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Computational thinking on concept pattern number: A study learning style Kolb

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Abstract

This research aimed to determine how the number pattern concept's computational thinking characteristic picture was reviewed from the Kolb model's learning style. The research method used in this study is qualitative descriptive. The research was conducted at one of the state's small schools in Bandung. The research subjects consisted of 29 students in the ninth grade. One of the 29 study issues is selected with assimilator learning styles. The data-gathering techniques used are questionnaire tests, test instruments, and interviews. Angket is used to group subjects into four groups of learning style types. The test instrument was used to describe the computational thinking characteristics of high school students on the concept of number patterns, and the interview was used to strengthen the test summary results of the subject. The results of this study show that the characteristics of computational thinking that each type of learning style dominates are different. Computational thinking students with an assimilator learning style in solving mathematical problems of number patterns can solve issues by involving decomposition, pattern identification, abstraction and generalization, and algorithms. They can generalize patterns using accurate, thorough, complete, and systematic problem-solving strategies.

Keywords: computational thinking; number pattern; learning style Kolb

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Introduction

An essential skill in the 21st century is computational thinking. The ability to think computationally is an essential basic skill for students in today's digital age. This ability is related to computers and technology and has many applications in various disciplines and everyday life. The ability to think computationally is also no less important than the ability to read and count arithmetic (Zhong et al., 2016) and become a predictable supply for life in the future (Choi et al., 2017). Competence in computational thinking is a fundamental skill for students in education, comparable in importance to the foundational skills of reading, writing, and arithmetic calculations (Zhong et al., 2016). The wrong thing that can be developed from the ability to think is computational thinking (Danindra & Masriyah, 2020). It is because computational thinking is used to solve problems (Delyana, 2015). *Computational thinking* is an essential skill that covers a wide range of fields. The field of education also involves computational thinking in solving mathematical problems. It includes solving problems of human behavior by describing the basic concepts of computer science (Wing, 2017). The significance of computational thinking lies in its recognition as a crucial competence, as contemporary students engage not only in professions influenced by computing but also encounter computational aspects in their daily routines and within the context of the present global economy (Bower et al., 2017; Grover & Pea, 2021).

Computational thinking, as explained by Wing (2008), includes the intellectual ability to detail and solve problems in a way that allows their implementation by humans, robots, or even computers. In other words, computational thinking involves formulating solutions that are effective for humans and can be implemented in a technological context by artificial entities such as robots or computing systems. It shows the increasingly important role of computational thinking skills in the context of daily life, technological developments, and current global dynamics. The phases of computational thinking include decomposition, pattern identification, abstraction, and thinking algorithms (Lee et al., 2014). The process of simplifying complex problems to be easily understood, broken down, developed, and evaluated separately is called decomposition. Decomposition can make it easier for students to solve problems because, through this decomposition, students' cognitive activity disaggregates problems into small, easy-to-solve parts (Angeli et al., 2016). Pattern identification is finding different or similar characteristics to determine a solution to a problem. This stage is also done to discover how methods are used to solve various life problems. It helps students solve problems and build solutions. Abstraction is a quick method of solving new problems that are used to solve problems through experience against similar problems. Abstraction is also another way to make problems easy to solve by eliminating unnecessary complexity (Curzon et al., 2014). It is done by filtering important information or making conclusions by removing non-essential parts of the settlement plan. Thinking algorithms are phases of solving a problem by giving a definition that matches the existing facts (Selby & Woollard, 2016). Moreover, algorithms of thinking are the stages used to find solutions in a logical and structured way.

Stimulating computational thinking in solving problems requires complex mathematical problems. One of these mathematical problems is the problem of complexity. To create the level of complexity of a complex problem, you can use an alternative; the problem presented is connected with geometry. Identifying and applying patterns will bring order to relationships and enable students to generalize beyond known information. Selling those patterns can contribute to developing mathematics and student creativity(Vale & Barbosa, 2015).

