KnE Social Sciences
ICMScE
International Conference On Mathematics And Science Education
Volume 2024

Research Article

Learning Obstacles of Junior High School Students in Computational Thinking on Number Pattern Lessons

Dwi Fitriani Rosali[1*], Didi Suryadi[2], and Suhendra Suhendra[3]

Department of Mathematics Education, Universitas Pendidikan Indonesia Jl. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia

ORCID
Didi Suryadi: https://orcid.org/0000-0003-0871-8693

Abstract.
This qualitative research employed a phenomenological approach with the aim of describing students' learning obstacles in computational thinking related to the lesson on number patterns. This study took place at one of the MTsN schools in Makassar, involving 74 students of grade 8th , out of which 12 students were selected for interviews. The research employed tests, questionnaires, and interview guidelines as research instruments. The results revealed that students faced various learning obstacles, including (a) ontogenical obstacles such as instrumental ontogenical obstacle, psychological ontogenical obstacle, and conceptual ontogenical obstacle; (b) epistemological obstacles, encompassing difficulties in pattern recognition, abstraction, and generalization due to limitations in students' contextual abilities to solve problems related to number patterns; and (c) didactical obstacles, including limitations in the teaching of number pattern lesson. The learning process fails to involve students in the process of abstraction and , resulting in incomplete material presentation. Moreover, it lacks emphasis on students' thinking process during abstraction and generalization process, and places less emphasis on problem decomposition and algoritmic thinking.

Keywords: computational thinking, junior high school, learning obstacles, number pattern lessons.

Corresponding Author: Dwi Fitriani Rosali; email: dewirosali@upi.edu

Published: 26 April 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

1. INTRODUCTION

One of the crucial and basic subjects learned in school is Mathematics. Its power and role make mathematics learning is very influential on the development of science and technology. In mathematics learning, the planting of the problem solving skills can be done through habituation in solving mathematical problems. The cultivation of problem-solving skills has basically been integrated in the education system. Problem solving becomes one of the mathematical ability that must be possessed by students [1]. In line with that, problem solving becomes a necessary ability for students in mathematics learning [2, 3] and in modern life [4]. One of the abilities that can support the student's problem-solving process is computational thinking.

Computational thinking becomes a basic skill that must be possessed by all students as the same as reading, writing, and counting [5, 6]. The Institute for the Future suggests that one of the skills that must be mastered and needed in the present is computational thinking [7]. The concept of computational thinking was first revealed by Seymour Papert [8] and various studies have been conducted for the development of the concept. Computational thinking is basically closely related to computer science that can be seen from the definition put forward by Wing [9] that computational thinking includes problem solving, designing systems, and understanding human behavior by applying the basic concepts of computer science. However, computational thinking represents a collection of attitudes and expertise that can be applied universally not only in computer science [10], but also in mathematics education [11]. Then, it is not surprising that the aspect of computational thinking is included as one of the assessment components in the implementation of PISA 2021 [12]. This adds to the pre-existing problem solving component.

Integration of computational thinking skills into PISA assessments is in line with initiatives of the establishment for Bebras International Challenge on Informatics and Computational Thinking. The idea for its development came from the Institute of Mathematics and Informatics, Lithuania [13] and have implemented since 2004. Bebras challenges the participants in terms of problem-solving and informatics skills (computational thinking skills). Based on the description above, then computational thinking becomes one of the abilities need to be considered and needs to be integrated into learning, especially in mathematics learning [14]. One of mathematics materials closely related to computational thinking is number patterns. However, students still have errors, difficulties, and obstacles, both in solving number pattern problems and in the material of number patterns in general [15]. It is possible that there are still many errors and other difficulties experienced by students related to number pattern lessons, especially related to computational thinking skills. These mistakes and difficulties can be said to be part of the learning obstacles. Learning obstacles consists of ontogenical obstacle, epistemological obstacle, and didactical obstacle [16].

Based on the above exposure, there needs steps to overcome the learning obstacles experienced by students, especially in understanding the number patterns lesson. Therefore, the purpose of this study is to describe students' learning obstacles in computational thinking on number pattern lessons. By knowing the learning obstacles experienced by students, then anticipatory steps can be done in the future.

