan dalam menemukan urutan pola. Penelitian ini bertujuan untuk mengetahui dan membahas strategi kognitif yang digunakan anak usia 5-6 tahun dalam menyelesaikan masalah pola berulang. Pendekatan kualitatif dengan metode studi kasus digunakan agar proses eksplorasi terhadap pengalaman anak yang membentuk cara berpikir dalam penyelesaian pola berulang dapat diketahui oleh guru. Penelitian dilakukan pada 3 orang anak usia 5-6 tahun di Kelompok Bermain Al Haida. Hasil penelitian menunjukkan bahwa terdapat tiga kategori strategi yang digunakan anak untuk menyelesaikan masalah pola berulang, yaitu perhatian pada karakteristik tunggal, perbandingan dan klasifikasi, serta fokus pada urutan. Bagi guru, hasil penelitian ini diharapkan dapat menjadi umpan balik terhadap pembelajaran pola berulang yang dilakukan dengan memperhatikan karakteristik dan strategi penyelesaian masalah setiap anak. Bagi peneliti selanjutnya, penelitian ini bisa menjadi rujukan awal untuk lebih mendalami penggunaan ketiga strategi penyelesaian pola berulang pada jumlah subjek anak usia 5-6 tahun yang lebih banyak. Implikasi dari penelitian ini adalah membantu proses penyusunan bahan ajar pembelajaran pola agar memperhatikan aktivitas yang lebih efektif sesuai karakteristik kemampuan anak.

Kata Kunci: *Proses Kognitif; Anak Usia Dini; Menyelesaikan Pola Berulang*

ABSTRACT. *Learning repeating patterns is the basis for children to understand further math concepts. However, previous research revealed that there are still children aged 5-6 years who have difficulty in finding pattern sequences. This study aims to find out and discuss the cognitive strategies used by children aged 5-6 years in solving repeating pattern problems. A qualitative approach with a case study method is used so that the exploration process of children's experiences that shape the way of thinking in solving repeating patterns can be known by the teacher. The research was conducted on 3 children aged 5-6 years in one of the kindergartens located in Bandung Regency. The results showed that there were three categories of strategies used by children to solve repeating pattern problems, namely attention to single characteristics, comparison and classification, and focus on sequence. For teachers, the results of this study are expected to be a feedback to the learning of repeating patterns carried out by paying attention to the characteristics and problem-solving strategies of each child. For future researchers, this research can be an initial reference to further explore the use of the three strategies for solving repeating patterns in a larger number of 5-6 year old child subjects. The implication of this research is to help the process of preparing pattern learning teaching materials to pay attention to more effective activities according to the characteristics of children's abilities.*

Keyword: *Cognitive Process; Early Childhood; Resolving Repeating Patterns*

INTRODUCTION

Mathematics is one of the fields of study taught at all levels of education. At the early childhood education level (ECE), the learning provided is considered a foundation for success in subsequent levels. Mathematics learning, which aims to develop critical, logical, and creative thinking skills, should be delivered in accordance with the level of education (Febriana, Ameliya, Napitu, Purba, & Piliang, 2022). The distinction between pre-mathematics concepts and mathematics concepts lies in their presentation, thought patterns, and levels of abstraction (Krisnadi, 2022). Therefore, to teach problem-solving processes at the ECE level, the fundamentals of mathematics, referred to as pre-mathematics concepts, are introduced (Björklund & Barendregt, 2016; Adisty, Kurnia, & Chairilsyah, 2021; Johnson, Turrou, McMillan, Raygoza, & Franke, 2019). Pre-mathematics concepts serve as the foundation for understanding mathematical problem-solving processes from an early age. Pre-mathematics learning utilizes concrete objects to help children grasp the meaning of actual mathematical concepts (Amanda, Nisa, & Suriani, 2024). Mathematics in early childhood is better focused on fostering mathematical thinking rather than performing mathematical operations (Van Oers, 2010). Content that supports pre-mathematics learning includes arithmetic operations, data analysis, measurement, geometry, and patterns (Clements & Sarama, 2014). As a field of study aimed at facilitating problem-solving processes, understanding the orderliness of a solution is essential. For example, in the movement and song activity "Head, Shoulders, Knees, and Toes," children need to understand the structural sequence of the movements, as the actions are performed repeatedly. If children are not introduced to the idea that the sequence they need to grasp is a pattern consisting of various unified elements, they will focus only on individual elements rather than recognizing the pattern itself. This can lead to confusion, as children may struggle to determine what movement to perform next. Pre-mathematics content that teaches the orderliness of diverse elements arranged into a structured sequence is pattern learning.