The importance of patterns in mathematics, often called the "saints of patterns" (Steiner & Resnik, 2000), provides an essential basis for mathematical learning and thinking. Selling these patterns can significantly contribute to students' mathematical and creative development (Vale & Barbosa, 2015). Patterns are essential subjects underlying learning and thinking mathematics. Mathematics is often called "the science of patterns" (Steiner & Resnik, 2000). The pattern is an early step in algebraic thinking because algebra involves using variables and symbols to express relationships and generalizations. Understanding patterns helps students understand how numbers and variables interact and form more complex mathematical relationships. The introduction of patterns can also help students to connect different mathematical concepts. It helps students see how the concepts of mathematics interact. A number pattern usually has a specific rule or property that can be identified and used to design an algorithm. In the context of a number pattern, an algorithm can generate a row of numbers following a pattern or identify a pattern in an existing string of numbers. In a geometric number model, these numbers relate to a line of geometrical build-ups in which each image is derived from the previous image with several procedures performed (Bishop, 2000). Patterns are also associated with pattern recognition and generalization phases, which are phases in computational thinking. Students understand sequence through the mathematical relationships that students find and give a specific meaning (Rivera, 2010). These patterns of numbers can give new ideas that can support computational thinking.

Computational thinking is essential to solving pattern problems; students think computationally differently. However, how each child thinks depends on how they understand and process data. In this context, individuals' "learning style," defined as their preference for an activity or learning process, is the main factor causing these differences.

Beijaard et al. (2000) define *learning style* as a process that involves cognition and affection for material, mental learning models, and learning orientation. Therefore, understanding individual learning styles is critical in exploring how students use computational thinking to solve pattern problems. The individual's "learning style," defined as their preference for an activity or learning process, is the source of this difference (Beijaard et al., 2000) defines a *learning style* as a process of cognition and affection for the material, a mental learning model, and learning orientation. According to (Beaty et al., 1997), Learning orientation covers an individual's goals, intentions, motives, expectations, attitudes, and interests during the learning process. James & Gardner (1995) define "learning styles as the complex ways and conditions in which students realize, process, store, and remember what they are trying to learn the most efficiently and effectively." They believe the most effective learning method is understanding, processing, storing, and remembering.

As students solve number pattern problems, they will naturally encounter variations in computational thinking. These differences arise because each student has a unique background experience, directly influencing how they approach and solve the problem. Students' individual experiences, whether obtained through formal education or daily experience, provide the foundation for understanding the concepts and strategies for solving number pattern problems. In addition, differences in information processing also play a role in variations in students' computational thinking. Each student has his own way of managing the information given to him. Some may be more inclined to use a logical and analytical approach, while others may rely more on intuition or a creative approach to solving problems. Students in solving the problem of number patterns will involve different computational thinking. The differences are due to the experience the student has gained and the differences in the processing of information given to him. Not only that, differences in students' learning styles are also a critical factor influencing their understanding and achievement of learning outcomes. The student's learning style will affect the achievement of his or her learning outcome (Cassidy, 2004). Kolb divides learning styles into different types: diverger, accommodator, assimilator, and converger (Amin & Suardiman, 2016).

Previous research that was considered relevant to this study, a study conducted by Mufida (2018), revealed that the computational thinking of students with high mathematical logic intelligence in solving these tasks is decomposition, pattern recognition, algorithm thinking, and generalization and abstraction of patterns. Furthermore, Danindra (2020) reveals that the computing thinking process of male and female students is highly capable of mathematics through the stages of decomposition, the introduction of the pattern, the thinking of the algorithm, and the generalization of pattern and abstract. Research the student's thinking process in solving mathematical problems (Herlina Budiarti et al., 2022; Ioannidou et al., 2011; Simanjuntak et al., 2023). Based on the description of these studies, research related to the characteristics of computational thinking for students with an assimilator learning style on the concept of number pattern has yet to be reviewed. This research aims to develop the characteristics of computational thinking, focusing on analyzing the steps to solving students who use an assimilator learning style.

However, despite the related interconnections that have been discussed before, there needs to be in-depth research related to the characteristics of computational thinking reviewed from the learning style of the Kolb model on the concept of the number pattern. Therefore, it is necessary to make a search effort on how the characteristic of computable thinking is reviewed by the style of Kolb's model learning to get an idea of the student's thinking process and can give an appropriate treatment in the students understand the pattern of numbers. Based on the descriptions of computational thought on the model number reviewed of the model learning style Kolb and the importance of this to be known with the lack of information about this, then it is essential to know how the picture of characteristic thinking computational on the concepts of numbers patterns reviewed through the model Kolb learning style. This research is expected to be a source of information for improving the education system in the future, specifically in mathematics learning.

