III.C.4. AIP

by Tim Turnitin

Submission date: 04-Aug-2023 03:20PM (UTC+0700)
Submission ID: 2141207074
File name: III.C.4._AIP.pdf (1.42M)
Word count: 4022
Character count: 21408

AIP Conference Proceedings

RESEARCH ARTICLE | MAY 15 2023

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AIP Conference Proceedings 2595, 060007 (2023)
https://doi.org/10.1063/5.0123713

How Computational Thinking Skills Students in Solving Problems on Pattern Numbers?

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Abstract. Computational thinking skills are essential 21st-century skills that enable thinking differently, solving real-world problems, and analyzing everyday problems from different perspectives. This skill is essential to be taught to students. The purpose of this study was to describe students' computational thinking skills in solving number pattern problems. The subjects of this study were 49 students who had studied number pattern material from SMP Muhammadiyah 9 Yogyakarta, SMP N 1 Pleret and SMP MBS Prambanan. Data were collected through tests which were then analyzed based on indicators of computational thinking ability, namely problem decomposition, pattern recognition, algorithmic thinking, abstraction, and generalization. The results showed that students' computational thinking skills in solving number pattern problems were categorized into three groups. First, the upper group who could fulfill all the indicators of computational thinking correctly were three students. Second, the middle group can fulfill 2 or 3 indicators correctly. There were 11 students in the middle group. Third, the lower group that only fulfilled one indicator correctly or did not meet the indicator at all were 33 students.

INTRODUCTION

The development of technology is so rapid. It is very influential in the development of the world of education. Life in the 21st century demands various skills that a person must master, so it is hoped that education can prepare students to master these skills to become successful individuals in life. Sinlarat in [1] states that learning in this era allows students to grow with their knowledge and skills as a provision for life, not only reading and writing. To equip students in this generation is certainly not an easy task. It not only requires students to equip with basic skills of reading, writing, and arithmetic, but they also need to have the ability to solve any problem in study or their daily life.

According to[2], some of the skills students need to survive in the era of the industrial revolution 4.0 include problem-solving skills, critical thinking, creativity, managing people, effective collaboration skills, emotional intelligence, and strong decision making. The Partnership for 21st Century Skills (P21) explains the framework of skills needed in the 21st century, including learning and innovation skills, which are translated into critical thinking skills, creative thinking skills, communication skills, and collaboration skills [3-5]). Meanwhile, the Assessment and Teaching of 21st Century Skills (ATC21S) categorizes 21st-century skills into four categories: a way of thinking, way of working, tools for working, and skills for living in the world [6].

4C skills must be possessed in this current era, but other skills are integrated into these four skills, namely computational thinking. Computational thinking is an essential 21st-century skill [7-10], this is supported by [11,12] mentioning that computational thinking is a skill that deserves to be "Fifth C" in21st Century Skills. Papert first introduced computational thinking in 1996, widely known for the development of Logo software. [13] defines computational thinking as the ability to solve problems, design systems, and understand human behavior by draws on fundamental computer science concepts. Computational thinking, although derived from computer science, can be applied to several problem-solving contexts.

[14] explained that computational thinking in solving problems is done by (1) breaking down complex problems into simpler problems (decomposition), (2) recognizing patterns that arise from the problems that have been described (recognize the patterns), (3) perform abstractions to find general concepts that can be used to solve the problems at hand (abstraction), and (4) develop step-by-step solutions to the problems at hand (algorithm). Meanwhile, according

Young Scholar Symposium on Science and Mathematics Education, and Environment
AIP Conf. Proc. 2595, 060007-1–060007-8; https://doi.org/10.1063/5.0123713
Published by AIP Publishing. 978-0-7354-4491-1/$30.00

to [15], computational thinking is a thinking process that utilizes elements of abstraction, generalization, decomposition, algorithmic thinking, and debugging (error detection and correction). On the other hand, [16] states that computational thinking is breaking down complex problems into more familiar problems that we can solve (problem-solving), using a set of rules to find solutions (algorithms), and using abstractions to generalize these solutions to similar problems. Lastly, automation is the final step in computational thinking that can be implemented through computational tools. This concept crosses disciplines and can be applied to subjects in primary and secondary schools.

