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Exploration of students computational thinking abilities in solving sequences and series problems based on learning style

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ABSTRACT

Computational thinking skills play an important role in the 21st century to help students solve math problems. One way in which students' problem-solving abilities are influenced by learning style. This research aims to explore the computational thinking abilities of students studied according to visual (V), auditory (A) and kinesthetics (K) learning styles. This research uses a qualitative method through a case study model. The researcher applies data collection instruments in the form of test questions, learning style questionnaires, and interviews. Based on the test results and the learning style questionnaire, the researcher selected 2 students from each learning style. The results of this study revealed that students with a visual style showed indicators of abstraction, pattern recognition, algorithmic thinking, and generalization. Furthermore, in students with an auditory learning style, indicators of abstraction, decomposition, pattern recognition, algorithmic thinking and generalization emerge. In kinesthetics learning style students, indicators of abstraction, pattern recognition and algorithmic thinking emerge. Based on this, the conclusion obtained is that the difference in students' learning styles has an impact on indicators of computational thinking ability in solving problems related to sequences and series.

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INTRODUCTION

Industrial revolution 4.0 in the 21st century, the development of technology has greatly affected various areas of life, including education. The educational aspect plays a big role in improving students' abilities to be able to compete at the global level. All students need to be equipped with the appropriate technical knowledge and abilities to compete in this era (Tsai & Tsai, 2018). One of the skills in the 21st century that students should have is computational thinking (C. C. Selby, 2015). In line with Maharani et al. (2019)

who said that computational thinking skills are an important aspect for students in the 21st century because they not only find solutions to problems but also how to solve them. Students' computational thinking abilities play a role in helping students solve math problems (Vourletsis & Politis, 2020). So, computational thinking skills need to be trained in learning mathematics (Azizah et al., 2022).

Computational thinking (CT) is a widely applicable form of literacy that is now needed in solving problems in various fields (Lee et al., 2023). Computational thinking is a strategy or approach with basic calculation concepts to solve problems, develop systems, and understand actions performed by individuals (Wing, 2006). In line with Bocconi et al. (2016) stated that computational thinking is a thinking process to design, evaluate and solve problems using analytical techniques and algorithms. Computational thinking is defined as the skill to solve problems with the systematic application of abstraction, decomposition, algorithm design, generalization, and evaluation that can be carried out by digital devices or humans (C. Selby, 2013).

There are various indications of computational thinking. CT indicators consist of decomposition, pattern recognition, algorithmic thinking, abstraction and generalization (Csizmadia et al., 2015; Angeli et al., 2016). Purwasih et al., (2024) stated that computational thinking can be seen from someone who is able to (a) make meaning from problem data that has been obtained (abstraction); (b) breaking down complex problems into simpler ones (decomposition); (c) recognize and develop completion patterns (pattern recognition); (d) problem solving process in the form of steps (algorithms); (e) making decisions in solving new problems based on solving previous problems (generalization). Therefore, indicators of computational thinking ability are abstraction, pattern recognition, decomposition, algorithmic thinking, and generalization.

Based on the results of the Bebras 2023 competition, it shows that 1% of the participants scored above 80 and 97% of the 9092 participants scored less than 60 (Bebras Indonesia, 2023). In addition, based on the results of the International Student Assessment Program (PISA) 2022, Indonesia is ranked 69th out of 81 countries in the mathematics category. Referring to the results of PISA 2022, it shows an increase in ranking but also a decrease in scores compared to 2018, which in 2018 scored 379, while in 2022 it was 366 (OECD, 2023). PISA measures problem solving and reasoning skills (Rosana et al., 2020). If the PISA results are not good then CT ability will also be weak because CT ability is seen from the way a person solves mathematical problems (Supiarmo et al., 2022).

The characteristics of students' learning methods are one of the factors that influence the ability to solve problem (Firmansyah & Syarifah, 2023). Every student has his own method and technique to understand information (Sheromova et al., 2020). The way or habit of an individual to understand, process and store information is called learning style (Reid, 1995). Sulisawati et al., (2019) stated that learning style is an individual characteristic in understanding, organizing and processing information. According to DePorter and Henacki (2013), learning styles are grouped into three types, namely visual (V), auditory (A), and kinesthetic (K). Visual type students prefer to learn through sight, auditory type like to learn through hearing, and kinesthetic type tend to learn through physical activity and direct involvement of students, that is by moving, feeling or experiencing it themselves.