2. RESEARCH METHOD

This research uses qualitative research with a phenomenological approach and focus on studying students' learning obstacles in computational thinking on number pattern lessons. The study was conducted at one of schools MTsN in Makassar with subjects two classes of 8^{th} grade with total 74 students that 12 students were selected for interview. Data collection is carried out using research instruments: test, questionnaires, and interview guidelines. The test consisted of 4 described questions that refered to computational thinking ability indicators tested to 74 students. Questionnaires were given to get an overview of students' interests, preparations, conditions, and responses when studying number pattern lesson and were also tested on 74 students with 20 closed statement items. The interview guidelines are semi-structured and were conducted to 12 the selected students. The collected data is then analyzed using data analysis techniques which the steps are data reduction, data presentation, and conclusion drawing.

3. result and discussion

The description of research results refers to students' learning obstacles on number pattern lessons. Research data analyzed by code "S1" for the first subject, "S2" for the second subject, and so on, "P" for the researcher, and "G" for teacher. The following are the research results.

3.1. Ontogenical Obstacle

Ontogenical obstacle is related to obstacles arising due to limitations of students' mental and cognitive development related to the material. Based on the results of tests, questionnaire results, and interviews conducted to students, there are still students who are not able to solve the problem of number pattern, especially in identifying patterns, determining the formula of the n-th term, and also in calculations. The students' interests to number pattern lessons are still low. From the results, the researcher suspected the presence of ontogenical obstacles experienced by students.

Table 1 shows the results of students' answers to questions involving calculations. The table shows that students experienced miscalculations in questions number 2.b, 3.a, and 4. The problems requires calculation, while other questions demand on students' abilities related to the identification and understanding of patterns in a row of

TABLE 1: The results of the answers of students who have miscalculated.

Problems	Description	Number of Students (Percentage)
2.b	False, due to errors in calculations	10 (**13.5%**)
3.a.		26 (**35.1%**)
4		12 (**12.2%**)

numbers/images. From the table, there are still students who answer wrongly because students make miscalculations. Basic-level mathematics involves calculations. Calculation (computation) is defined as a mathematical problem involving basic operations and includes an understanding of values and numbers as well as algorithms [17]. However, the results show that students still have errors in calculating the next term of a series of numbers.

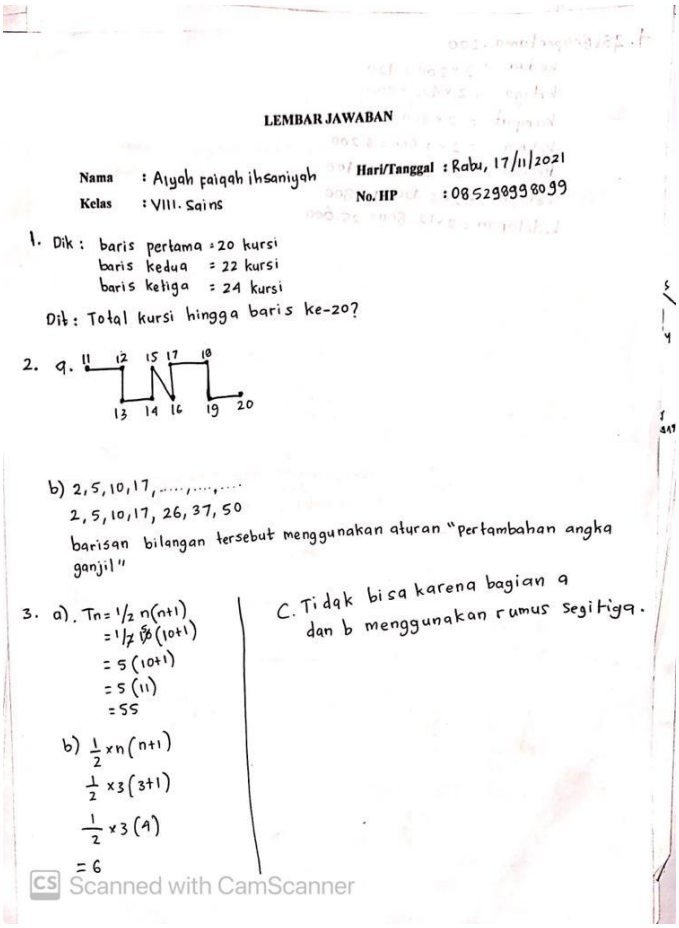

Figure 1: One of the students' answers to the problem number 2.a.

