Computational Thinking Processes of Junior High School Students in Solving Problems of Number Patterns in Terms of Gender Differences

Lintang Sekar Danindra [1], Masriyah[2]* *Umi* Hanifah[3]

[1] Multazam Junior High School, Bogor, Indonesia
[2] Universitas Negeri Surabaya, Mathematics Department, Surabaya, Indonesia
[3] Institut Teknologi dan Sains Nahdlatul Ulama Pasuruan, Mathematics Department, Pasuruan, Indonesia

Abstract. The subjects in this study were one male student and one female student. The results of this study are the computational thinking processes of male and female students with high mathematical abilities through the stages of decomposition, pattern recognition, algorithmic thinking and abstraction and pattern generalization. The male student in the process of decomposition chose to read over and over the problem-solving question. In the process of pattern recognition, he made rows and columns to recognize the solution pattern, and then checked the solution pattern again. In the process of algorithmic thinking, he mentioned logical steps that were in accordance with the recognized solution pattern. In the process of abstraction and pattern generalization, he wrote the general pattern and conclusion of the answer to the problem-solving question and was very sure of the answer. Meanwhile, the female student in the process of decomposition read the question while underlining some important information from the problem-solving question. In the process of pattern recognition, she separated any important information that existed and gathered the information with the same characteristics to recognize the solution pattern and re-checked the pattern. In the process of algorithmic thinking, she mentioned logical steps that were in accordance with the identified solution pattern.

Keywords: Computational Thinking, Number Patterns, Gender.

1 Introduction

The challenges that occur in the world of education, especially in the increasingly dynamic school curriculums require Indonesia to be more sensitive in creating a strategic educational framework, in order to respond to global competition in the 21st century that is full of developments in technology and information science. In the 21st century, science and technology are developing so fast; therefore, students are required to be able to master a variety of skills in order to compete globally. [1] states that in the learning process, skills that should be developed in the 21st century are thinking skill and problem-solving skill. This is in line with the learning objectives of mathematics contained in the National Council of Teacher Mathematics/ NCTM (in [2]) that in mathematics learning the students can develop abilities of: (1) problem solving; (2) reasoning and proof; (3) communication; (4) connection; (5) representation. From the description above it shows that thinking skill and problem-solving skill are important factors in learning mathematics at schools, especially in this 21st century.

[3] states that a person is said to think when he is doing mental activities. The mental activity is the thinking process that occurs in the brain. [4] states that the basic mathematical objects in the form of facts, concepts, relations / operations and principles are abstract things so as to understand them, it is not enough just to memorize but a thinking process is needed. Meanwhile, according to [5] thinking is a mental activity that occurs in the mind to process information that is received and can be observed in visible behavior. Thus, in mathematics learning there needs to be an emphasis on students' thinking processes. One of the goals is to get students accustomed to processing and transforming information to solve a mathematical problem.

[6] states that computational thinking will become a basic skill used by all people in the world in the mid-21st century. This opinion is in line with Riley & Hunt's in a book entitled Computational Thinking in The STEAM Disciplines which suggests that having computational thinking skills can improve problem-solving skills and is a key attribute for the success in the 21st century. In addition, Bailey & Borwein (in [7]) state that introducing practices of computational thinking into

* Corresponding author : masriyah@unesa.ac.id

mathematics classes is important because students will plunge in the professional world later on. According to [8], computational thinking is a series of thinking patterns that include: understanding problem-solving questions with an appropriate description, reasoning at several levels of abstraction, and developing automatic solutions.

[9] defines computational thinking as a cognitive skill that enables educators to define patterns, solve complex problems into small steps, organize and make a series of steps to provide solutions and build data representations through simulations. Computational thinking is actually an approach in the learning process that has an important role in developing a computer application, but actually computational thinking can also be used to support problem-solving in mathematics learning. [10] state in his book entitled Computational Thinking that "computational thinking is sometimes portrayed as a universal approach to problem-solving". This shows that computational thinking can also be used as an approach to problem-solving. Based on the explanations above, this study used the indicators of problem-solving in accordance with computational thinking skills based on [8] as provided in the table below.