A pattern is an arrangement or awareness of the relationship between elements that form an orderly structure. Elements that can help create a pattern include colors (white-yellow-white-yellow-white-yellow-white), movements (head-shoulders-head-shoulders-head-shoulders), beats, or sounds (Papic & Mulligan, 2007). Patterns play a crucial role in fostering children's discipline both in the context of school learning and in everyday life. The process of observing, arranging, and drawing conclusions from a pattern's rules is key to solving problems mathematically (Harefa & Lase, 2023). This process guides children toward understanding a structure that will be essential when they study mathematics at formal education levels (Watts, Duncan, Clements, & Sarama, 2017; Dumas, McNeish, & Clements, 2019; Mulligan, Gabrielle, & Lyn, 2020; Fyfe, Evans, Matz, Hunt, & Alibali, 2017). Patterns can also be replicated and varied, making pattern learning in pre-mathematics concepts encompass several types, including repeating patterns (consisting of repeating units with the same number of elements), growing patterns (consisting of elements that increase with each repetition), and relational patterns (consisting of two sets of patterns, e.g., 1-2, 2-4, 3-6). Among these types, the foundational pattern for understanding patterns at the early childhood education level is the repeating pattern. Repeating patterns are defined as linear patterns with repeating units and are considered the easiest type of pattern (Rittle-Johnson, 2013). Repeating patterns are composed of repeating units (individual elements that are repeated) with a cyclic and predictable structure. Repeating patterns also represent an orderliness that teaches children about repetition, ultimately forming a structure (Luken, 2021).

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The simplest structure of a repeating pattern consists of two elements, while the more elements added, the more complex the pattern becomes. If children can understand more complex repeating patterns, their problem-solving skills improve (Irmawati, 2020). Children's understanding of repeating patterns can serve as a foundational asset for recognizing order, which helps them organize their world, particularly their play environment (Masyithoh, 2015). Moreover, when children observe, arrange, identify, and create their own patterns, literacy and language skills are crucial (Schmerold, 2017). For instance, when children play high jump, there are rules they must follow. However, they still need to devise their own way to overcome challenges, as the strategies others use may not work for everyone. The methods children develop to overcome challenges are based on their analysis of how others approach the task. Thus, children jump over the rope in their own way without disregarding the rules. When successful, the pattern of play they created can be applied to future rope-jumping activities.

In Indonesia, pattern learning at the early childhood education level is included in the current *Merdeka* Curriculum. Pattern learning has several learning objectives that teachers need to teach children aged 3–6 years to achieve the goals of pre-mathematics learning, including recognizing, imitating, continuing, identifying, and creating patterns (Badan Standar & Kementerian Pendidikan, 2022). From these learning achievement indicators, a sign that a child understands patterns is when they can identify patterns (Clements & Sarama, 2014), The process of identification occurs with unorganized data, requiring children to observe and analyze until they form a sense of order. For example, when children are given a problem "O- - O - - O - - O - - O - …" Children may initially perceive the sequence as unorganized data. However, once they understand the pattern, they can identify a structured arrangement in the sequence, such as the pattern "O - .". This enables them to complete the sequence according to the repeating pattern established at the beginning. This process requires children's mental readiness and symbolic abilities to observe and visualize symbols in discovering patterns. Such skills are related to the early algebraic thinking concept, which involves representing situations using concrete objects, symbols, and appropriate language with simple quantities (Yuniati & Suparjono, 2021; Komang, 2022). Early pattern recognition skills also have a positive correlation with arithmetic abilities in school (Luken, 2018).