Figure 1 shows the results of the student's answer to problem number 2.a. The problem is in the form of a row of numbers in certain positions connected with lines that have certain shapes and characteristics. Students basically already know the pattern,

but they miss the details of the shape of each segment, so the implementation in determining the position of thepoints and lines becomes false. Student errors arose because they do not pay attention to every detail.

Therefore, another obstacle faced by students is the difficulty in doing the pattern recognition process because students do not pay attention to every detail and important things that are in the row of numbers/images carefully. The precision is an important thing in learing mathematics. From the quistionnaire, it is shown that most students only know and memorize the formula of the number pattern. This can hinder students in solving problems related to number patterns, namely students cannot perform the process of abstraction and generalization well because students only memorize the formulas for n-th term that have been given. By relying on the n-th formula for each pattern, then it will make students difficult to solve various problems because each pattern will have a different n-th term formula.

The meaning of students about mathematics, especially the pattern of numbers will be diminished if they only always memorize the formula for each number pattern. Mathematical knowledge is not formed by accepting or memorizing formulas, but by building the meaning. The same goes for number patterns, students need to develop their own patterns and do generalizations to determine the formula, so the students' thinking ability will be more developed. By only memorizing the formula, students are only based on how the formula is applied and not on existing patterns. Consequently, students have difficulty when faced with different problems/patterns. Overall, it is obtained that the student made a mistake related to the basic calculations, difficulty in pattern recognition because the students do not pay attention to the important things in the row of numbers/images, and difficulty in carrying out the process of abstraction and generalization because the students only memorizes the given n-th term formula. The findings were then categorized into instrumental ontogenical obstacles.

Table 2: Recapitulation of students' interest in number pattern lessons.

No.	Statements	Number of Students (Percentage)	
		TS	S
1.	I enjoy learning number pattern lessons	11 (**15%**)	63 (**85%**)
2.	I like to do problems on numbers patterns.	19 (**26%**)	55 (**74%**)

Table 3 shows that there are still students who are not happy to learn number pattern lessons and also in particular there are still students who are not happy to do number pattern problems. The student's interest factor to a certain lesson will affect the enthusiasm or motivation of students in studying the lesson. The teacher should build the student's interest to mathematics, particularly to number pattern, such as

presenting its wide application to daily activities and presenting why we should learn number pattern.

Table 3: Recapitulation of student preparation before learning number patterns.

No.	Statements	Number of Students	
		TS	S
1.	I learned number pattern lessons before the class	45 (**61%**)	29 (**39%**)
2.	I did the number pattern problems before the class took place	51 (**69%**)	23 (**31%**)
3.	I discussed the number pattern lessons before the class with my friend	43 (**58%**)	31 (**42%**)

Table 4 shows the results of student responses related to student readiness before participating number pattern lessons. The table indicate that most students did not learn number pattern lessons before class, did not work on the number pattern problems before the class, and not discussing with friends about number pattern lesson before the class. These results show that students' learning readiness related to number pattern lessons is still low.

Table 4: Recapitulation of student conditions when learning number pattern lessons.

No.	Statements	Number of Students	
		TS	S
1.	I was in good condition when the number pattern lessons took place	10 (**14%**)	64 (**86%**)
2.	I often lack focus when learning mathematics number pattern lessons	44 (**59%**)	30 (**41%**)

Table 5 shows that there are still students who are in a not good condition when learning number patterns and most students lackly focus when learning number pattern lessons. This shows that students cannot accept the learning of number pattern lessons well, so it can create a lack of understanding and ability of students in number pattern lessons. Overall, the obstacles experienced by students are in the form of low interest in mathematics materials, especially number patterns, lack of student learning preparation, and the condition of students who lackly focus when learning takes place. These obstacles are then categorized in psychological ontogenical obstacles.