Table 1. Indicators of Computational Thinking

Computational Thinking Skills	Indicators
Decomposition	Identify information that is known from the problem-solving question presented.
	Identify information asked from the problem-solving question presented.
Pattern Recognition	Identify the same or different patterns or characteristics in solving the problem-solving question in order to build a solution.
Algorithmic Thinking	Mention the logical steps used to arrange the solution for the problem-solving question presented.
Abstraction and Pattern Generalization	Mention the general pattern of similarities / differences found in the problem-solving question presented.

In connection with mathematics lessons at school, number patterns are one of the materials taught to junior high school students. Based on the 2013 curriculum, one aspect that is studied in the material of number patterns is solving problems related to number patterns. In addition, number patterns can also be used to hone students' thinking skill. Anno (in [11]) states that learning number patterns can explore students' thinking skill. [11] argues that learning number patterns is very important because it is a mathematical activity that can develop students' thinking skill. In addition, the lesson material of number patterns can also be modified into types of problem-solving questions in mathematics, so that through its use it is expected that the computational thinking processes of junior high school students can be examined.

One of the most important things during learning in the class is the factor of student's gender. Male and female students certainly have cognitive differences that affect students' ability in learning, so male and female students certainly have many differences in solving a mathematical problem. [12] explains that there are cognitive differences between male and female, including in solving the problem-solving questions in math. The different ways of thinking certainly will affect the computational thinking processes of male and female students in solving the problems of number patterns.

Based on the description above, the researchers want to examine how the computational thinking processes of junior high school students goes in solving problems of number patterns in terms of gender differences.

2 Research Methods

This type of study is a descriptive study with a qualitative approach. This study was designed to understand and describe an experienced phenomenon by describing it in the forms of words and language. The data described were qualitative data about the computational thinking processes of junior high school students in solving the problems of number patterns in terms of gender differences. The instruments used in this study were the Mathematics Ability Test (TKM) sheet, the Mathematics Problem Solving Test sheet, and the interview guidelines that had been consulted with and approved by the supervisor and teacher of mathematics at SMPN 13 Surabaya.

The Mathematics Ability test was given to 35 students in class VIII-G and students were allocated 30 minutes to complete the test. Afterward, the results of mathematics ability tests were categorized into high, medium, and low math abilities. As a result, two students with equal high mathematics abilities were chosen, one male student and one female student. Both students were then provided with a problem-solving test sheet and allocated 60 minutes to finish the test. Then interviews were conducted to obtain more in-depth information about the computational thinking processes of junior high school students in solving the problems of number patterns. Systematically the research design can be seen in Figure 1.

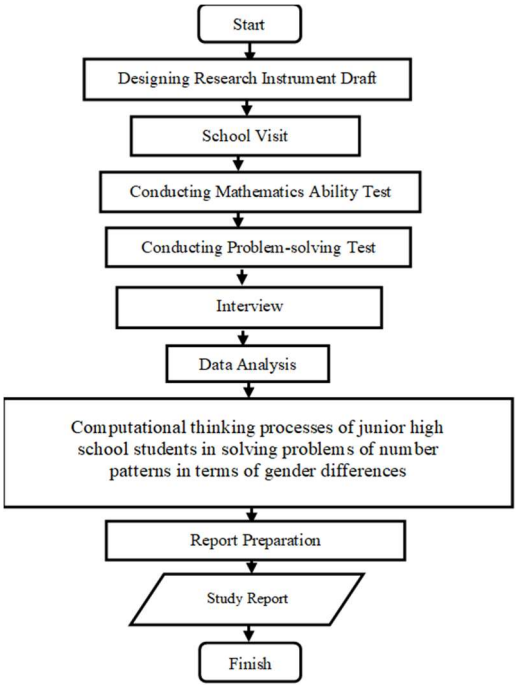

Fig. 1 Research Design

3 Result and Discussion

Table 2 shows the outcome of mathematics ability test from 35 students

Table 2. Outcome of mathematics ability test

Mathematics Ability Category	Test Score	Number of Students	
		Male	Female
High	$80 \leq x \leq 100$	1	5
Medium	$60 \leq x < 80$	5	15
Low	$0 \leq x < 60$	7	4

Note: x is the score of mathematics ability tes

Viewed from the mathematics ability categories above, two students with high mathematics ability were selected. One student was male and another student was female, and it was consulted with the subject teacher regarding student communication skills. The following are the details of the subjects selected in this study.