Methods

The method used in this research was qualitative research (Cohen et al., 2017). The purpose of this study was to find out how the characteristics of computational thinking of the students of the secondary school solved the concept of number patterns reviewed from the learning style of the Kolb model. The research was carried out in one of the primary schools of the State of Bandung. The data described was qualitative data about the computational thought process of the Secondary school pupils in solving the problem of the number pattern reviewed of the learning styles of the Model Kolb. The instruments used in this research were the researchers as the main instruments, the mathematical Problem-Solving Test sheet, and the interview guidelines that the validator has validated.

The research subjects were class IX students of one of the state high schools in Bandung. One sample was selected to represent the assimilator learning style sample. The researcher first consulted with the mathematics teacher who taught the class regarding his communication skills to determine the research subject. The data collection technique uses a direct technique, where the researcher is the key instrument directly investigating the object to be studied. The 29 students were given a learning style leaflet adapted from the learning style inventory (LSI) to identify and group students into four learning styles: assimilator, accommodator, diverger, and converger. Then, the researchers grouped students based on the Kolb model.

Table 1. Classification of students' learning styles

Learning Style Type	Students
Diverger	6
Assimilator	7
Converger	12
Accommodator	4

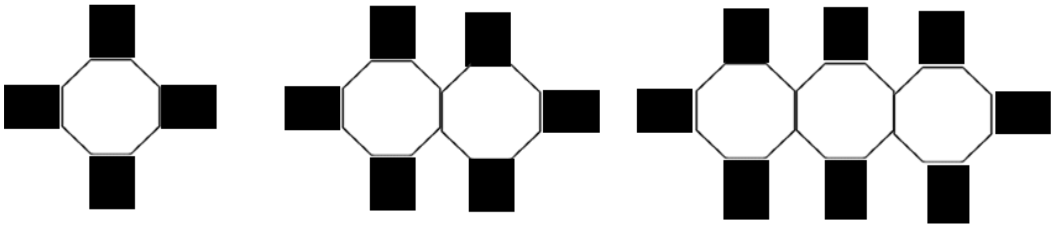
After that, the researchers consulted with the mathematics teacher who taught in the classroom about his communication skills and obtained one student, consisting of one student representing the assimilator learning style group. As for the selection of subject, as follows.

Table 2. Research subject selection results

Learning Style Type	Kode Subject
Assimilator	PA

Then, the researchers gave students a test of a computable thinking question. The interview used is a semi-structured interview whose execution is freer than a structured interview.

The picture below shows the tables and chairs that will be used closely. The table was eightfold, with four tables, two tables with six tables, and three tables with eight tables.



Question:

1. Do you try to find the number of seats on the 10th and 20th rows? How do we find it? Could you give me an explanation?
2. If the assembly process continues until n, then write down the general rule of the number of tables and seats in the order n and write down also the steps to count the numbers of those tables or seats!

Figure 1. Computational thinking test instruments

Computational thought test data results, observations, and interview results are analyzed in stages:

1. Transcribe the entire verbal data resulting from the interview
2. Reduce the data by making abstractions
3. Organize into units of units categorized by making coding
4. Analyze the computational thinking process number patterns reviewed from the learning style, and (5) draw conclusions

The *Computational Thinking* answer sheet and the interview results are analyzed. The indicators of computational thinking processes used in this study are as follows (Choi et al., 2017; Lee et al., 2014).

Table 3. Computational thinking indicators

No	Phase of Computational Thinking	Indicators
1	Decomposition	Students can identify known information from a given problem. Students can identify requested information from the given problem.
2	Pattern Recognition	Students can find similar or different patterns used to build problem-solving.
3	Abstraction and Generalization Patterns.	Students can conclude by removing unnecessary elements when implementing a problem-solving plan. The student was referring to the general pattern of similarities or differences found in the problem-solving presented.
4	Algorithms	Students discuss the logical steps used to find solutions to a given problem.

For the semiotic type, this research uses opinions (Palayukan et al., 2020; Radford et al., 2019), which are modified according to research needs, namely about computational thinking and the concept of number patterns.