Figure 2 shows the teacher's powerpoint slide related to number pattern lesson especially pascal triangle pattern. From the picture, it can be seen that the teacher presents an example involving exponent equation lessons. In its implementation, the teacher explains pascal's triangular number pattern using the concept of exponent, especially related to exponent equations. Even though the exponent equation lessons will be taught to students at the Senior Hight School. In general, students' cognitive

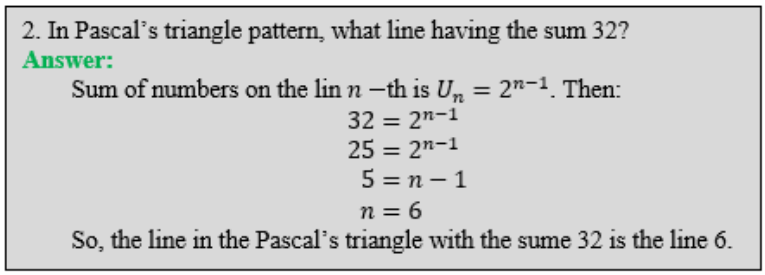
2. In Pascal's triangle pattern, what line having the sum 32?
Answer:
Sum of numbers on the lin n −th is $U_n = 2^{n-1}$. Then:
$$32 = 2^{n-1}$$
$$25 = 2^{n-1}$$
$$5 = n - 1$$
$$n = 6$$
So, the line in the Pascal's triangle with the sume 32 is the line 6.

Figure 2: Presentation slides of teachers when teaching number pattern lesson.

abilities in the material of exponent are still at the initial level, but students are given material with a further level in the form of exponent equations. In other words, Students are required to use the concepts that have never been known before. This indicates that there is a mismatch between the student's thinking demands and the student's cognitive development [18, 19] because exponent equation lessons has never been taught before. Obstacles in the form of non-conformity of student thinking demands in solving the number patterns problem, especially the use of the concept of exponent equations, is categorized into conceptual ontogenical obstacles.

3.2. Epistemological Obstacle

Epistemological obstacle is an obstacle that arises due to the limitations of students' understanding and mastery of something (concept, problem, or other) that is only associated with a certain context [20]. The test questions given to students are not routine problems. The problem are given to measure the extent of a student's computational thinking skill and how students identify a problem. Based on the results of the tests, questionnaire results, and deep interviews conducted to students, there are still students who have difficulty when the context of the given question undergoes changes/variations. This is because students assume that the questions given have never been taught or are not in accordance with the example that has been taught by teachers in the classroom. Therefore, researchers suspect the existence of epsitemological obstacles experienced by students. Here's an excerpt of an interview conducted with S11 and S5.

P : "Please telling me the pattern used in number 2a!"

S11 : "I follow the rule, namely from 5 to 6 first."

P : "But, why the answer is only a horizontal line and a straight line? Even though the pattern is not so?"

S11 : "Eh, yes. I should have followed the picture. I think my answer in not right"

P : “Have you had something like this before?”

S11 : “No, so when I answer this problem, I am dizzy and it turns out to be my wrong answer.”

P : “If faced with a new problem like before, are you going to have trouble?”

S5 : “Yes, because it is not given an example before, especially if none formula given, I don’t know what to do.”

The interview excerpt indicates that the student has never gotten the type of the problembefore, in this case the type of pattern contained in problem number 2.a. In other words, The pattern presented in question number 2.a is a new for students. Moreover, Some students have difficulty in working on number pattern problems that involve new patterns for them because students only memorize the given formula and not on their own thought process. Hence, it can be said that the student’s ability is limited to a specific context. The limitation of the context is the limitation of students’ problem-solving skills that are only limited to questions with patterns that have been taught by teachers in the classroom. Students have difficulty in doing pattern recognition because they experience limited context. Students will have difficulty when facing problems with patterns that have never been faced before [21].