Table 3. Subjects of Study

No	Student Initial	Score	Gender	Mathematics Ability
1	RVR	95	M	High
2	LLPD	92	F	High

To simplify the presentation of interview transcripts, several codes are used that can represent the researcher and selected subjects. The codes are presented in the following table.

Table 4. Transcript of Interview

No	Code	Note
1.	Pn-00i	Question number i from the resercher to the subject of the study.
2.	SLt-00i	Answer number i from the male subject to the resercher's guestion.
3.	SPt-00i	Answer number i from the female subject to the resercher's guestion.

3.1 Results of Study

Following are the results of data analysis of the computational thinking processes of male and female junior high school students in solving problems of number patterns.

Danin Bakery sedang menawarkan beberapa paket kue menarik khusus di hari ini, karena hari ini adalah hari ulang tahun Danin Bakery yang ke-7. Pada hari ulang tahunnya yang ke-7 ini, Danin Bakery menyediakan penawaran 7 paket kue yang menarik. Paket kue yang ditawarkan yaitu, paket A terdiri dari satu kue dengan satu ceri, paket B terdiri dari dua kue dengan dua ceri untuk setiap kuenya, paket C terdiri dari tiga kue dengan tiga ceri untuk setiap kuenya, dan seterusnya. Tidak hanya itu, Danin Bakery juga memberikan bonus kue untuk pembelian mulai dari paket B. Setiap pembelian paket B, maka mendapat tambahan bonus satu kue dengan satu ceri. Pembelian paket C, tambahan bonus yang diberikan yaitu satu kue dengan dua ceri. Pembelian paket D, tambahan bonus yang diberikan yaitu satu kue dengan tiga ceri, dan seterusnya. Pada saat itu, Arya ingin membeli paket kue E, berapakah ceri yang didapatkan oleh Arya untuk pembelian paket kuenya?. Bagaimana cara anda mendapatkan jawaban tersebut? Jelaskan secara terperinci!

Fig. 2 Question of Problem-Solving Test

3.1.1 The computational thinking processes of the male student with high mathematics ability in solving the problems of number patterns.

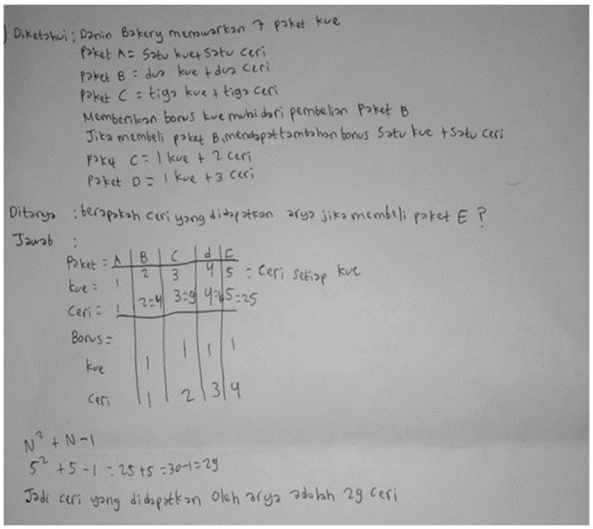

Fig. 3 Male student's answer

Based on the description of the answer from the male student, the researcher conducted interviews to explore more in-depth information about the computational thinking processes of the male student in solving the problems of number patterns.

3.1.2 Process on Decomposition Skill

Pn-001 : How do you identify information from the problem-solving question?

SLt-001 : I read it over and over Sis, and then I wrote what is known and asked on the answer sheet.

Based on the results of the work and the results of interviews, it appeared that in the decomposition process, the male student chose to read the problem-solving question over and over to identify the important information presented, and then wrote the important information on the answer sheet.

3.1.3 Process on Pattern Recognition Skill

Pn-002 : What did you do to answer the problem-solving question?

SLt-002 : At first, I was confused, Sis. I just made columns and rows so that I could do it easier.

Pn-003 : Can you explain it? (Pointing to the answer sheet)

SLt-003 : First, I made columns and rows to separate packages, cakes, cherries and bonuses, so that I wasn't confused, Sis. Then, I wrote down what packages were there. Then I wrote in all the columns for each package with the number of cakes, the number of cherries and the bonuses. Because it is related to number patterns, then I equate every package with a number pattern. Package A is the first number pattern; in package A there is one cake with one cherry. I equate package B with the 2nd number pattern. In package B there are two cakes with two cherries per cake, so package B has four cherries. Because there are additional bonuses, one cake and one cherry for purchasing package B, five cherries are added for purchasing package B. I equate Package C with the 3rd number pattern. In package C there are three cakes with three cherries per cake, so the total cherries are nine. Package C gets an additional bonus of two cherries, so the total of cherries in package C is eleven.