However, research by Irmawati (2020) reported that 64% of children aged 5–6 years are able to recognize patterns. Factors such as maturity, stimulation, and individual characteristics contribute to differences in children's understanding of repeating pattern learning. Some children can independently identify the sequence of colors according to a pattern, while others may still struggle with arranging the pattern correctly. Initial observations conducted by the author showed similar results: each child has their own way of solving repeating pattern problems. Lestari (2020) explained that children solve problems based on how they think, understand, and make decisions. Therefore, educators need to provide effective teaching to achieve learning objectives (Ginsburg, Lee, & Boyd, 2008). One approach is to understand the learning object and the learning situation (Dolong, 2016). Given these challenges, it is crucial for educators to understand the thinking processes children use to comprehend repeating patterns. This study explores the question: *"How do the cognitive processes of 5–6-year-old children in Al Haida Playgroup determine their strategies for solving repeating pattern problems?"* The aim is to identify and discuss the cognitive strategies used by 5–6-year-old children in solving repeating pattern problems so that teachers can plan subsequent repeating pattern learning activities by considering the unique characteristics and abilities of the children.

METHOD

This study aims to understand and discuss children's cognitive processes in determining strategies for solving repeating pattern problems. A qualitative approach with a case study method was used to enable exploration of children's experiences that shape their thinking in solving repeating patterns, which can be valuable for teachers. The research involved participants who had undergone learning activities focused on repeating patterns. Three children aged 5–6 years were selected as participants, as they are considered to be at a developmental phase requiring preparation for formal education. The study was conducted at an early childhood education institution called Kelompok Bermain Al Haida, located in Bandung Regency. This location was chosen because it is close to the researcher's residence, the institution has already implemented repeating pattern learning, and the researcher assessed that solutions to pre-mathematics learning issues, such as repeating patterns, need to be well-understood by children in areas far from urban centers. Data collection techniques included observation and interviews. Open observation was conducted to allow participants to be aware of and provide opportunities for the researcher to observe their activities (Moleong, 2018). Meanwhile, interviews were used to verify the accuracy of observational findings. Data were gathered alternately through semi-structured interviews and observations of participants. Subjects were identified as R1, R2, and R3.

The framework for describing the research findings was based on the strategy categories outlined by Lüken & Sauzet (2021), which include five categories of pattern-solving strategies: no reference to patterns, attention to single characteristics, comparison & classification, focus on sequence, and recognition of repeating units. While each category corresponds to an age-related benchmark for problem-solving, these are influenced by children's knowledge, skills, and experience with pattern learning. The rationale for applying these strategies is the cognitive development characteristics of children aged 5–6 years, who can combine and transform information, articulate reasons for their ideas, understand cause-and-effect relationships, engage in imaginative thinking, exhibit egocentric language use, possess high curiosity, and show rapid language development (Khadijah, 2016). The difference between this study and previous research lies in the types of tasks assigned and the participants studied. The materials used for analysis consisted of worksheets containing four tasks: imitating simple patterns, continuing patterns, matching patterns, and extending patterns. Preschool children are often given tasks such as copying and extending patterns, and they are capable of creating new forms and identifying core repeating units (Rittle-Johnson, Hofer, Farran, & Fyfe, 2016). Below is an illustration of the four tasks provided to the children.

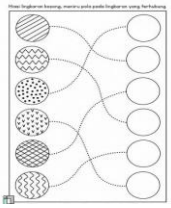

Figure 1. : Patterns

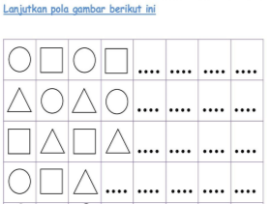

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Figure 2. Continuing Simple Patterns (AB-AB and ABC-ABC)