Table 5: Recapitulation of student responses to number pattern lessons.

No	Statements	Number of Students	
		TS	S
1.	I like to do a number pattern problem similar to the given example	7 **(9%)**	c67 **(91%)**
2.	I am difficult in solving a number pattern problem that is different from the example	25 **(34%)**	49 **(66%)**

Table 6 shows that most students have difficulty in answering questions different from the examples given earlier. Students tend to do questions similar to examples, so it cause students having difficulty in doing abstractions and generalizations. Students are still fixated on the formula used and not on their own thinking process, so students will have difficulty when facing different problems. Students have difficulty in abstractions and generalizations because students only know and memorize the number pattern formulas that have been given by the teacher. To produce an effective learning, the learning should be arranged that makes students not only memorize the given formula [22].

Overall, it is obtained that students experience context limitations in solving number pattern problems. Context limitations on the number pattern lessons include students’ difficulty in solving number pattern problems involving new patterns/other different

patterns and the difficulty of students working on questions that are different from the examples that have been given before. Students cannot do pattern recognition well because students have difficulty when facing problems with new patterns. Students have difficulty in carrying out the abstraction and generalization to determine the formula of the n-th term because most students only know and memorize the formula of the number pattern that has been given by the teacher and they have difficulty when faced with a question that is different with the example. Hence, it can be said that students have difficulty in pattern recognition or the process of abstraction and generalization due to context limitations. All of these are then categorized as epistemological obstacles.

3.3. Didactical Obstacle

Didactical obstacle is related to the learning process that takes place in the classroom. Didactical obstacle is an obstacle that arises as a result of the selection of learning systems [23]. Based on the tests, questionnaire results, and interviews, there are still students having difficulty in determining the formula of the n-th term of a certain number pattern. Therefore, researchers suspect the existence of didactical obstacles experienced by students.

P : “Wah, it is awesome Mom, learning system now. According to you Mom, are the learning activities that have been carried out effective to teach number pattern lessons?”

G : “Yah, Of course, with all conditions or systems used, students should already understand the material of the number pattern. We don’t have another choice except carrying out such learning system. Teachers are also difficult to measure the effectiveness.”

P : “Because of online learning system, what are the obstacles you face in conveying the material?”

G : “not all do students join the online class. When asked the reason why don’t attend the class, their answers are various, because of the network quality dan some students still used their parents’ smartphone.

The interview excerpts indicate that teachers have difficulty in supervising each student in online learning to keep students focused. Another obstacle faced is the internet network which is sometimes problematic and also related to the availability of smartphone for students as a media to follow the learning. Therefore, students have difficulty and cannot even solve the given problems. The same is stated by Agustini dan Salayan [24], that one of the consequences of the limitations of learning that takes place is that students cannot solve the problem of number patterns well. Hence, it can be said

that there are learning limitations in the number pattern lessons. In the implementation of classroom learning, the teacher gives examplse of how to use formulas. The examples are of two types. The first type is to determine U_n (by using the n-th term formula that has been given before). The problems of determining U_n (by using formulas that given before) basically simple because it only needs to calculate manually and problems like this repeat on every example of number patterns presented by the teacher in the class.

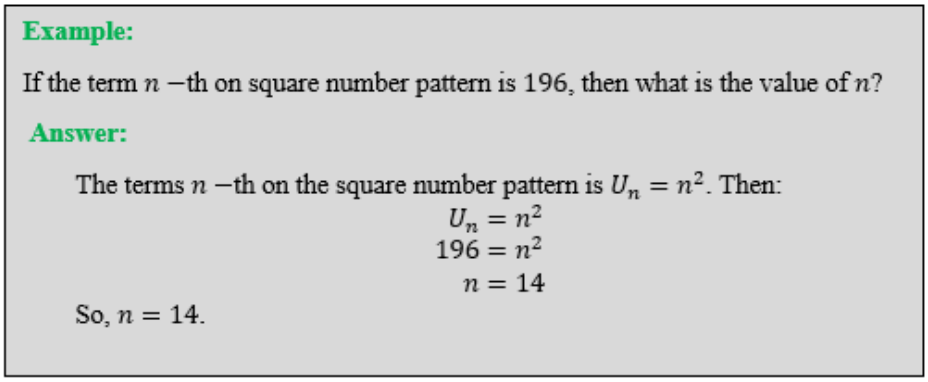

Figure 3: Presentation slides of teachers when teaching number pattern lessons.