Computational thinking in Indonesia has been included in the 2013 curriculum for informatics subjects as stated in the Appendix of the Minister of Education and Culture Number 37 of 2018 as one of the basic competencies studied in informatics subjects. Until now, computational thinking has not penetrated into other subjects that do not use computers in learning. [17] explained that among researchers in the field of computational thinking, the term Computer Science Unplugged Activities, a term to refer to learning activities for computer science principles that do not require the use of computers, this means that in studying computational thinking, you do not have to use a computer, because teaching computational thinking is teaching how students can think like a computer when solving problems. So, subjects other than informatics can also be a medium for developing students' computational thinking. [14] including computational thinking in compulsory education aims to develop computational thinking skills in children and adolescents to think in different ways, express themselves through various media, solve real-world problems, and analyze everyday problems from a different perspective. different. [18] Computational thinking has always been a part of mathematics and mathematics education. The disciplines of mathematics and computer science is closely related. Therefore, one of the subjects that can also be used to develop computational thinking is mathematics.

Characteristics of computational thinking skills belong to the HOTS higher-order thinking skills in mathematics. The results of the 2018 PISA show that the mathematical abilities of Indonesian students are still not encouraging. Indonesia achieved an average reading score of 371, math 379, and science 396, which is still far from the average for all participating countries [19]. This result certainly triggered reactions from various groups, including the Minister of Education and Culture. They stated that he would use the PISA results as one of the evaluation materials for the quality of education in Indonesia. On the other hand, at PISA 2021, the measurement of computational thinking aspects will be included in mathematical assessment [20].

One of the junior high school mathematics materials exploring students' computational thinking skills is number patterns. In number patterns, one of the challenges of mathematical thinking is to determine the elements of a number sequence that are difficult to decide on by counting one by one. As a result, solving these problems requires students to make general rules that can be treated easily for each case. In other words, in junior high school, the problem is no longer determining three terms from the sequence 2, 4, 6, … and determining certain difficult terms to find by listing one by one. In this case, it demands generalization or general symbolic form [21]. Learning on number pattern material can develop students' thinking skills [22,15] stated that computational thinking should focus on real-life problems and solve problems from simple to complex.

Based on the description above, the purpose of this article is to describe the computational thinking ability of junior high school students in solving problems on number pattern material.

RESEARCH METHOD

This research is descriptive research with a qualitative approach. The data collected is from students' computational thinking processes in solving problems on the number pattern material. The instrument used in this study is a number pattern problem-solving problem developed from the test instrument from the research [23]. It has been validated by an expert in mathematics education at the Universitas PGRI Madiun. The test was given to 49 students who had studied number pattern material from diyah 9 Yogyakarta, SMP Negeri 1 Pleret and SMP MBS Prambanan. The computational thinking test questions can be seen in Figure 1.

A junior high school student named Alvian is looking for books and stationery at the ANIDA Bookstore. At that time, the store held a grand opening at its newest branch by providing an attractive offer of 20 book packages (Package A – T in alphabetical order) with big bonuses and discounts. The packages offered are Package A consisting of two books and one pencil for each book, Package B consists of three books and two pencils for each book, Package C consists of four books and three pencils for each book, Package D consists of five books and four pencils for each book, and so on. Every purchase starting from package C will get an additional bonus. Bonuses for purchasing package C are one book and one pencil, for bonus packages for purchasing package D are one book and two pencils, for bonus packages for purchasing E packages are one book and three pencils, and so on. If Alvian buys package G, how many pencils will Alvian get? What if Alvian buys the R package? How many pencils will he get? Explain how to solve the problem in detail!

FIGURE 1. Computational Thinking Test Questions on Number Pattern Material

The results of the written test were then analyzed based on indicators of computational thinking ability. The indicators of computational thinking ability are presented in table 1 as follows.

TABLE 1. Indicators of Computational Thinking Skills

Component	Indicator
Decomposition	Breaking complex problems into smaller parts that are easier to understand and solve
Pattern recognition	Identify, recognize and develop patterns, relationships, or equations to understand data as well as strategies used to understand big data and can strengthen abstraction ideas
Algorithm	Designing a series of step-by-step operations/actions on how to solve a problem
Abstraction and Generalization	Capturing common characteristics or actions into a set that can be used to represent all other examples Skills in formulating general solutions so that they can be applied to different problems

The results of the analysis of computational thinking skills are grouped based on the completeness of the indicators of computational thinking that are met. Then one student is selected to represent each group. Selected students were also interviewed to describe their computational thinking skills. The credibility of the data in this study using triangulation techniques (tests and interviews).

RESULT AND DISCUSSION

Based on the computational thinking test results conducted by 49 students, students were grouped based on the number of indicators that were met. The upper group if the students meet all the indicators of computational thinking, the middle group if the students only meet two or three indicators, and the lower group if the students only meet one indicator or not at all.

