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Computational Thinking Process of High School Students in Solving Sequences and Series Problems

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Abstrak

Kemampuan berpikir komputasi merupakan keterampilan berpikir yang dibutuhkan pada abad 21. Penelitian ini bertujuan untuk mendeskripsikan proses berpikir komputasi siswa SMA/MA dalam menyelesaikan masalah barisan dan deret. Penelitian ini merupakan penelitian deskriptif dengan pendekatan kualitatif. Teknik pengumpulan data dilakukan dengan tes dan wawancara. Subjek dalam penelitian ini adalah siswa kelas XI IPA MA Muhammadiyah Kota Pekanbaru sebanyak 15 orang. Analisis terhadap kemampuan berpikir komputasi siswa dilihat melalui indikator. Hasil analisis menunjukkan bahwa siswa yang berkemampuan tinggi berada dalam kategori sangat baik pada indikator dekomposisi (87,5%) dan abstraksi (97,5%), kategori baik pada indikator berpikir algoritma (65%) dan kategori cukup pada indikator pengenalan pola (50%). Siswa berkemampuan sedang dalam kategori baik pada indikator abstraksi (62%), kategori cukup pada indikator dekomposisi (51,5%), kategori rendah pada indikator pengenalan pola (33,5%) dan berpikir algoritma (39%). Siswa berkemampuan rendah berada dalam kategori rendah untuk tiga indikator yaitu dekomposisi (38,3%), abstraksi (33,3%), berpikir algoritma (21,7%), dan kategori sangat rendah pada pengenalan pola (11,67%).

Kata kunci: Berpikir Komputasi, Barisan dan Deret

Abstract

The ability of computational thinking is logical thinking that is needed in the 21st century. This research aims to describe the process of computational thinking in the Senior High School students in completing the problem of arithmetic sequence and series. This research is descriptive research using a qualitative approach. The data collection technique uses tests and interviews. Furthermore, the subject of the research is 15 students of class XI IPA at MA Muhammadiyah Pekanbaru. The students' computational thinking could be seen through decomposition indicators, pattern recognition, abstraction, and algorithmic thinking. The results of the analysis indicate that students with high abilities are in a very good category on the decomposition indicators (87.5%) and abstraction (97.5%), good categories on the algorithmic thinking indicator (65%), and, the moderate category on the indicators pattern recognition (50%). For students with moderate abilities, they are in a good category on the abstraction indicator (62%), sufficient category on the decomposition indicator (51.5%), the low category on the pattern recognition indicator (33.5%), and algorithmic thinking (39%). Meanwhile, low-ability students are in the low category for three indicators, namely decomposition (38.3%), abstraction (33.3%), algorithmic thinking (21.7%), and very low category on pattern recognition indicators (11.67%).

Keywords: *computational thinking*, *arithmetic sequence and series*

1. INTRODUCTION

The Industrial Revolution 4.0 in the 21st century has an impact on all areas of life, including education. The education sector has a big role in improving students' skills so that they can be globally competitive and take a significant role in it. The skill that can support the above is computational thinking. According to Maharani et.al (2019) that the ability to think computationally is an important ability of students in the 21st century, because in the process, problem solving is not only focused on solving the problem but more focused on how to solve it. Zahid (2020) also said that the PISA framework illustrates that computational thinking can function in the problem solving process, when carrying out problem formulation and when carrying out mathematical reasoning. According to Citta (2019) that computational thinking is a series of abstract mental activities in the form of reasoning processes such as abstraction, parsing, pattern drawing, pattern identification, algorithmic thinking, automation, modeling, simulation, evaluation, experimentation.Wing (2011) states that computational thinking will become a basic skill used by all people in the world in the mid-21st century. According to Bailey and Borwein in Weintrop et.al (2016) that by introducing the practice of computational thinking into science and mathematics classes is something important because later students will enter the professional world. So that computational thinking skills are needed in the 21st century and need to be trained in learning mathematics.