The second type is determining the value of n with the known U_n as in the Fig. 3. The problem in the form of determining n with the known U_n is prosedural. The both types of problems do not facilitate students to conduct analysis conceptually. Teachers do not present questions that allow students' involvement in doing the construction of their own formulas. This makes students have difficulty in carrying out the process of abstraction and generalization. Therefore, it can be concluded that there is no variation of the problems given to students. Moreover, Students are only given examples and practical problems that are simple and procedural, and does not facilitate students to conduct analysis conceptually, mainly related to the process of abstraction and generalization.

P : "Now number 4, what are you thinking about after reading the problem? It is difficult?"

S12 : "I don't understand and I confused faced with problems like this and rarely does teacher teach us like this."

The interview indicate that students are difficult in solving words problems and teachers put less emphasis on words problems. The first thing that students need to do is to identify the known and asked from the problems, so the provision of word problems is closely related to problems decomposition. From the interview, it is obtained that the student cannot identify the information contained in the problem, so the students' problems decomposition is still low. Words problems arising in daily life bascially allow students to develop their algoritmic thinking skill. The lack ole giving word problems

not only leads to a lack of student ability in problems decomposition, but also makes students less trained their algorithmic thinking skills. In other words, the learning is less emphasis on problem decomposition skill and algorithmic thinking such as the lack of giving about words problem will lead the lack of student's computational thinking skills. The lack of variation of example and problems indirectly causes the lack of students' experience facing another type of problems, and then cause students being difficult in solving problems.

Overall, it is obtained obstacles in the form of learning limitations on number pattern lessons. Moreover, the learning does not involve students in the process of abstraction and generalization that makes the presentation of number pattern lessons incomplete. The learning did not emphasize the student's thinking process in identifying patterns and doing generalization to determine the n-th term formula. The teacher gives the formula without giving any explanation about how to construct the formula. Examples/problems given are also simple and procedural. In addition, these questions do not facilitate students to conduct analysis conceptually, especially related to the process of abstraction and generalization. Moreover, the learning carried out less emphasizes decomposition process and algorithmic thinking such as the lack of the words problem. These obstacles are categorized into didactical obstacles.

4. CONCLUSION

Based on the discussions, it was obtained that there are learning obstacles in computational thinking on number pattern lesson. Ontogenical obstacles identified in computational thinking on number pattern lessons includes: (a) instrumental ontogenical obstacle in the form of student errors related to basic calculations, difficulties in pattern recognition because students do not pay attention to the details in the row of numbers/images, and difficulty in doing abstractions and generalizations because students only memorize the formula given by the teacher; (b) psychological ontogenical obstacle in the form of low student interest in number pattern lessons, lack of student learning preparation, and student conditions that lackly focus when learning number patterns; and (c) conceptual ontogenical obstacle in the form of the use of of exponent equations that have never been taught to students, so it causes a mismatch on students' thinking demands in solving the number patterns problems. Epistemological obstacles found in computational thinking on number patterns lessons is difficulty of students in doing either pattern recognition or abstraction and generalization processes due to context limitations in solving problems. The didactical obstacle identified in computational

thinking on number pattern lessons is the occurrence of learning limitations on number pattern lessons because the learning system that takes place is online learning, learning does not involve students in the process of abstraction and generalization that makes the presentation of number pattern lessons becomes incomplete, and learning is also less emphasized the decomposition of problems and thinking algorithms, such as the lack of giving word problems.

References

[1] Allen CE, Froustet ME, LeBlanc JF, Payne JN, Priest A, Reed JF, et al. National council of teachers of mathematics. Arith Teach. 2020;29(5):59.