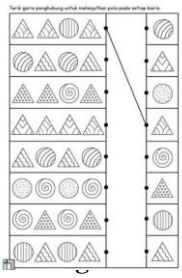

Figure 3. M Pattern

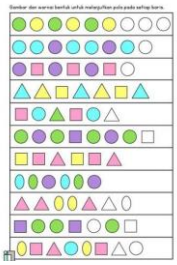

Figure 4. Extending Color and Shape Patterns (AB-AB, AAB-AAB, ABC-ABC, ABCD-ABCD)

RESULTS AND DISCUSSION

The research findings indicate that different pattern tasks elicit different strategies. The tasks provided consist of four types: starting with imitating simple patterns, where children replicate the given model pattern; continuing simple patterns, which involves finding the next element in an AB-AB pattern; matching pattern shapes, which means continuing with the appropriate pattern; and extending color and shape patterns (ranging from simple to complex). Below is an explanation of the problem-solving process for repeating patterns conducted by three children aged 5–6 years:

Imitating Simple Patterns

In the imitating patterns task, R1 and R2 completed the task quickly, while R3 took a relatively longer time to finish.

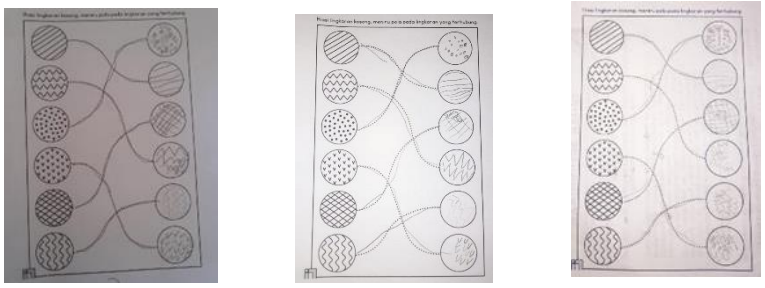

Figure 5. Responses of R1, R2, and R3 to the Simple Pattern Imitation Task

When the author asked the children, "How did you complete this task?" the following conversation occurred:

R1: "I just looked at this one (pointing to the model pattern)."
R2: "Because this circle is the same as this one (pointing to the previous shape), so the contents are the same too."

R3: "I followed this (pointing to the previous pattern, but the shape copied did not match the example)."
(*Interview with R1, R2, and R3 on June 19, 2024.*)

R1 imitated the pattern accurately according to the model, while R2 and R3 imitated it with incorrect alignment to the model pattern. Despite the discrepancies in replicating the pattern's content, all three respondents used the same strategy. This strategy exemplifies matching the same shape with the last element, which falls under the *comparison & classification* strategy category. Imitation is one of the most common learning methods used by children. The ability to imitate shapes is an essential activity that supports children in following lessons, as they replicate what is presented (Ningrum, Haenilah, & Sasmiati, 2017). Imitating shapes is part of the *comparison and classification* strategy because, during imitation, children compare shapes from various perspectives and engage in one-to-one correspondence. As noted by Lüken (2021), this category is often employed by children in copying or replicating patterns. From a cognitive perspective, children aged 5–6 years are capable of understanding cause-and-effect relationships through comparison. This method demonstrates an emerging sense of order in patterns, even though children may not yet fully comprehend the specific structure of the pattern (Clements & Sarama, 2014), such as counting the number of line elements within a circle.

Continuing Simple Patterns (AB-AB and ABC-ABC)

The second task was designed to assess children's skills in continuing a given pattern. The pattern structure was created using three geometric shapes: a circle, a triangle, and a square.

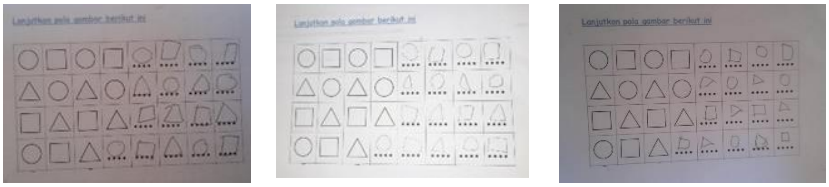

Figure 6. Responses of R1, R2, and R3 to the Task of Continuing Simple Patterns

During the observation process, the difference among the three participants was R3, who continued the pattern of circle – square – triangle into square – triangle – circle – triangle – square. The researcher asked, "How did you continue this pattern?" Here is part of the conversation from the three respondents:
R1: "The first one is circle – square – circle – square, so these points are also the answer: circle – square – circle – square. Then this one is the same, ma'am (3-element pattern), it's circle – square – triangle, so I just go back to the beginning (circle – square – triangle)."
R2: "For me... the start is circle, so I fill this square again like the first picture."
R3: "Hmm... look at this, ma'am" (pointing to the second-to-last shape)
(Interview with R1, R2, R3 on June 19, 2024).