Table 3. Mathematical semiotic indicators

Mathematical Semiotic	Indicators
Representation	• Students use arithmetic symbols to represent concepts, operations, variables, or ideas. • Students use mathematical symbols to express pattern relationships or sequences of number patterns.
Mathematical Object	• Students analyze the relationship of symbols between mathematical patterns in a sequence of numbers or data, • Students predict how the pattern changes from one iteration to the next.
Interpretant	• Students explain the meaning linking the representation to the studied object. • Students provide arguments to validate and explain propositions and procedures

Results

Observing the ability to think computing is done by giving the problem of solving matter number patterns to the research subject. The data in this study is documentation of written computational thinking test results, interview results, and learning style lifts. Through these data, the process of computational thinking through the stages of decomposition, pattern identification, abstraction, and algorithm thinking can be a boost measure for the researchers in concluding how the ability of the students to think computationally in solving mathematical problems on the matter of number patterns reviewed from the Kolb model learning style. Here are the results of observations of two students selected on some particular consideration to be the subject of research that has worked on computational thought of the number pattern material. Besides that, analysis of students' answers related to mathematical semiotics in solving the test questions.

Analysis of PA students' computational thinking

Based on the data collection that has been carried out at one of the state high schools of Bandung, here is the data analysis in studying the computational thinking ability of students who have the learning style of the Kolb model type Accommodator in solving mathematical problems on the concept of number patterns. Below is a preview of the written test results of an assimilator student's learning style (PA).

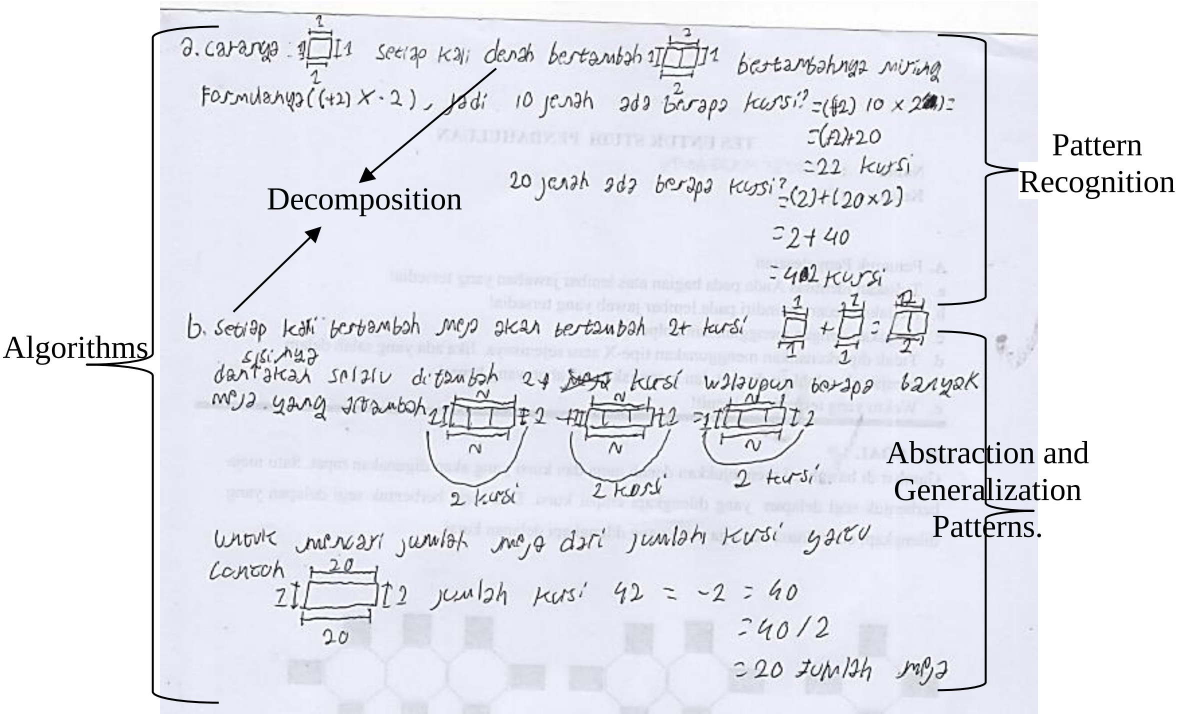


Figure 2. Analysis of PA students' answers seen from computational thinking

Decomposition Stage

Based on Figure 2, we can see that the subject does not write the information known and asked for from the given problem, but the subject PA has written the information asked for from a given problem. Based upon the description of the PA subject's answers, the researchers conducted interviews to dig for more profound information about the answers of the student PA about the decomposition skills in the subject's work. Here is a snapshot of the results of the interview of the students of PA about decomposition skills in working on the topic.