[2] Pradani SL, Nafi'an MI. Analisis kemampuan pemecahan masalah siswa dalam menyelesaikan soal matematika tipe Higher Order Thinking Skill (HOTS). Kreano, Jurnal Matematika Kreatif-Inovatif. 2019;10(2):112–8.

[3] Umrana U, Cahyono E, Sudia M. Analisis kemampuan pemecahan masalah matematis ditinjau dari gaya belajar siswa. Jurnal Pembelajaran Berpikir Matematika. 2019;4(1):67–76.

[4] L.D. English and J. Gainsburg. "12 Problem solving in a 21st-century mathematics curriculum.," In: *Handbook of International Research in Mathematics Education*. pp. 313 (2015).

[5] Hunsaker E. "Computational thinking.," In: *The K-12 Educational Technology Handbook* (2020).

[6] Wing JM. "Computational thinking benefits society.," *40th anniversary blog of social issues in computing*. vol. 2014, p. 26, 2014.

[7] Mohaghegh DM, McCauley M. "Computational thinking: the skill set of the 21st century.," *(IJCSIT)*. Int J Comput Sci Inf Technol. 2016;7(3):1524–30.

[8] Papert S. "Children, computers and powerful ideas.," *New York: Basic Books*. vol. 10, no. 1990, p. 1095592, 1990.

[9] Wing JM. Computational thinking. Commun ACM. 2006;49(3):33–5.

[10] Lye SY, Koh JH. Review on teaching and learning of computational thinking through programming: what is next for K-12? Comput Human Behav. 2014;41:51–61.

[11] Maharani S, Kholid MN, Pradana LN, Nusantara T. Problem solving in the context of computational thinking. Infinity Journal. 2019;8(2):109–16.

[12] Pisa O. Mathematics Framework. Draft; 2021.

[13] Dagiene V. Competition in information technology: An informal learning. EuroLogo; 2005. pp. 228–34.

[14] Weintrop D, Beheshti E, Horn M, Orton K, Jona K, Trouille L, et al. Defining computational thinking for mathematics and science classrooms. J Sci Educ Technol. 2016;25(1):127–47.

[15] Agustina S, Patimah S. Analisis hasil belajar matematika siswa kelas viii pada materi pola bilangan di Kota Cimahi. UNION: Jurnal Ilmiah Pendidikan Matematika. 2019;7(2):201–8.

[16] Brousseau G. Theory of didactical situations in mathematics: Didactique des mathématiques, 1970–1990. Springer Science & Business Media; 2006.

[17] Nelson G, Powell SR. Computation error analysis: students with mathematics difficulty compared to typically achieving students. Assess Eff Interv. 2018;43(3):144–56.

[18] Bakar MT, Suryadi D, Darhim D. "Learning obstacles on linear equations concept in junior high school students: Analysis of intellectual need of DNR-based instructions.," In: *Journal of Physics: Conference Series*. pp. 32104. *IOP Publishing* (2019). https://doi.org/10.1088/1742-6596/1157/3/032104.

[19] Noto MS, Pramuditya SA, Handayani VD. Exploration of learning obstacle based on mathematical understanding of algebra in junior high school. Eduma: Mathematics Education Learning and Teaching. 2020;9(1):14–20.

[20] Suryadi D. *Monograf 2: Didactical Design Research (DDR. Gapura Press*, Bandung, 2019.

[21] Simon MA. Reconstructing mathematics pedagogy from a constructivist perspective. J Res Math Educ. 1995;26(2):114–45.

[22] Sari NI, Subanji S, Hidayanto E. Diagnosis kesulitan penalaran matematis siswa dalam menyelesaikan masalah pola bilangan. Jurnal Kajian Pembelajaran Matematika. 2018;2(2):64–9.

[23] Brousseau G. Theory of didactical situations in mathematics: Didactique des mathématiques, 1970–1990. Springer Science & Business Media; 2006.

[24] Agustini WT, Salayan M. Efektifitas pembelajaran daring pada mata pelajaran matematika selama pandemi Covid-19 di MTs. Swasta Nurul Amaliah Tanjung Morawa; 2021.