Research related to CT in terms of learning style differences was conducted by Veronica et al., (2022). In their research, Veronica et al. found that students with visual and auditory learning styles have every indicator of computational thinking, that is, identifying important information that is known and asked, building mathematical models, solving problems by breaking them into several parts, and solving them to get the correct results, while kinesthetics learning styles do mistakes when understanding problems and creating mathematical models, so the steps to solve them and the results obtained are less accurate. However, Veronica's research was conducted on elementary school students. Meanwhile, studies to examine CT abilities based on the learning style of high school students have yet to be found. Thus, this study aims to explore the computational thinking abilities of students studied through the VAK learning style. The findings from this research are expected to be a basis for educators who are interested in developing and improving students' computational thinking abilities.

METHOD

This research uses a qualitative method with a case study model. The case study design is suitable for use in this research because the researcher will explore computational thinking abilities with the characteristics of students who have visual, auditory, and kinesthetic learning styles. And students are selected based on the criteria of ability in solving high computational thinking ability test questions.

The subjects involved in this study were 60 class X students at one of the Boyolali State High Schools, Central Java. The researcher selected tenth grade students since the material used to assess computational thinking ability, namely arithmetic and geometric sequences, is taught in tenth grade. Next, interviews were conducted with 6 students, divided into 2 students for each learning style category: visual, auditory, and kinesthetic.

The research design uses qualitative analysis which can be seen in Figure 1

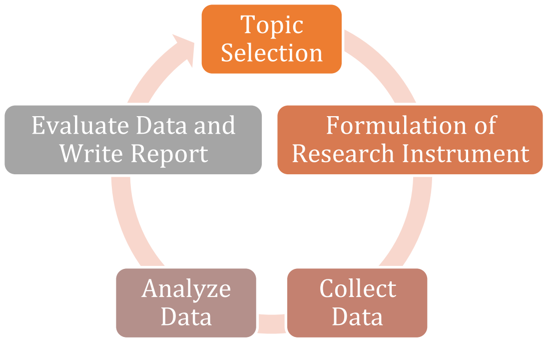
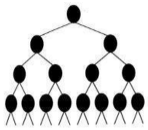


Figure 1. Qualitative Research Stages

The research instruments in this study include written tests, learning style questionnaires, and interviews. In this study, the researchers adapted 5 test questions on arithmetic and geometric sequence material from Sartini (2023) and (Azizah et al., 2022). Furthermore, the questions were designed and validated by three experts in mathematics education. Based on the results of expert confirmation, the researcher made improvements to the instrument, namely improving the question editor so that it is easier for students to understand. Then, the questions were tested on 5 high school students in the class. Therefore, the researcher only used 3 test questions as an instrument to collect data about students' computational thinking abilities which included questions about the execution of sequences, arithmetic series and geometric sequences. The test questions used in this research are presented in Table 1.

Table 1. Computational Thinking Ability Test Questions

No.	Questions
1.	Mr. Herman uses his motorcycle for daily activities. Mr. Herman recorded the number on his motorcycle's speedometer as follows: On the first day the number was recorded as 160, meaning that the motorcycle had traveled a distance of 160 kilometers. Then the next day 200, 240, 280, 320, 360, If Mr. Herman had to service his motor after traveling 2,000 kilometers, determine when Mr. Herman must service the motor?
2.	A ceramics company produces 5000 pieces of ceramics in the first month of production. With the addition of workers, ceramic production also increased by 300 ceramics per month. If production remains constant each month, how many ceramics are produced in the first year?
3.	Bacteria are free-living, single-celled microscopic organisms that can be found in air, soil, water, dust, and in the bodies of living things, including humans. The size of bacteria is so small that it can only be seen using a microscope. Bacteria can be beneficial and harmful to humans. Examples of beneficial bacteria such as Lactobacillus casei are used in the process of making yogurt and cheese. While dangerous bacteria such as Vibrio cholerae and Salmonella typhi cause disease to humans. Bacteria can reproduce sexually or asexually. Bacteria reproduce asexually by dividing or called binary fission. Binary patterns can be described as follows.  If there are initially 50 bacteria, then they multiply every 30 minutes based on a binary fission pattern. Determine the number of bacteria after 1 hour

Next, the researcher used a learning style questionnaire developed by Sugianto (2021) using a multiple choice format A (Visual), B (Auditory), and C (Kinesthetics) to identify students' learning style choices which were compiled based on learning style indicators. Referring to the results of the learning style questionnaire that was distributed to 60 students, the data obtained is contained in Table 2 below.