To see students' abilities, it is necessary to have indicators of computational thinking abilities. According to Bocconi in Ariesandi et.al (2021) that computational thinking can be seen from someone who is able to (a) parse complex problems into simpler ones (decomposition), (b) from problems that have been parsed to then identify emerging patterns (c) carry out abstractions in order to get generalizations. Used in solving the problem (abstraction), (d) a step-by-step solution developed to solve the problem (algorithm). In line with CSTA's opinion in Asbell-Clarke et.al (2021) indicators of computational thinking are decomposition, pattern recognition, pattern generalization and abstraction and algorithmic thinking. So that the indicators of computational thinking ability are decomposition, pattern recognition, abstraction, and algorithmic thinking.

Several previous studies related to computational thinking processes, including research Supiarmo et.al (2021) The students' computational thinking ability in working on PISA questions is only at the pattern recognition stage, students can't yet at the abstraction stage and think algorithmically. Sa'diyyah et.al (2021) it was found that the students' computational thinking ability was still relatively low, students had not been able to describe the problem and get the problem solving pattern correctly. Mufidah (2018) said that it is necessary to improve computational thinking skills in mathematics learning because students are still not able to work on problems by integrating the information obtained which results in low computational thinking skills. Study Danindra & Masriyah (2020) which describes that there are differences in the computational thinking processes of male and female students in solving number pattern problems. Based on previous research, the novelty of this research is to describe the computational thinking process of senior high school students in solving problems on sequences and series.

Sequence and series material is one of the materials taught to senior high school students in class XI even semesters. The material of sequences and series is related to patterns. According to Fauzi et.al (2022) that computational thinking is one of the abilities to recognize pattern recognition. In line with Ferrara et.al (2004) also says the concept of sequences can be used to help find patterns. So that by thinking computationally, students can more easily recognize and generalize a pattern on the material of sequences and series.

Based on the problem and supported by the absence of research related to the context of the computational thinking process that students have in solving problems of sequences and series.

Therefore, researchers need to conduct research with the title "Computational Thinking Process of Senior High School Students in Solving Sequences and Series Problems".

2. METHOD

This research uses descriptive qualitative research. The subjects in this study were 15 students of class XI IPA MA Muhammadiyah Pekanbaru, then six students were taken consisting of 2 people from each category of high, medium, low ability to be interviewed. The research procedure used is carrying out preliminary activities, compiling tests and interview guidelines, validating tests and interviews, collecting data and drawing conclusions.

Tests and interview guidelines are instruments used in this study. Students were interviewed to get more detailed information about high school students' computational thinking processes in solving sequences and series problems. The interview used is a semi-structured interview. While the description test questions consist of 5 questions on line and series material which have been validated by 2 supervisors.

The description test refers to the indicators of computational thinking ability according to Bocconi in Ariesandi et.al (2021) namely (a) decomposition, students' ability to break down problems into detailed components, (b) pattern recognition, students' ability to identify the same or different patterns or details in problem solving given to find solutions, (c) abstraction, students' ability to identify important details so that find patterns or form representations (ideas) to find solutions, (d) think algorithms, students' ability to find the right solution.

In addition to requiring question indicators, there is a need for scoring guidelines that are used as a reference in processing and analyzing test result data. Modified scoring guidelines Hadi (2021) namely: each indicator of decomposition, pattern recognition, abstraction, and thinking algorithms will get a score of 4 if students are able to write answers in detail and accurately, score 3 if students write answers correctly but there are still shortcomings, score 2 if students can write answers but still an error was found, a score of 1 if the student wrote an answer but it was wrong, and a score of 0 if he did not write down the answer.