Researcher : *What do you understand about what you have given?*
PA Student : *A little, I understand.*
Researcher : *Try to explain and mention everything that's known and asked about the subject that was given. There are four seats on the table. Two tables have six seats, and three tables have eight seats.*
Researcher : *Is there anything else known about that?*
PA Student : *Yes, ma'am.*

Pattern recognition stage

Based on picture 2 shows the results of the description of the PA students' answers in the subject's work. The picture shows that the PA students write that each table and chair increase is two seats. Based on the answers to the students' descriptions of PA, the researchers interviewed to dig for more profound information about the students' answers about pattern recognition skills in the working of the topic.

Researcher : Do you try to understand more about that?
Students PA : A bit of an understanding, researcher, but what do you mean by the same thing you wrote on this answer sheet? Yeah, a little hehe. For every table that grows, the chair also grows. Missal, the first order has a table with four chairs, the second has two tables with six seats, and the following three tables have eight seats.
Researcher : That is where you saw that nickel? (Students PA: From this picture).
PA Students : From this, we can tell the difference between two of each pol sequence, that is, the researcher: Yeah, continue. The PA student: From here, we know this difference is two, so we can get the set number of seats for the 10th and the 20th seats. For the 10th seat, I use the method Number of seats = (2 x10) + 2= 20+2=22, and the number of chairs on the -20 seat is (2 x 20) +2 = 42.

Based on the above PA student interview quotation, it is known that in completing the question, PA students can determine the pattern by using the formula they find themselves to find the following number of tribal seats. There is a formula that PA students find: Un = (2 x Un) + 2.

Abstraction and generalization stage

Figure 2 shows the results of PA students' answers in working on number patterns. The picture shows that the PA student can solve the problem correctly and needs to be more complete than what was asked. In solving the problem, PA students use the formula already mentioned at the pattern recognition and modification stage. This PA student searches for many tables in the following sequence in an inductive way. Suppose in the 20th order done on the first issue, the number of seats available is 42.

Based on the description of the PA students' answers, the researchers conducted interviews to dig for more profound information about PA students' pattern abstraction skills in the subject's work.

Reseacrhe :I mentioned the finishing formula. Then what steps did you take to solve this?
PA Students : I have already found the formula for the number of chairs (2 X Un) + 2. Nach, I am considering what this is looking for in the table. I have not found a formula for the number of tables on the tribe -n.

Based on the above PA student interview quotation, it can be seen that PA students can mention the solution to the issue with steps that are less complete than what is asked. According to the PA student, the number of seats in the n-order is (2 x Un) + 2, and the number of tables in the n-quarter is (seat-2) divided by 2.

Algorithm thinking stage

Based on Figure 2, the results of PA students' descriptions in solving the issue of number patterns can be seen. PA students have answered correctly but must complete steps to solve the given problem. The researchers conducted further interviews based on the PA student's answers to learn more about algorithm thinking skills. Here is a presentation of his interview.

Researcher : *Now, explain the steps you have taken for the problem.*
PA student : *I understand the matter first. So I looked for the number of seats asked according to the pattern that I found that the difference between the first quarter and the second quarter was two seats and then too. From here, it is derived that. The pattern includes arithmetic row patterns. While looking for a table, I have been telling you the same.*

Based on the above PA student interview quotation, it can be seen that the researchers give reflection to PA students to outline steps in finding solutions. The PA students explain the problem-solving, from understanding the problem to finding the final solution. PA students exhibit what is asked, and the first completion steps still need to be at the second completion, so PA students still need to meet algorithm thinking skills.

PA students in the Accomodator type learning style category can meet the well-thinking computing and decomposition skills indicator. The skill of decomposition is a method of separating problems and solving them into smaller, easier-to-understand parts. PA students can already identify known and queried information on the number patterns. Therefore, students of the Accomodator type learning style category do not experience difficulties in solving issues at the decomposition stage. Pattern recognition skills are the stages of pattern determination to learn how the method is used. PA students can determine the pattern to solve problems and build related solutions on the number pattern material. It is concluded that students in the Accomodator type learning style category do not experience difficulties in solving issues at the stage of pattern identification.