Table 2. Data from Student Learning Style Questionnaire

No.	Learning Style	Many Students
1.	Visual	25 people
2.	Auditory	20 people
3.	Kinesthetic	7 people
4.	Combination	9 people

Based on Table 1, there are 25 students who have a visual learning style, 20 students have an auditory learning style, 7 students have a kinesthetics learning style, and 9 other students have a combination of two learning styles. Next, the researcher selected 2 students from each visual, auditory, and kinesthetics learning style to further explore the computational thinking process through interviews. Researchers took 2 students from each learning style based on high computational thinking ability test scores. To facilitate data analysis, students with a visual learning style were coded V1 and V2, students with an auditory learning style were coded A1 and A2, and students with a kinesthetics learning style were coded K1 and K2.

The data obtained based on student answers in solving problems in the computational thinking ability test was then analyzed using the evaluation rubric presented in Table 3.

Table 3. Computational Thinking Skills Assessment Rubric

Indicator	Form of Assessment	Score
Abstraction	Students cannot represent mathematical concepts with symbols or mathematical language	0
	Students can represent some mathematical concepts with symbols or mathematical language	1
	Students can represent mathematical concepts with symbols or mathematical language but inaccurate	2
	Students can represent mathematical concepts with symbols or mathematical language correctly	3
Decomposition	Students cannot decompose complex problems into simple form	0
	Students can decompose complex problems into simple form but inaccurate	1
	Students can break down complex problems into simple form but imperfect.	2
	Students can break down complex problems into simple form correctly	3
Pattern recognition	Students cannot use patterns that matches the problem presented	0
	Students can use patterns from the problems presented but inaccurate	1
	Students can use patterns from the problems presented but imperfect	2
	Students can use patterns that matches the problems presented	3
Algorithmic Thinking	Students cannot formulate the appropriate steps to find a solution to the problem presented	0
	Students cannot arrange the steps to find a solution to the problem presented but the answer is correct	1
	Students can arrange solution steps to get a solution to the problem presented but the answer is wrong	2
	Students can arrange solution steps to get a correct answer to the problem presented	3
Generalization	Students cannot conclude important objects from previous problems to solve new problems	0
	Students can conclude important objects from previous problems but cannot use them to solve new problems	1
	Students can conclude important objects from previous problems to solve new problems but the answers are wrong	2
	Students can conclude important objects from previous problems to solve new problems and get the right answers	3

At this stage, the researcher obtains each student's computational thinking ability score for each indicator, namely the abstraction score, decomposition, pattern recognition, algorithmic thinking and generalization indicator scores. Next, in order to gain a deeper understanding of students' computational thinking abilities, the researcher conducted in-depth interviews to find out the students' thinking process to solve problems related to computational thinking indicators. In the next stage, based on the analysis of answers and interviews, the researcher makes a conclusion regarding the students' computational thinking abilities.

RESULTS AND DISCUSSION

This section presents students' answers regarding mathematical computational thinking skills in terms of visual, auditory and kinesthetics learning styles.

1. Computational Thinking Abilities of The Subject of Visual Learning Style

(1) Abstraction

Based on the results of the analysis of the answers to the test questions, both visual subjects were able to represent the concepts contained in the questions in the form of symbols. This can be seen in the example of answer V1 as a result of question number 1, as in Figure 2.

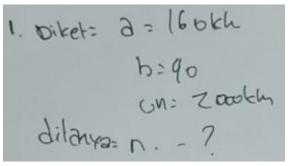


Figure 2. Answer V1 to question number 1 abstraction indicator

Figure 2 shows that V1 represents the distance travelled by Mr. Herman's motorcycle as an element of an arithmetic sequence which is the first term by writing notation a = 160 km, the daily travel distance as a difference by writing notation b = 40, and the distance travelled by Mr. Herman at time n by writing the notation Un = 2000 km. V1 is also able to represent the motor service time after traveling a distance of 2000 km with the notation n. V1's ability to identify and represent mathematical concepts in questions is supported by excerpts from interviews as follows:

P : “Explain again how you can write this information?”