From the results of student work, only three students were able to complete correctly and fulfill all the indicators of computational thinking. Students can solve complex problems into minor problems so that they are easy to understand. They record important information in the questions, both what is known and what is being asked. They also arrange patterns from the data obtained into a number sequence and design a solution algorithm to find the n^{th} term. After that, students abstracted and generalized by applying the same algorithm to solve the second problem.

In the middle group, 11 students can fulfill two indicators of computational thinking correctly. Students only write down important information in the problem, such as what is known and asked, and arrange a series of numbers. After that, students have difficulty in solving the problem.

In the lower group, 35 students can only fulfill one indicator correctly. Some do not meet the indicator all because of difficulties in understanding long story questions. Judging from the results of their work, students can write down important information that is known and asked. Students have not recognized and developed patterns or relationships from questions and difficulties in determining strategies to solve problems.

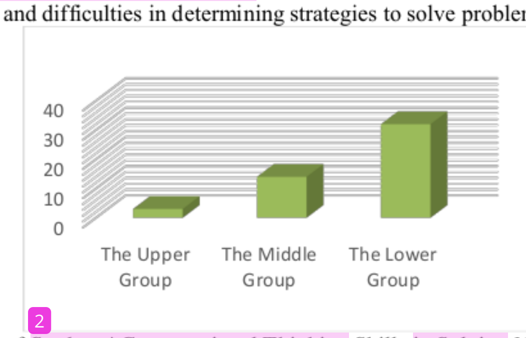
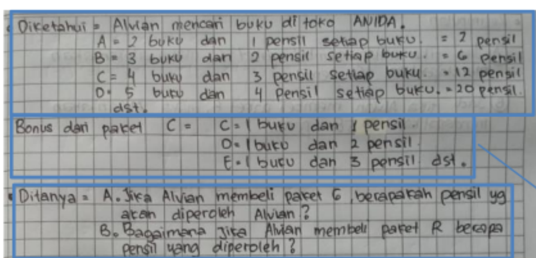


FIGURE 2. Diagram of Students' Computational Thinking Skills in Solving Number Pattern Problems

From the three groups, one student was taken from each group to describe their computational thinking ability. One student, namely AR, took the top group. One student, namely SR, took the middle group, and one HF student also took the lower group. The following is an explanation of the computational thinking ability of each student in each group.

Subject 1 (AR)

AR can solve problems correctly and fulfill all indicators of computational thinking. In problem decomposition, AR can solve complex problems into smaller parts that are easier to understand, as shown in Figure 3.



Translation:
Known: Alvian is looking for a book in Anida's shop
A: 2 books and 1 pencil for each book = 2 pencils
B: 3 books and 2 pencils for each book = 6 pencils
C: 4 books and 3 pencils per book = 12 pencils
D: 5 books and 4 pencils per book = 20 pencils
etc

Translation:
Bonus from package C: C = 1 book and 1 pencil
D = 1 book and 2 pencils
E = 1 book and 3 pencils, etc

Translation:
Asked = A. If Alvian buys package G, how many pencils will Alvian get?
B. What if Alvian buys package R, how many pencils do you get?

FIGURE 3. Problem Decomposition (AR)

In figure 3, AR writes down what information is known correctly. The number of pencils in the purchase package is n pencils times the number of books. Likewise, the bonuses obtained from every package purchase are written correctly. AR stated that "*I read the questions over and over again to understand what information was in the questions, then I wrote them down on the answer sheet.*"

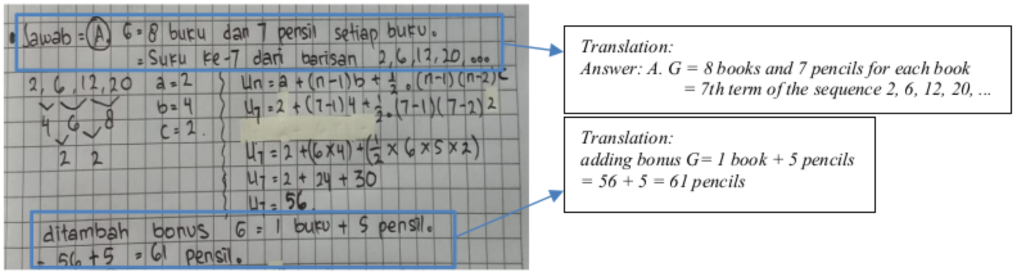


FIGURE 4. Pattern Recognition and Algorithm Thinking (AR)

Then in Figure 4, AR students can identify, recognize and make patterns related to many pencils according to what is asked. AR students make a sequence of numbers and determine the difference of each term to produce a sequence of multilevel numbers. After finding the pattern, AR students solve using the Un formula for multilevel arithmetic sequences.