Pn-004 : Please explain your conclusions on how to find out how many cherries you get for each purchase of the package!

SLt-004 : In conclusion, because this is related to the number patterns, I equate each package with variable n, so n is the number pattern of the 1st through the 7th. Thus, in order to find out the number of cherries in each package, namely n, I square n. Then I add n and deduct it with 1.

Based on the results of the work and the results of interviews, it showed that in the pattern recognition process, the male student initially experienced confusion; therefore, he finally decided to make columns and rows which were then filled with the packages of cakes along with the number of cherries in each cake package purchased. Next, he equated each package with a number pattern. Then he recognized the pattern in order to build the solution pattern from the problem-solving question; n was squared, added with n and deducted with 1. Finally, he checked the solution pattern recognized.

3.1.4 Process on Algorithmic Thinking Skill

Pn-005 : Please mention what are your steps to find out how many cherries that Arya got for purchasing package E!

SLt-005 : So here goes Sis. Because Arya bought the cake package E, the number pattern was the 5th number pattern, Sis.

Pn-006 : I see. And then?

SLt-006 : Next, I made 5 squared, and then I added it with five, and after that I deducted it with one.

Based on the results of interviews, it appeared that in the process of algorithmic thinking the the male student showed logical steps in answering the problem-solving question which in accordance with the solution pattern that was recognized previously.

3.1.5 Process on Abstraction and Pattern Generalization

Pn-006 : Please mention the general pattern/formula from the problem-solving question!

SLt-006 : The formula established from the problem-solving question is N^2+N-1.

Pn-007 : Did you use uppercase letters to write the variables?

SLt-007 : Ummm, is it incorrect? It should have been written using lowercase letters.

Pn-008 : Please mention it in a complete form.

SLt-008 : So, the general formula is $Un = n^2+n-1$, and n is the formulated number pattern.

Pn-009 : Could you please let me know what your answer for the problem-solving question is?

SLt-009 : $U_5 = 5^2 + 5 - 1$
$= 25 + 4$
$= 29$

Based on the results of the work and the results of interviews, it appeared that in the process of abstraction and pattern generalization the male student mentioned the general formula for the problem-solving question in accordance with the pattern that has been identified before. Although in writing the general formula he did not do it correctly, it was already rectified during the interview process. The male student drew the conclusion in the form of the answer to the problem-solving question using the general formula established.

3.1.6 The computational thinking process of the female student with high mathematics ability in solving the problems of number patterns.