Abstraction and generalization skills are a step in finding a way to implement a problem-solving plan and mentioning the general patterns of similarities or differences found in the problem-solving issues presented. Therefore, students who have high categories do not experience difficulties. For algorithm thinking skills, students are asked to mention the steps used to solve the problem based on the information obtained by Bai. Based on the above analysis, PA students can already mention the correct steps in solving the problem. It can be concluded that students with high categories can already solve issues at the algorithm-thinking stage.

PA students in elementalizing computational thinking in solving problems of number patterns involve five stages of computational thought (Angeli & Valanides, 2020). Subjects solve the problem without writing down the information they know and ask. It is because the subject has already understood what the problem means. According to him, the differential values of the tribes should be sought in order to find the following pattern. In this case, the subject has already profoundly understood the concept of lines. PA subjects can use formulas obtained from the algorithm process from the beginning to the end through the abstraction stages. Abstraction is an essential element of computational thinking (Cetin, 2019). Solve step by step of each implemented problem requires abstraction to decide which data should be deleted and saved (Mgova, 2018)

The subject describes the table and chair layout in the abstraction process to produce concrete and dynamic visualizations. The visualization in the abstraction process significantly helps students understand concepts (Yilmaz & Argun, 2018). This PA student can write into a general rule form pattern of numbers. This process is known as generalization. Mathematical symbols influence the generalization done by this PA student. It is in line with Vale & Barbosa (2015) that patterns found from visualization results can produce different ideas and will subsequently make a different generalization anyway. In addition, PA students, to ensure the correctness of the solution to the mathematical problem, perform a re-examination of the answers to ensure that the given solution is correct.

Semiotic analysis of PA students' mathematics

Mathematical semiotic analysis requires understanding how components such as representations, mathematical objects, and interpretations interact to shape students' understanding of a given mathematical problem. Using this understanding, teachers can provide feedback that helps students improve their understanding of number patterns and ensure that the mathematical representation is appropriate to the desired concept. To show the addition pattern in the nth term, students use pictures to show the increase in chairs for each table increasing by one. Although no general formula is shown explicitly, this notation shows that students understand the mathematical concept. As a field of knowledge, mathematics displays a unique and complex language. This uniqueness is reflected in the use of symbols, which are one of the prominent features in the representation of mathematical concepts. These symbols are not just markers but are an essential tool that allows for conveying information concisely and precisely in a mathematical context.

PA students find a sequence of numbers that follow a specific pattern by describing the arrangement of chairs and tables. This shows PA students' ability to find and show a sequence of numbers that follow the pattern described. These rules help PA students associate mathematical symbols with previous knowledge. Of course, this shows that PA students understand mathematical concepts to be solved according to existing number patterns. Using mathematical symbols in this formula shows PA students' ability to explain the relationship of patterns or sequences of numbers mathematically. Apart from that, PA students also create mathematical models related to number patterns by developing systematic steps to find general rules for the nth term. These steps include identifying the values of a and b and using general rules to find the general formula for Un. Therefore, PA students' answers demonstrate the communication of mathematical concepts in different languages in different ways. Overall, PA students' answers meet the criteria for mathematical semiotics: using mathematical symbols to predict different patterns, trying to solve problems, finding sequences of numbers, and linking symbols with previous knowledge.

Discussion

The subject understands the problem well. Students with assimilating learning styles trigger the subject to see problems as complex and solvable in several ways. The subject has several alternative solution ideas, and the most effective solution is chosen. The subject also tends to generate ideas because it has multiple alternative solutions. The PA subject's circuitry is rotary and does not repeat stages. It is because the subject chooses the way he thinks it is most effective. Solving a problem in various ways or strategies can make a student more inclined to create other strategies and improve the quality of that student (Larsson & Ryve, 2011). Students with a solid mathematical background and comprehensive experience in computation apply slightly different strategies to identify new patterns that some of the napa have undertaken (Suntusia et al., 2019). These PA students accurately showed the rough calculations on each array and did it systematically. It is consistent with Kolb's study(2014) that individuals with the learning style of the assimilator model analyze something abstract, solve problems logically, step by step, and conclude at the end of the solution. Also, in line with research by Anwar et al. (Anwar et al., 2023) and Wicasono (2021), students with an assimilator learning style can implement the resolution plan well and explain it logically. However, Ghufron and Risnawati's statement (Nur, 2013) states that students of assimilators do calculations carefully and sometimes take a long time. The results of this study show that students who are stylish learning assimilators solve problems in detail and systematically.