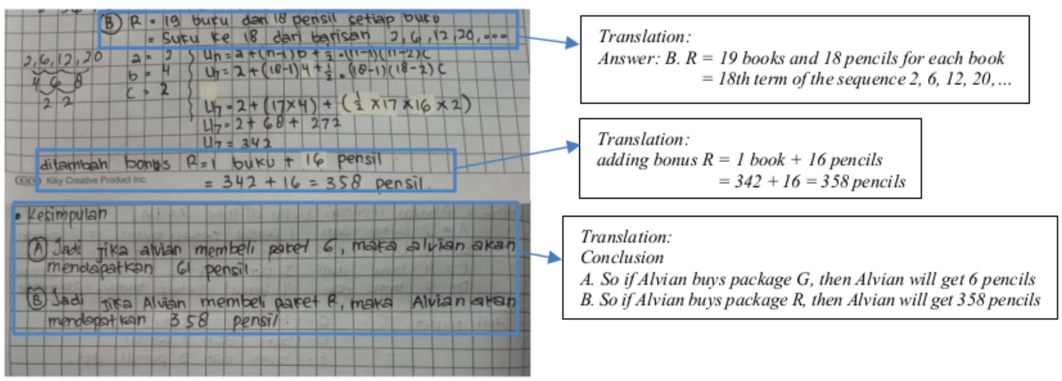
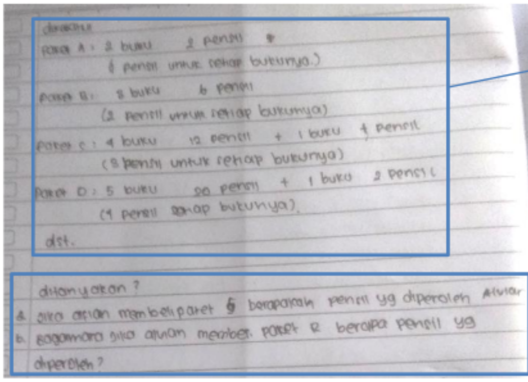


FIGURE 5. Abstraction and Generalization (AR)

After AR students can solve the first problem, AR can see the same characteristics in the second question so that the way of solving in the second case is the same as in the first question. Based on this, AR students can carry out the abstraction and generalization stages well, namely formulating general solutions so that they can be applied to different problems [15].

Subject 2 (SR)

SR is able to understand the problem well and is able to break down the information in the question into small, easy-to-understand information, as shown in Figure 6.

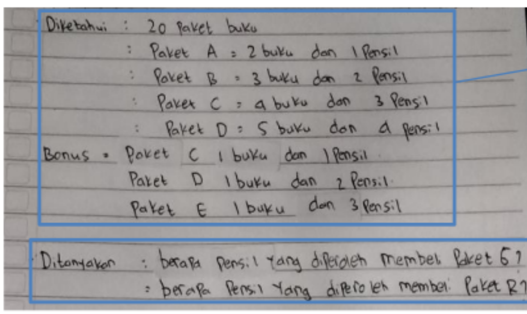


Translation:
Known:
package A: 2 books 2 pencils
(1 pencil for each book)
package B: 8 books 6 pencils
(2 pencils for each book)
package C: 4 books 12 pencils + 1 book 4 pencils
(8 pencils for each book)
package D: 5 books 20 pencils + 1 book 2 pencils
(4 pencil for each book)
etc

Translation:
Asked?
A. If Alfian buys package G, how many pencils does Alvian get?
B. What if Alvian buys package R, how many pencils do you get?

FIGURE 6. Problem Decomposition (SR)

In Figure 6, SR writes down information by emphasizing the number of pencils for each book in the package purchased and adding a bonus in the form of many books and pencils starting from package C.



Translation:
Known: 20 packs of books
Package A: 2 books and 1 pencil
Package B: 3 books and 2 pencils
Package C: 4 books and 3 pencils
Package D: 5 books and 4 pencils
Bonus: Package C: 1 book and 1 pencil
Package D: 1 book and 2 pencils
Package E: 1 book and 3 pencils

Translation:
Asked:
how many pencils will alvian get if he buys a package of G?
how many pencils will alvian get if he buys a package of G?