V1 : “Based on the information from the question is that a = 160 because on the first day it was 160 then the next day it was 200 and the difference is 40 from 200 minus 160 while Un = 2000 and what is asked is n, which is the time Mr. Herman serviced the motorbike after traveling 2000 km”

Based on the results of the analysis of student answers and interviews, the conclusion has been made that subjects with a visual learning style are able to demonstrate the ability to calculate for mathematical thinking against abstraction indicators that is representing mathematical concepts in the form of symbols or mathematics. notation.

(2) Pattern Recognition

Based on the results of the analysis of the answers to the test questions, both visual subjects were able to recognize the problem-solving pattern presented. This can be seen in the sample answer V1 from question number 1, as shown in Figure 3.

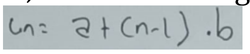


Figure 3. Answer V1 to question number 1 indicator of pattern recognition

Figure 3 shows that V1 can correctly recognize the problem-solving pattern number 1. V1 can recognize the pattern to determine the motor service time after traveling 2000 km with the notation n using the arithmetic sequence pattern which is $Un = a + (n - 1)b$. V1's ability to recognize patterns to solve problems in questions is supported by the following interview excerpt:

P : “Okay, explain why the solution can be obtained by $Un = a + (n - 1)b$?”

V1 : “Because, it is a problem with an arithmetic sequence that has a difference”

Based on the analysis of answers and interviews from students, it was concluded that subjects with a visual learning style can demonstrate the ability to think mathematically in relation to pattern recognition, which is to determine the appropriate solution pattern to solve a problem.

(3) Algorithmic Thinking

Based on the results of the analysis of the answers to the test questions, both visual subjects were able to develop steps to solve the problem and get the right answer. This can be seen in the sample answer V2 from question number 1, as shown in Figure 4.

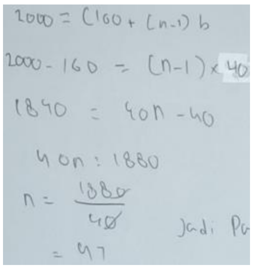


Figure 4. Answers to V2 question number 1 indicator of algorithmic thinking

Figure 4 shows V2 is able to organize the steps to solve problem number 1 systematically. V2 was able to record the steps for finding time to service a motorcycle after traveling 2000 km and produced a score of 47. V2's ability to develop steps to solve the problem in the question is supported by the following interview excerpt:

P : "Try to explain the steps to solve problem number 1?"

V1 : "From *Un* = *a* plus in brackets *n* minus 1 close the brackets times *b* next 2000 = 160 plus *n* minus 1 times b then 2000 minus 160 = *n* minus 1 multiplied by 40 then 1840 = 40*n* minus 40, 40 move side to 1840 so 1880 = 40*n* so *n* = 1880 divided by 40 gets 47"

Based on the analysis of answers and interviews from students, it was concluded that subjects who have a visual learning style can demonstrate computational mathematical thinking skills on the indicator of algorithmic thinking, which is to organize solution steps to get the correct solution to the problem and the correct answer.

(4) Generalization

Based on the results of the analysis of the answers to the test questions, both visual subjects were able to write the conclusion of each problem correctly. This can be seen in the example of V2's answer to question number 2, as in Figure 5.

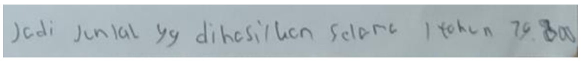


Figure 5. Answer V2 to question number 2 indicators of generalization

Figure 5 shows V2 can write the conclusion on question number 2 correctly. V2 can write a conclusion that the number of ceramics produced in 1 year is 79800. V1's ability to write a conclusion to the problem in the question is supported by the following interview excerpt:

P : "Why do you conclude that the number of ceramics produced in a year is 79800 pieces?"