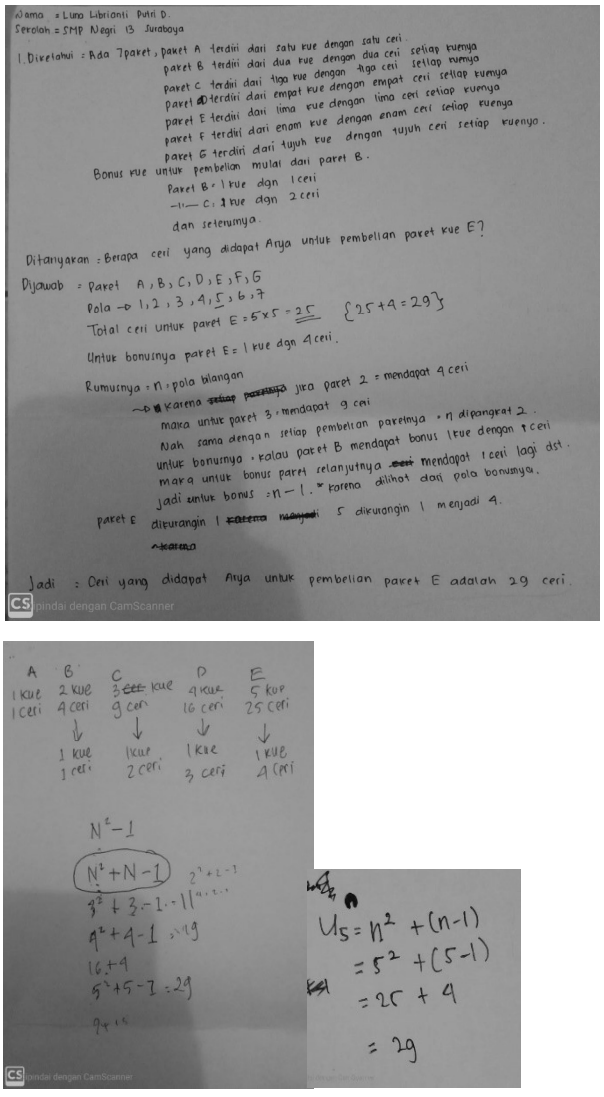

Fig. 4 Female student's answer

Based on the description from the female students' answer, the researcher conducted interviews to explore more in-depth information about the computational thinking processes of the female student in solving the problems of number patterns.

3.1.7 Process on Decomposition Skill

Pn-001 : How can you identify the information in the problem-solving question?
SPt-001 : I read the question while underlining what is known and what is asked.

Based on the results of the work and the results of interviews, it was found out that in the decomposition process the female student chose to read the problem-solving question while underlining the important information about what is known and what is asked to identify the important information presented in the question. Only then she wrote the important information on the answer sheet.

3.1.8 Process on Pattern Recognition Skill

Pn-002 : What did you do to answer the the problem-solving question?
SPt-002 : First, I equated each package with a number pattern, and then I separated each cake package available. Afterward, I wrote down the number of cakes and the number of cherries obtained for each purchase of the package, like this Sis (pointing to the answer sheet).
Pn-003 : Please explain if there was any relationship between each package and the number of cherries obtained!
SPt-003 : So, here goes Sis. First, I equated packages A, B, C, D to G to become the first, second, third pattern and so on. So, the first pattern got one cherry. The second pattern got four cherries plus one cherry as a bonus. The third package got nine cherries plus two cherries as bonuses, and so on.
Pn-004 : Could you recognize the solution pattern?
SPt-004 : So, at first, I replaced each package with n, and squared n, added it with n again, and then deducted it with 1.

Based on the results of the work and the results of interviews, it was found out that in the pattern recognition process, the female student equated each cake package with a number pattern, then separated each cake package available and put together with the number of cakes and cherries obtained for each purchase of cake package with the same characteristics. She then recognized the pattern in order to build a solution for the problem-solving question, by equating each package with n and squared it, added it with n, and deducted it with 1, and finally checked the solution pattern identified.

3.1.9 Process on Algorithmic Thinking Skill

Pn-005 : Please let me know the steps you used to find out how many cherries that Arya got for purchasing package E!
SLt-005 : So, firstly package E is equated with the 5th pattern, and 5 is squared, added with five, and deducted with 1.

Based on the results of the interview, it was found out that in the algorithmic thinking process the female student mentioned logical steps in answering the problem-solving question presented that was in accordance with the solution pattern recognized beforehand.

3.1.10 Process on Abstraction and Pattern Generalization

Pn-006 : Please mention the general pattern/formula from the problem-solving question!

SLt-006 : The formula that can be made from the problem-solving question is $U_n = n^2+n-1$.

Pn-007 : Could you please explain your answer to the problem-solving question?

SLt-007 : So, I used the formula that I already develoved. Since the formula is Un = n2+n-1, the outcome is U5 = 52+5-1 = 25 + 4 =29. Thus, the cherries that Arya got for purchasing package E are 29 cherries.

Based on the results of the work and the interview, it can be seen that in the process of abstraction and pattern generalization the female student mentioned the general formula of the problem-solving question in accordance with the pattern that had been identified previously, and drew the conclusion in the form of the answer to the problem-solving question using the general formula developed.

3.2 Discussion

Based on the data analysis described above, the discussion about the computational thinking processes of male and female junior high school students in solving the problems of number patterns is as follows.

3.2.1 The computational thinking processes of the male student with high mathematics ability in solving the problems of number patterns.