The data analysis techniques in this study are: (1) data reduction, performing data reduction in this case is the answer to the material test of sequences and series and the results of semi-structured interviews in the form of verbal expressions of computational thinking processes. The results of the computational thinking ability test are then grouped into categories of students who have high computational thinking ability, moderate computational thinking ability and low computational thinking ability based on the results of the answers to the description of the sequence and series material, (2) data presentation, data is analyzed and described as a reference in make conclusions about the research that has been carried out, (3) draw verification/conclusion, researchers make conclusions to carry out the final analysis in the form of articles.

3. RESULTS AND DISCUSSION

Based on the test results for the description of the sequence and series material, students are grouped based on the categories of high, medium, and low computational thinking abilities. The criteria for grouping student abilities can be seen in the following table:

Table 1. Criteria for Grouping Students based on Computational Thinking Ability

Category Computational Thinking Ability	Test Score	Total students

Tall	$x \geq 50$	2
Currently	$50 < x < 26$	10
Low	$x \leq 25$	3

Description: x is the test value
*Source:*Lestari & Yudhanegara (2015)

Table 2. Division of High, Medium and Low Computational Thinking Ability

Tall	**Score**	**Currently**	**Score**	**Low**	**Score**
S-5	70	S-1	34	S-7	20
S-13	50	S-2	31	S-10	23
		S-3	37	S-11	20
		S-4	36		
		S-6	34		
		S-8	45		
		S-9	41		
		S-12	32		
		S-14	47		
		S-15	35		

From the categories of mathematical ability detailed in Table 2., then two students were randomly selected from each category and have been consulted with the subject teacher about the students' abilities. The following are the details of the research subjects selected in this study to be interviewed.

Table 3. Research Subject

Student Initials	**Ability Category**
S-5	Tall
S-13	Tall
S-14	Currently
S-1	Currently
S-10	Low
S-11	Low

The result of the analysis of student answers based on high, medium, and low ability categories for each indicator of computational thinking ability are detailed in the Table 4.

Table 4. Percentage of Ability Categories High, Medium, and Low

Indicator \ Category	Tall	Currently	Low
Decomposition	87.5%	51.5%	38.3%
pattern recognition	50%	33.5%	11.67%
Abstraction	97.5%	62%	33.3%
thinking algorithm	65%	39%	21.7%

The results of the percentage of computational thinking abilities per indicator are then qualified according to Arikunto in Khairani et.al (2021).

Table 5. Qualification Percentage Computational Thinking Ability

No	Percentage	Criteria
1	81% – 100%	Very good
2	61% – 80,99%	Well
3	41% – 60,99%	Enough
4	21% – 40,99%	Low
5	0% – 20,99%	Very low

Based on Table 4., the result can be seen that students with high abilities are in a very good category on the decomposition and abstraction indicators, in the good category on the algorithm thinking indicator and in the moderate category on the pattern recognition indicator. For students with moderate abilities, they are in a good category on the abstraction indicator, the sufficient category on the decomposition indicator, the low category on the pattern recognition indicator and algorithmic thinking. Meanwhile, low-ability students are in the low category for three indicators, namely decomposition, abstraction, algorithmic thinking and very low category on pattern recognition indicators.

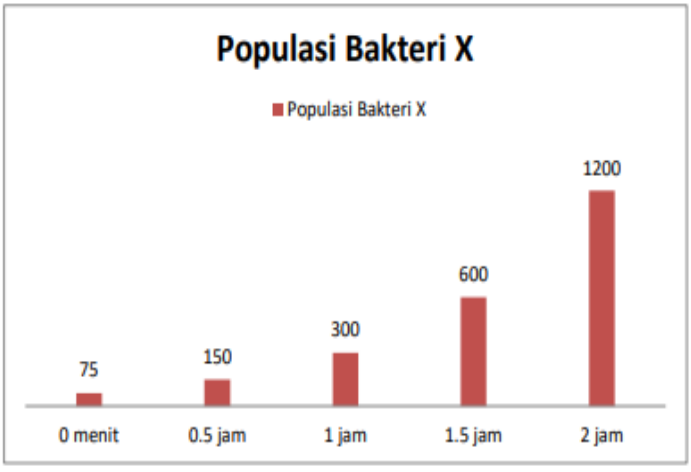
In more detail, the researcher will describe the results of students' answers in solving problems of sequences and series based on the categories of high, medium, and low abilities of each indicator of computational thinking ability. This description aims to be able to see the differences in the computational thinking processes of each student's ability.