V2 : "Because the calculation result I got was 79800, I wrote the conclusion like that"

Based on the analysis of answers and interviews from students, it was concluded that subjects who have a visual learning style can demonstrate the ability to think computationally in mathematics against the generalization indicator, which is to deduce important objects from previous problems to solve new problems and get the right ones. answer.

2. Computational Thinking Ability of The Subject of Auditory Learning Style

(1) Abstraction

Based on the results of the analysis of the answers to the test questions, both listening subjects were able to represent the concepts contained in the questions in the form of symbols. This can be seen in the example of A2's answer from question number 2, as in Figure 6.

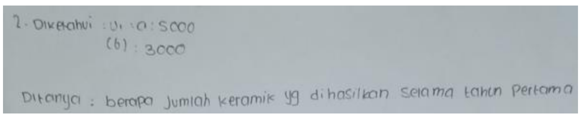


Figure 6. Answer to A2 question number 2 abstraction indicators

Figure 6 shows that A2 is able to represent the production of ceramics in the first month as an element of an arithmetic series which is the first term by writing the notation a = 5000 pieces of ceramics and the increase in ceramics every month as the difference by writing the notation. b = 300. A2 is also able to represent the total production of ceramics produced. generated for one year with the notation Sn. A2's ability to identify and represent mathematical concepts in questions is supported by interview excerpts as follows:

P : "Explain again how you can write this information?"

A2 : "For what is known I wrote $U1 = a$ = 5000, b = 3000 and what was asked was how many ceramics were produced during the first year"

Based on the analysis of student answers and interviews, it was concluded that subjects who have an auditory learning style are able to demonstrate the ability to think computational mathematics on the abstraction indicator, which is to represent mathematical concepts in the form of symbols or mathematical notation.

(2) Decomposition

Based on the results of the analysis of the answers to the test questions, both hearing subjects were able to break down a complex problem into several simpler parts than the questions presented. This can be seen in the example of A1's answer from question number 1, as shown in Figure 7.

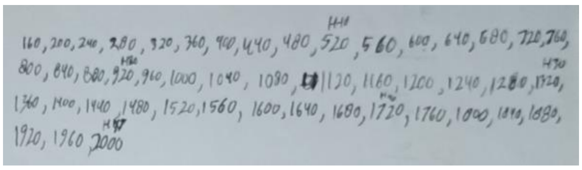


Figure 7. Answer to A1 question number 1 decomposition indicators

Figure 7 shows that A1 is able to solve complex problems more easily than problem number 1. A1 can write the number n by making a sequence starting from 160 to 2000 in detail and clearly. A1's ability to identify and break down complex problems into simple questions is supported by excerpts from the interview as follows:

P : " Try to explain how to solve the problem in question number 1?"

A1 : " I wrote the answer to number 1 at first using reason, the method is 160 plus 40 = 200 and so on until 2000, then count the number of numbers from 160 to 200 to get 47"

Based on the analysis of student answers and interviews, it was concluded that auditory learning style subjects can demonstrate computational mathematical thinking skills on the decomposition indicator, which is breaking down complex problems into simple ones.

(3) Pattern Recognition

Based on the results of the analysis of the answers to the test questions, both auditory subjects were able to recognize the problem-solving pattern presented. This can be seen in the example of A1's answer from question number 8, as shown in Figure 8.

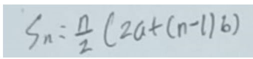


Figure 8. Answer A1 to question number 2 indicators of pattern recognition

Figure 8 shows A1 can recognize the solution pattern in question number two correctly. A1 can recognize the pattern to determine the number of ceramics in the first year with the notation Sn using the series pattern $Sn = \frac{n}{2}(2a + (n - 1)b)$. A1's ability to recognize patterns for solving problems in questions is supported by the following interview excerpt:

P : " Okay, explain why the solution can be obtained by $Sn = \frac{n}{2}(2a + (n - 1)b)$"

A1 : "Because what is being asked is the quantity, so we use the arithmetic series formula *Sn*"

Based on the analysis of answers and interviews from students, it was concluded that subjects with an auditory learning style are able to demonstrate the ability to think mathematically based on pattern recognition, which is determining the correct pattern to solve a problem.

(4) Algorithmic Thinking

Based on the results of the analysis of the answers to the test questions, both auditory subjects can develop steps to solve the problem and get the right answer. This can be seen in the example of A1's answer from question number 2, as in Figure 9.