In the process of decomposition, the male student chose to read the problem-solving question over and over in order to identify information that is known and asked, and then wrote down the information on the answer sheet. He also explained whether the important information presented was enough to find the answer to the problem-solving question. In the process of pattern recognition, the first thing he did was to make rows and columns to separate each cake and cherry contained in each package. He then equated each package of cakes with a number pattern, and recognized the same or different characteristics in order to establish a solution, and finally concluded that the solution pattern of the problem-solving question was that each package was equated with *n* variable; therefore, the solution was that *n* was squared, added with *n*, and deducted with 1. He also checked the solution pattern that had been identified. After that, in the process of algorithmic thinking he mentioned the logical steps used to establish a solution for the problem-solving question that was in accordance with the conclusion of the pattern that had been recognized previously. In the process of abstraction and pattern generalization, the first activity he did was to link and deduce the general formula to the problem-solving question from the pattern recognition process done previously, so he mentioned that the general formula for the problem-solving question was Un = n^2+*n*-1. However, in the process of pattern generalization, he wrote *F* variable using capital letter and during the interview process he acknowledged this incorrectness. Furthermore, in the process of drawing the conclusion from the general pattern found in the problem-solving question, he used a general formula that he already developed so that he provided himself with the conclusion to problem solving problems with the correct answer. This is in accordance with what is stated by [13] that students with high mathematics ability are better able to solve the problem-solving question correctly.

Overall, the male junior high school student in the process of solving the problems of number pattern used four aspects of computational thinking skills. It is in accordance with the opinion of [8] stating that there are four aspects of computational thinking skills in solving a mathematical problem. This is also consistent with the result of the study conducted by [14], which suggests that male students' computational thinking in solving mathematical problems includes all aspects of computational thinking skills.

Although there was a stage where the male junior high school student had difficulty in expressing reasons in the process of solving the problems of the number pattern presented, it is most likely that the male junior high school student was not sure of the alternative answer he made, so when describing the thinking process, he needed to be directed by a few questions to get the appropriate answers.

3.2.2 The computational thinking process of the female student with high mathematics ability in solving the problems of number patterns

In the process of decomposition, the female junior high school student chose to read the problem-solving question while underlining the information about what is known and asked, and then wrote the information on the answer sheet in her own language. It is in accordance with what [17] state that female students tend to write down what they understand. In the process of pattern recognition, she first equated each package with a number pattern, then separated each package of cakes and wrote the number of cherries obtained for purchasing each cake package. She then recognized the same / different characteristics in order to establish a solution for the problem-solving question, and concluded that the solution pattern for the problem-solving question is by equating each package with n variable, and then squaring n, adding it with n and deducting it with 1. Finally, the female junior high school student double checked whether the conclusion of the solution pattern applied to each cake package available. In addition, in the process of algorithmic thinking she mentioned the logical steps used to establish a solution for the problem-solving question which was in accordance with the conclusion of the pattern that had been identified previously. In the process of abstraction and pattern generalization, she first linked and concluded the general formula with the previous process of pattern recognition, and thus stated that the general formula for the problem-solving question was Un = n2+n-1. Next, she drew the conclusion from the general pattern found in the problem-solving question presented using the general

formula that had been obtained, so she gave the answer to the problem-solving question correctly. This is in accordance with Nurman's (2008) opinion that students with high mathematics ability are better able to solve the problem-solving questions correctly.

Overall, in solving the problems of number patterns the female junior high school student used four aspects of computational thinking skills. This is in accordance with the opinion of [8] that there are four aspects of computational thinking skills in solving a mathematical problem. This is also in line with the result of the study conducted by [14], which asserts that the female students' computational thinking in solving mathematical problems includes all aspects of computational thinking skills.

4 Conclusion

The processes of computational thinking of the male junior school student in solving the problems of number patterns are as follows: (1) in the process of decomposition, he chose to read the problem-solving question several times, identified the information about what is known and asked from the problem-solving question and then wrote down the important information on the answer sheet. (2) In the process of pattern recognition, he made columns and rows which were filled with the packages of cakes along with the number of cherries obtained for each purchase of cake packages. Next, he equated each package with a number pattern. Then recognized the pattern in the problem-solving question in order to establish a solution, and finally checked the solution pattern that had been recognized. (3) In the algorithmic thinking process, he mentioned the logical steps in answering the problem-solving question that was presented and in accordance with the solution pattern previously recognized. (4) In the process of abstraction and pattern generalization, he mentioned that the general formula for the problem-solving question was in accordance with the pattern that had been recognized before. Although in writing the general formula the student was mistaken, he admitted it during the interview process. He drew the conclusion in the form of the answer to the problem-solving question using the general formula established.