Overall, students' answers demonstrate the ability to make arguments, apply number patterns, and set concepts in a broader mathematical context, providing a concrete picture of how mathematics as a unique and complex language is realized. Students' astuteness in using mathematical symbols reflects their understanding of concepts. It illustrates their skills in operating mathematical language, which is characterized by the use of symbols as a means of communication. In students' hands, these symbols become an essential means of expressing arguments, applying number patterns, and linking mathematical concepts in a broader context (Presmeg, 2006; Quinnell & Carter, 2012; Skemp, 2012).

Based on the interview excerpt with PA students above, the analysis submitted by the students reflects several indicators of mathematical ability. First, students use arithmetic symbols to present solutions regarding the number of chairs and tables in a given pattern. Furthermore, they also use mathematical symbols to express pattern relationships or sequences in the number patterns discussed. Even though it is not directly stated, students can be considered to be analyzing the relationship of mathematical symbols between patterns in a sequence of numbers or data, especially involving the formula used to calculate the number of chairs and tables.

Furthermore, although not explicitly stated in the quote, students likely made predictions or understood how patterns would change from one iteration to the next, reflecting their ability to project pattern changes. The student's explanation of the meaning of the formula used shows the relationship between the symbolic representation and the object being studied, namely the number of chairs and tables in the pattern. Finally, students provide arguments regarding their solutions, showing their efforts to validate and explain the procedures applied in solving the mathematical problem. This is in line with research from Lestari et al (2020), which revealed that mathematical representation is a capability that has to be mastered by students in the learning of mathematics. Overall, students' analyses reflect their efforts to use mathematical symbols, understand pattern relationships, and provide arguments to support their solutions. However, their answers could develop clarity and comprehensiveness further. while at the interpretant phase, PA students can explain the meaning that links representations with the objects being studied and provide arguments to validate and explain propositions and procedur (Purwasih et al., 2023).

Conclusion

In solving the problem of number patterns at the decomposition phase, the PA student needs to write the information known and asked on the subject. At the stage of pattern introduction, the PA student tries to identify the patterns that may exist in the sequence of given numbers in a way that involves observing the differences between sequential numbers, multiplication, division, or other mathematical relationships. At the phase of abstraction and generalization, students use more strategies that lead to finding patterns and general forms of a problem.

The results of the mathematical semiotic analysis are that at the representation phase, PA students can express number pattern problems in mathematical symbols to express pattern relationships or sequences of number patterns and create pictures to visualize series of number patterns. At the mathematical object stage, PA students can predict how patterns change from one iteration to the next and solve problems involving number patterns. At the interpretant stage, PA students can explain the meaning that links the representation to the object being studied and provide arguments to validate and explain propositions and procedures.

The suggestion for future researchers is that this study is only limited to the computing thinking ability of students in solving mathematical problems. Therefore, other researchers wishing to undertake advanced research should study more deeply about the ability to compute students to solve other problems and are expected to be able to design existing learning to train the ability to think computing. This research can contribute to developing more effective learning strategies for understanding number patterns by considering Kolb's learning style. Teachers can adapt teaching methods more appropriate to the assimilator's learning style. This research implies that teaching must be adapted to student learning styles. Teachers can use these research findings to discover and understand students' learning preferences, which will help them create more appropriate and effective teaching strategies. Another implication was that teachers could choose teaching methods more aligned with students' computational thinking characteristics. They involve students in strategies emphasizing decomposition, pattern recognition, abstraction, and generalization and algorithms that can improve students' understanding and computational thinking skills in learning mathematical concepts.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies, have been completed by the authors.

Author Contributions

Ratni Purwasih: Conceptualization and design, writing - original draft, analysis and interpretation of data, editing, and visualization;**Turmudi:** review & editing, validation formal analysis, methodology, supervision.; **Jarnawi Afgani Dahlan**: Review, editing, and supervision.

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