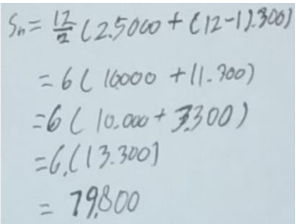


Figure 9. Answer to A1 question number 2 indicators of algorithmic thinking

Figure 9 shows that A1 can arrange the steps to solve problem number 2 correctly. A1 was able to write the steps to find the number of ceramics produced in one year and produce a value of 79800. A1's ability to develop steps to solve the problem in the question is supported by the following interview excerpt:

P : " Try to explain how to solve the problem in question number 2?"

A1 : "*Sn* = *n* divided by 2 multiplied by open bracket 2 multiplied by *a* plus open bracket *n* minus 1 closed bracket multiplied by *b* closed bracket = 12 divided by 2 open bracket 2 multiplied by 5000 plus open bracket 12 minus 1 closed bracket multiplied by 300 = 6 multiplied by open bracket 10000 plus 11 times 3 closing brackets = 6 times opening brackets 10000 plus 3300 closing brackets = 6 times opening brackets 13300 closing brackets = 79800"

Based on the analysis of student answers and interviews, it was concluded that subjects who have an auditory learning style are able to demonstrate the ability to think in computational mathematics on the basis of algorithmic thinking, which is to organize solution steps to obtain a solution to the problem presented and the correct answer.

(5) Generalization

Based on the results of the analysis of the answers to the test questions, both visual subjects were able to write accurate conclusions from the three questions presented. This can be seen in the example of A2's answer from question number 3, as shown in Figure 10.

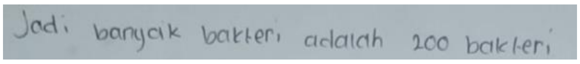


Figure 10. Answer to A2 question number 3 indicators of generalization

Figure 10 shows A2 can write the conclusion of problem number 3 correctly. A2 can write the conclusion that the number of bacteria for 1 hour is 200 bacteria. A2's ability to write a conclusion about the problem in the question is supported by the following interview excerpt:

P : " Why do you conclude that the number of bacteria after 1 hour is 200 bacteria?"

A2 : "Because the results I found were 200, so I wrote it like that"

Based on the analysis of student answers and interviews, the conclusion was made that subjects with an auditory learning style were able to demonstrate the ability to think in computational mathematics on the generalization indicator, i.e. inferring important objects from previous problems to solve new problems and get the right answer.

3. Computational Thinking Abilities of The Subject of Kinesthetics Learning Style

(1) Abstraction

Based on the results of the analysis of the answers to the test questions, both kinesthetics subjects were able to represent the concepts contained in the questions in the form of sentences or language. This can be seen in the example of A2's answer from question number 2, as in Figure 11.

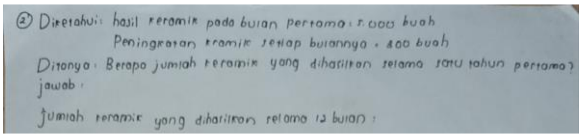


Figure 11. Answers to K1 question number 2 abstraction indicators

Figure 11 shows that K1 is able to represent the output of ceramics in the first month of 500 pieces and the increase of ceramics every month is 300 pieces. K1 can also determine the information requested in the question by writing the amount of ceramic production in the first year. K1's ability to identify and represent mathematical concepts in questions is supported by interview excerpts as follows:

P : " Explain again how you can write this information?"

K1 : "It is already known in the problem that *U1* in the first month = 5000 and the increase each month = *b* = difference = 300 then asked about the amount of ceramic production produced during the year

Based on the analysis of answers and interviews from students, it was concluded that subjects who have a kinesthetics learning style are able to demonstrate the ability to think mathematically with abstract indicators that represent mathematical concepts in the form of mathematical language.

(2) Pattern Recognition

Based on the results of the analysis of the answers to the test questions, both kinesthetics subjects were able to recognize the pattern of solutions to the problems presented. This can be seen in the example of K2's answer to question number 3, as shown in Figure 12.