FIGURE 7. Pattern Recognition, Algorithmic Thinking, Abstraction and Generalization (SR)

In Figure 7, SR can answer the questions correctly. At the pattern recognition stage, students wrote down the number of books and pencils by registering. As stated by SR, "I listed many books and pencils on scribbled paper starting from packages A to R, then I added them up with the bonus." The activity carried out by SR is one of the activities of looking for relationships between data and strategies that will be used to understand big data and can strengthen abstraction ideas [24]. From the pattern made, SR has not abstracted the relationship of the data obtained into a general solution. SR has not captured the general characteristics of the created pattern that can be used to represent other examples [25]. SR had difficulty in finding a general formula for the pattern formed into mathematical symbols. Nevertheless, SR was able to find the correct answer by looking at the pattern made.

Subject 3 (HF)

HF can break down the problems into small parts that are easy to understand, but HF performs this decomposition stage less precisely, as shown in Figure 8.

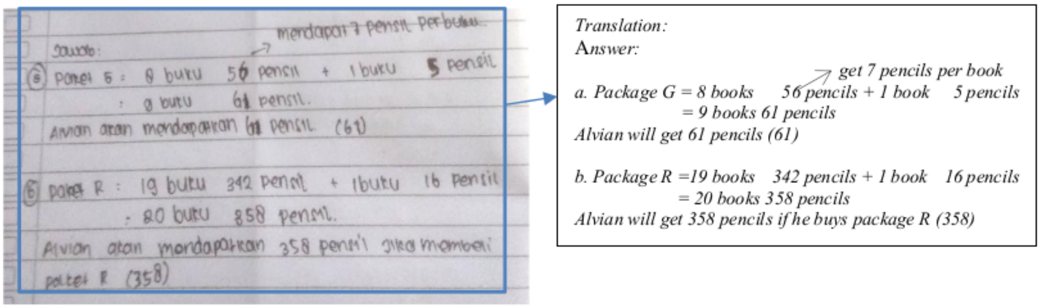


FIGURE 8. Problem Decomposition (HF)

In figure 8, HF is not careful in understanding the meaning of n pencils for each book. HF only writes n pencils without multiplying by the number of books in each package. This is also supported by HF's statement that "*questions with long sentences make me confused in understanding, so I am not careful in writing down the information in the questions*."

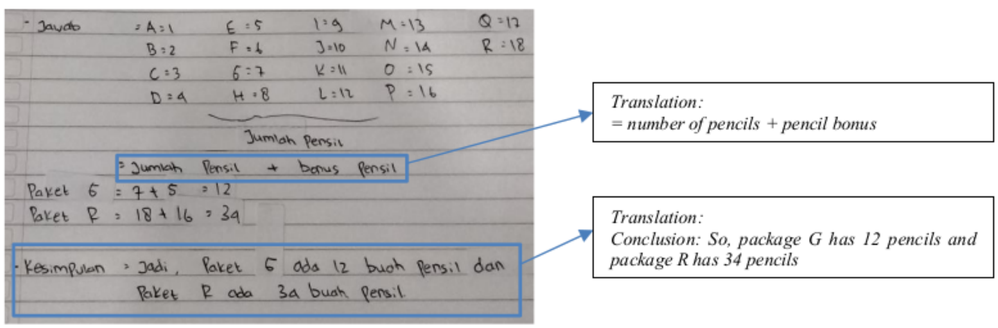


FIGURE 9. Pattern Recognition, Algorithmic Thinking, Abstraction and Generalization (HF)

In the pattern recognition stage, HF has not made a pattern of relationships from the information obtained. [24] stated that pattern recognition can help understand data and strategies used to understand big data and strengthen abstract ideas. As a result, at the stage of algorithmic thinking and abstraction and generalization, HF has not implemented it correctly. [26] stated that the ability to understand nonverbal problems underlies the skills in solving mathematical problems. This is experienced by HF, which has not been able to solve this computational thinking problem.s

CONCLUSION

The computational thinking ability of 49 students from three different schools showed varying skills. In the upper group, three students fulfill all indicators of computational thinking correctly. In the middle group, 11 students can fulfill 2 or 3 indicators of computational thinking correctly. In the lower group, 35 students can only complete one indicator of computational thinking correctly or do not meet the indicator at all. Based on these results, it is recommended to design learning that can train students' computational thinking skills.

ACKNOWLEDGMENTS

We want to thank the Directorate of Research and Community Service (DRPM) of the Ministry of Education, Culture, Research, and Technology for funding this research through the Doctoral Dissertation Research Scheme. We also thank the teachers and students of SMP Negeri 1 Pleret, SMP Muhammadiyah 9 Yogyakarta, SMP MBS

Prambanan who have assisted in this research. We do not forget to thank the Promoter and Co-Promoter and the Yogyakarta State University Postgraduate Program leaders who have guided and facilitated this research activity.

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