The computational thinking processes of the female junior high school student in solving the problems of number patterns are as follows: (1) in the process of decomposition, she read the problem-solving question while underlining the important information about what is known and asked from the problem-solving question, then wrote the important information on the answer sheet. (2) In the process of pattern recognition, she equated each package of cakes with a number pattern, and then separated each cake package available, and gathered with the number of cakes and cherries obtained for each purchase of the cake package. She then recognized the pattern in order to establish a solution for the problem-solving question, and finally checked the identified solution pattern. (3) In the algorithmic thinking process, she mentioned the logical steps in answering the problem-solving question which was in accordance with the solution pattern previously recognized. (4) In the process of abstraction and pattern generalization, she mentioned the general formula for the problem-solving question which was in accordance with the pattern that had been recognized, and drew the conclusion in the form of answer to the problem-solving question using the general formula established.

In general, computational thinking' male students better than female students. This is in accordance with the results of the study [16] that boys had a greater disposition than girls in decomposition thinking when solving problems using computer programming. In addition, programming learning experience, especially self-directed learning and after-school learning, had significant positive effects on all dimensions of CTS.

References

[1] NSTA, C. S. (2011). Computational Thinking Teacher Resource., Nasional Science Foundation Under Grant.
[2] Rock, D., dkk. (2013). Teaching Secondary Mathematics. New York: Routlegde Taylor and Francis Group.
[3] Hudojo, H. (2005). Pengembangan Kurikulum dan Pembelajaran Matematika. Malang: UM Press.
[4] Soedjadi. (2000). Kiat Pendidikan Matematika di Indonesia. Jakarta: Direktorat Jendral Pendidikan Tinggi, Departemen Pendidikan Nasional.
[5] Isroil, A., Budayasa, I.K., dan Masriyah. (2017). Profil Berpikir Siswa SMP dalam Menyelesaikan Masalah Pola Bilangan Ditinjau dari Kemampuan Matematika. JRPM, (2017), 2(2), 93-105
[6] Wing, J. (2011). Computational thinking. New York City: Association for Computing Machinery.
[7] Weintrop, D. (2015). Defining Computational Thinking for Mathematics and Science Classrooms. J Sci Educ Technol, DOI 10.1007/s10956-015-9581-5.
[8] Ioannidou, A. (2011). Computational Thinking Patterns . Annual Meeting of the American Educational Research Association (AERA), 4.
[9] Rachim, F. Computational Thinking Computer Science, Kompasiana, diakses pada tanggal 25 Oktober (2019). (online) tersedia: https://www.kompasiana.com/fathur_rachim/55e06cc71593736c0a109023/computational-thinking-computerscience?page=all
[10] Denning, P., & Matti, T. (2019). Computational Thinking. United State: Library of Congress Under Grant.
[11] Marion, dkk. (2015). Desain Pembelajaran Pola Bilangan Menggunakan Model Jaring Laba-Laba Di SMP. Jurnal Kependidikan, Vol **45**, Nomor 1, Mei (2015), Halaman 44-61
[12] Arends. (2008). Learning to Teach. Yogyakarta: Pustaka Belajar.
[13] Nurman, Try Azizah. (2008). "Profil Kemampuan Siswa SMP Dalam Memecahkan Masalah Matematika OpenEnded Ditinjau dari Perbedaan

Tingkat Kemampuan Matematika". Tesis tidak dipublikasikan. Surabaya: PPs Universitas Negeri Surabaya.

[14] Alfina, Azza. (2017). Berpikir Komputasional Siswa dalam Menyelesaiakn Masalah yang Berkaitan dengan Aritmetika Sosial Ditinjau dari Gender. Simki-Techsain Vol. **01** No. 04 Tahun (2017).

[15] Arifin, M., & Bharata, H. (2017). Proses berpikir kreatif matematis siswa ditinjau dari pengetahuan awal tinggi dan perspektif gender. In Prosiding Seminar Nasional Matematika Dan Pendidikan Matematika (Vol. **1**, No. 1, pp. 175-184).

[16] Tsai, M. J., Liang, J. C., & Hsu, C. Y. (2021). The computational thinking scale for computer literacy education. Journal of Educational Computing Research, 59(4), 579-602.