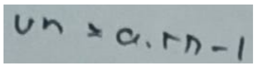


Figure 12. Answers to K2 question number 3 indicators of pattern recognition

Figure 12 shows that K2 can recognize the solution pattern in question number 3 correctly. K2 can recognize the pattern to determine the number of bacteria after 1 hour using the geometric sequence pattern which is Un= 〚ar〛^(n-1). K2's ability to recognize patterns to solve problems in questions is supported by the following interview excerpt:

P : "Okay, explain why the solution can be obtained by $Un = ar^{n-1}$"

K2 : "The formula is $Un = ar^{n-1}$ because it is known that r is a ratio which is a geometric sequence"

Based on the analysis of answers and interviews from students, it was concluded that subjects who have a kinesthetics learning style can demonstrate the ability to think mathematically computationally with pattern recognition indicators that is to determine the correct pattern to solve problems.

(3) Algorithmic Thinking

Based on the results of the analysis of the answers to the test questions, both kinesthetics subjects were able to develop steps to solve the problem and get the correct answer. This can be seen in the example of K2's answer for question number 3, as shown in Figure 13.

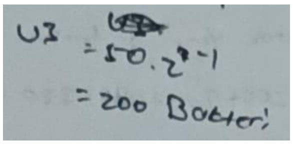


Figure 13. Answer to K2 question number 3 indicators of algorithmic thinking

Figure 13 shows that K2 can arrange the steps to solve the problem from question number 3 correctly. K2 can write the steps to find many bacteria after 1 hour and get the final result of 200 bacteria. K2's ability to develop steps to solve the problem in the question is supported by the following interview excerpt:

P : “Try to explain how to solve the problem in question number 3?”

K2 : “The answer is *Un* = *a* multiplied by r to the power of n minus 1 then enter what is known and ask, namely *U3* = 50 multiplied by 2 to the power of 3 minus 1 = 50 multiplied by 2 to the power of 2 = 50 multiplied by 4 = 200”

Based on the analysis of answers and interviews from students, it was concluded that subjects with a kinesthetics learning style are able to demonstrate the ability to think in computational mathematics with indicators of algorithmic thinking, which is to organize solution steps to obtain the correct solution to the problem and answer.

(4) Generalization

Based on the results of the analysis of the answers to the test questions, both kinesthetics subjects could not write the correct conclusions from the three questions presented. This can be seen in the example of K1's answer from question number 1, as shown in Figure 14.

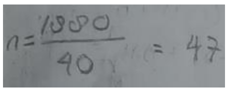


Figure 14. Answers to K1 question number 1 indicators of generalization

Figure 14 shows that K1 could not write a conclusion to the problem from the question, supported by excerpts from the interview as follows:

P : “Why don't you draw a conclusion from the problem in the question?”

K1 : “I forgot”

Based on the analysis of answers and interviews from students, it was concluded that subjects with a kinesthetics learning style could not display mathematical calculation thinking abilities with indicators of generalization, i.e. deducing important objects from previous problems to solve new problems.

Based on data analysis from the results of the computational thinking ability test and interviews, the similarities and differences in computational thinking ability can be formulated as presented as follows.

Table 4. Comparison of Learning Style Computational Thinking Abilities Visual, Auditory, and Kinesthetics

Indicator	Visual	Auditory	Kinestetik
Abstraction	Students can represent the concept of the given problem in the form of symbols or notations	Students can represent the concept of the given problem in the form of symbols or notations	Students can represent the concept of the given problem in the form of language or sentences
Decomposition	Students are cannot decompose complex problems into simple ones	Students can decompose complex problems into simple ones	Students cannot decompose complex problems into simple ones
Pattern recognition	Students can determine solution patterns according to the problem	Students can determine solution patterns according to the problem	Students cannot determine solution patterns according to the problem
Algorithmic Thinking	Students can arrange solution steps systematically to get the correct answer	Students can arrange solution steps systematically to get the correct answer	Students can arrange solution steps systematically to get the correct answer
Generalization	Students can give the correct conclusion from the problem	Students can give the correct conclusion from the problem	Students cannot give the correct conclusion from the problem

Table 4 shows that all subjects can correctly represent the mathematical concepts of the problem presented. Visual and auditory subjects represent concepts using symbols, while kinesthetics subjects represent concepts using language. The findings of this study are in line with the study of Azizah et al. (2021) and Pratiwi et al. (2021) concluded that students who tend to have an auditory, visual and kinesthetics learning style can identify and understand the concepts of problems that are known and asked completely and accurately. However, students tend to have a kinesthetics learning style that does not write and pay attention to mathematical symbols (Prayogo, 2022). Based on this, it can be concluded that the difference in students' learning styles does not affect the differences in students' computational thinking abilities towards abstract instructions.