The conversation above illustrates the difference in pattern-solving strategies for each child in the task of continuing simple patterns AB-AB and ABC-ABC. This difference may arise from the children's experience or skills in solving problems. Referring to the categories of pattern-solving strategies (Lüken, 2021), the strategies used by each respondent in this second task are:

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1. R1 uses the category "Focus on the sequence" by paying attention to the relationships between the elements without looking at the pattern structure. This strategy shows that R1's awareness of the sequence in the pattern is beginning to increase. The child's focus on the relationship between elements reflects recursive thinking, which leads to the question "What will happen next?", without breaking the pattern into its repeating units (the smallest parts of the pattern) (Papic & Mulligan, 2007).
2. R2 continues the repeating pattern by "Starting again from the first element." This strategy is the beginning of awareness of the regularity in the pattern. To see the start of the pattern, the child compares each element and observes the similarities between the patterns. However, Garrick explains that the concept of classification forms the basis of creating patterns.
3. R3 continues the pattern by guessing the possible element. This process occurs because the child "Focuses on a single characteristic of the pattern." The child's focus is on the appearance of the elements, while the relationship or regular order is not noticed. Thus, the child continues the pattern by observing the second form of the last element, such as circle – square – circle – square – "?" (the child continues with a circle because the previous element was square, and before square, there was circle). Similarly, in the pattern circle – square – triangle – "?" (the child continues with square – triangle – square – triangle – square). This strategy of focusing on a single appearance or relational similarity is commonly used by children when completing tasks such as copying and matching patterns (Collins, 2015).

Matching the next pattern

The structure of the pattern given to the children to match is AB-AB and AAB-AAB with additional lines inside. After being given the task, each child used the same strategy based on previous learning experiences in class on the topic of matching objects.

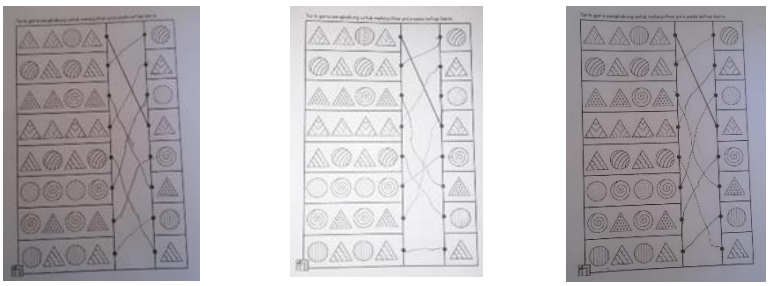

Figure 7. Responses of R1, R2, and R3 to the pattern matching task.

In the process of matching patterns, although the children used the same strategy, R1 was faster at identifying the pattern compared to R2 and R3. R3 required an explanation from the teacher first and validation of the correctness of the answers to each pattern. Therefore, even though it seemed easy by just drawing lines, this process could still be more challenging for children because they had to focus on the location of the points in the correct pattern. The completion of the pattern-matching task can help the teacher assess the children's knowledge of pattern structures, as this is part of the pattern identification process. The strategies used by the children in this task involved comparing and matching elements. The children compared the elements of the patterns and highlighted the similarities within the patterns (Collins, 2015). The

process of matching also naturally led the children to try to solve problems by establishing relationships within the task (Johnson, Turrou, McMillan, Raygoza, & Franke, 2019).