A. The computational thinking process of high-ability students

1) Process on the Decomposition Skill

Based on the student's answer sheet, the success rate on the decomposition indicator was 87.5%. In general, high-ability students have been able to describe the decomposition indicator, which is to describe the information contained in the questions. For the remaining percentage, students were less than perfect in writing down all the information on the questions, such as forgetting to write what was asked in the questions. The following is one of the student's answers.

4. Dalam sebuah laboratorium biologi ditemukan populasi bakteri X, apabila perkembangbiakannya sesuai dengan table dibawah ini, berapakah jumlah bakteri setelah 4 jam?. Berapa waktu yang dibutuhkan agar bakteri X tersebut mencapai jumlah 153.600?



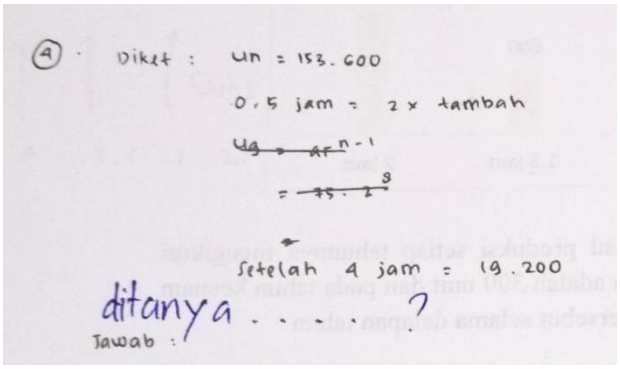


Figure 1. Question No. 4 and Answers of S-5 students

Figure 1. shows that the S-5 students' errors in solving questions No.4 were incomplete in identifying the information asked. To explore more in-depth information about students' computational thinking processes, the researchers conducted interviews with S-5 students. S-5 students said that in solving problems, S-5 students read the information on the questions repeatedly to identify the information that was known and what was asked in the questions. However, for question number 4, the students admitted that they were in a hurry so they forgot to write it down completely. In line with research Arista et.al (2022) that students make mistakes when understanding the questions, namely forgetting to write down the information that is known and asked in the questions. As for the other four questions, S-5 students have answered in detail and accurately.

2) Process on Pattern Recognition Skills

Based on the student's answer sheet obtained a success rate of 50% on the pattern recognition indicator. S-5 students have made a pattern on each question. While the S-13 students did not make it. The following is one of the student's answers.

5. Sebuah pabrik property mampu meningkatkan hasil produksi setiap tahunnya mengikuti aturan barisan geometri. Produksi pada tahun kedua adalah 300 unit dan pada tahun keenam adalah 4800 unit. Berapakah hasil produksi pabrik tersebut selama delapan tahun

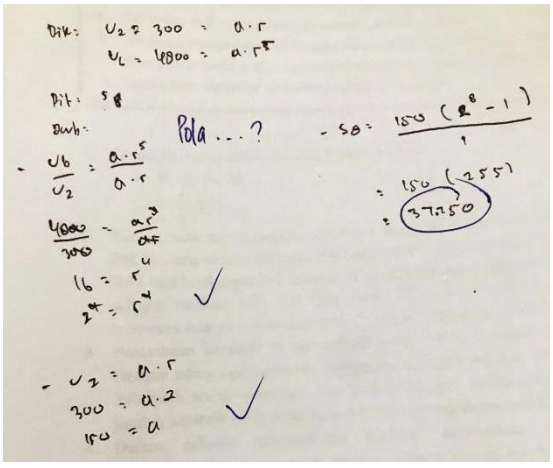


Figure 2. Question No. 5 and the Answers of S-13 Students

Figure 2. shows that S-13 students in solving problem number 5 do not make patterns but go directly to the calculation process and so are other questions. Researchers conducted interviews with S-13 students, it was known that the reason students did not make patterns was because students

immediately saw the pattern of the questions, did not write the pattern back into the answer sheet but students were able to answer the problems given. In line with research Hadi (2021) students are able to provide answers, but students do not explain in detail how to get these answers by looking at the pattern of the question.