Then, Table 4 shows that hearing subjects can decompose complex problems into simple ones. This situation is supported by the findings of Ramadhana et al. (2022) stated that students with an auditory learning style are able to create mathematical models or equations from the information provided. Students with an auditory learning style are able to show their reasoning process to solve complex problems more easily and get answers that are done very clearly and accurately (Zulfah et al., 2021).

Table 4 also shows that all subjects can use the correct pattern in solving the problem presented. The findings of this study are confirmed by previous findings that subjects with auditory, visual and kinesthetics learning styles are able to use mathematical concepts in solving problems in questions (Ayu Shofa et al., 2023; Murtiyasa & Wulandari, 2022). Based on this, it can be concluded that the difference in students' learning styles does not affect the difference in students' computational thinking abilities towards pattern recognition indicators.

Furthermore, Table 4 shows that all subjects were able to systematically develop solution steps to obtain the correct answer to the problem presented. The results of this study are supported by previous studies which state that students tend to use visual, auditory and kinesthetics learning styles and can prepare solution procedures using accurate calculations (Afifah & Apriyono, 2023; Gunawan et al., 2021). Ishartono et al. (2021) also explained that visual, auditory and kinesthetics learners have the ability to design ways to solve mathematical problems. Based on this, it can be concluded that the difference in students' learning styles does not affect the difference in students' computational thinking ability towards algorithmic thinking.

Table 4 shows that in the last indicator, which is generalization, visual and auditory subjects can deduce important objects from previous problems to solve new problems and get the correct answer. They can write and explain the conclusion of each problem correctly. This is in line with the results of the study by Septia & Nazilah, (2023) and Sholichah & Setyaningsih, (2024) showing that visual and auditory subjects are able to write or give a summary related to the given problem. On the other hand, kinesthetics subjects are unable to infer important objects from previous problems in order to solve new problems and obtain correct answers. This situation is also in line with previous studies, which is that students who have a kinesthetics learning style cannot present conclusions and prove answers to problems. (Trisnaningtyas & Khotimah, 2022).

Differences in learning styles can make a difference regarding the emergence of indicators of students' computational thinking abilities. In students with a visual learning style, indicators of abstraction, pattern recognition, algorithmic thinking and generalization appear. Furthermore, in students with an auditory learning style, indicators of abstraction, decomposition, pattern recognition, algorithmic thinking and generalization emerge. In students with a kinesthetics learning style, indicators of abstraction, pattern recognition and algorithmic thinking emerge. The findings of this study are confirmed by the findings of Alfauziyya & Masduki (2023) and Masduki et al. (2023) that students' learning styles affect students' mathematical abilities. Based on this, it can be concluded that the difference in students' learning styles has an impact on the indicators of students' computational thinking abilities regarding solving problems related to sequences and series.

CONCLUSIONS AND SUGGESTIONS

There are differences in learning styles that can make a difference regarding the emergence of indicators of students' computational thinking abilities. In students with a visual learning style, indicators of abstraction, pattern recognition, algorithmic thinking and generalization appear. Furthermore, in students with an auditory learning style, indicators of abstraction, decomposition, pattern recognition, algorithmic thinking and generalization emerge. In students with a kinesthetics learning style, indicators of abstraction, pattern recognition and algorithmic thinking emerge. Referring to this matter, it can be concluded that the difference in students' learning styles has an impact on the indicators of students' computational thinking abilities to solve problems related to sequences and series.

This finding provides the information needed by teachers to understand students' learning styles to improve computational thinking skills. The improvement of students' computational thinking will affect students' abilities in solving mathematical problems. Although this research presents significant information, the subjects involved are limited and the materials used are only lines and series. Further studies with the expansion of other subjects and topics in mathematics will provide in-depth information related to this research.

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