Expanding patterns of color and shapes (AB-AB, AAB-AAB, ABC-ABC, ABCD-ABCD)

The activity of expanding patterns means finding the next element. The elements that the children needed to focus on were color and shape. All three respondents were able to quickly identify the elements in the AB-AB and AAB-AAB structures. However, they faced difficulties when adjusting the color patterns in the ABC-ABC and ABCD-ABCD tasks.

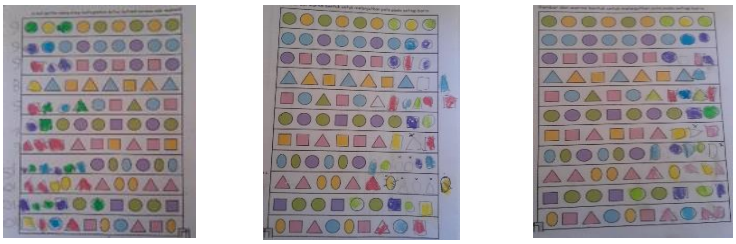

Figure 8. Responses of R1, R2, and R3 on the task of expanding color and shape patterns.

This is due to the combination of color and shape patterns, which requires more focus from the children. When the author asked, "How do you expand this pattern?", the children responded as follows:

R1: "For this one (AB-AB and AAB-AAB patterns), I look at the last color and shape. But for this one (ABC-ABC and ABCD-ABCD patterns), I just follow this (the initial pattern element). It's confusing, there are too many shapes."

R2: "I start from the beginning, and this one (the last) has this color, so the next one I should draw this (pointing to the previous matching pattern)."

R3: "I just draw it again (repeating from the initial pattern element)."

(Interview with R1, R2, R3 on June 19, 2024)

From the three responses above, each child continued the pattern using a different strategy. R1 used the strategy "Look and compare with the initial pattern," R2 used the strategy "Focus on the relationship of elements," and R3 used the strategy "Repeat the initial element." These different strategies occurred based on the children's experience and thinking skills in making decisions (Lestari, 2020). This difference shows that R1 and R2's understanding has increased compared to R3. R1 tried to identify the differences, R2 remained focused on the sequence, while R3 only paid attention to the singular characteristics. Although the strategy used by R3 is typical for a 4-year-old (Lüken, 2021), during this process, the children tried to analyze the differences in the sequence of each pattern. Patterns with only 2 elements helped the children predict the next shapes and colors more easily. However, providing patterns with 3-4 elements with shapes and colors proved to be a challenge. The children had to remember and illustrate two objects at once. Therefore, when the children successfully continued the pattern, it indicated they were able to identify the pattern as well.

The improvement in the categories of strategies used by the children as tasks became more complex shows that the cognitive process in the children's thinking is developing. Referring to Vygotsky's theory, the level of development determined by problem-solving, starting from adult guidance to independent problem-solving, defines the Zone of Proximal Development (ZPD) (Gauvain, 2019). Among the various types of repeated pattern activities given to the children,

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there are two differences: activities that require understanding the unit and activities that do not. Tasks such as copying, expanding, and filling missing elements in a pattern fall into the category of activities that do not require understanding of the unit, as these tasks encourage recursive thinking about pattern elements (McGarvey, 2012). When children are able to interpret or identify a pattern, they require an understanding of the unit of the pattern, as the next type of pattern growing patterns are considered more difficult (Wijns, Torbeyns, Bakker, Smedt, & Verschaffel, 2019).

CONCLUSSION

the five strategy categories used in this study, the participants employed three categories to solve problems in four repeated pattern tasks: attention to singular characteristics (focusing only on the appearance and number of elements), comparison & classification (beginning to compare each element of the pattern), and focus on the sequence (using awareness of order in the pattern). Although there were participants who used the "Focus on the rule" strategy, the understanding of pattern structure (determining the smallest unit) had not developed as expected. For teachers, the findings of this study are expected to provide feedback on the teaching of repeated patterns by considering the characteristics and problem-solving strategies of each child. For future researchers, this study can serve as an initial reference for further exploration of the use of these three strategies for solving repeated patterns among a larger sample of children aged 5-6 years.

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