3) Process on Abstraction Skills

Based on the student's answer sheet, the success rate of 97.5% on the abstraction indicator was obtained. From these percentages, it can be seen that students have been able to make abstractions from questions. The following is one of the student's answers.

1. Tentukan rumus suku ke-n dari barisan berikut.
   a. 8, 12, 16, 20, ...

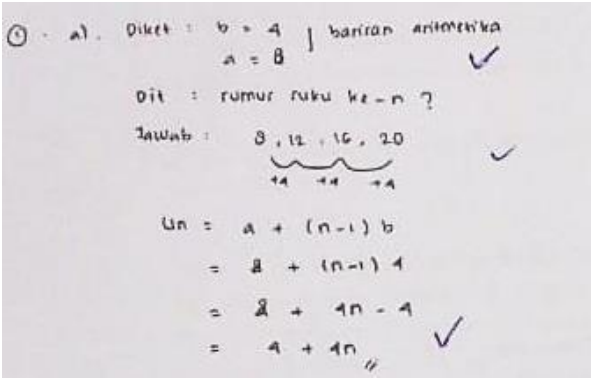


Figure 3. Question No.1a and Answers of S-5 Students

From Figure 3., it can be seen that the S-5 students have been able to make the general formula for the given problem. In this indicator, students do not experience problems in writing the general formula for the problem. The researcher also conducted interviews with S-5 students; it was known that the general formula was found based on the pattern that had been made previously. So that you can find out an arithmetic or geometric sequence, and continue by writing the general formula. In line with research Danindra & Masriyah (2020) that the general formula for problem solving problems is obtained from previously recognized patterns.

4) Process on Algorithmic Thinking Skills

Based on the student's answer sheet, the success rate of 65% on the algorithm thinking indicator was obtained. Student errors due to lack of accuracy in mathematical calculations. The following is one of the student's answers.

3. Perusahaan keramik menghasilkan 5.000 buah keramik pada bulan pertama produksi. Dengan adanya penambahan tenaga kerja, maka jumlah keramik juga meningkat sebanyak 300 buah setiap bulannya. Jika perkembangan produksinya konstan setiap bulan, berapa jumlah keramik yang dihasilkan selama satu tahun pertama?

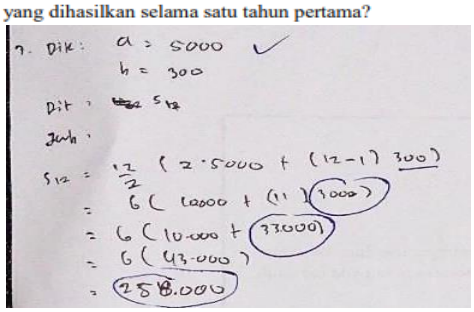


Figure 4. Question No. 3 and Answers of S-13 Students

Figure 4. shows that in the first line of the calculation process, students have correctly written down difference (b) from the arithmetic sequence problem, which is 300, but in the second line students write 3000. When the researcher interviewed S-13 students, the students realized the error during the calculation process and the reasons for this given by students because they are careless and not careful when doing mathematical calculations.Students actually have good numeracy skills, but accuracy and accuracy in the counting process need to be improved (Pramesti & Prasetya, 2021).

B. The computational thinking process of moderately capable students

1) Process on the Decomposition Skill

Based on the student's answer sheet obtained a success rate of 51.5% on the decomposition indicator. Student errors due to lack of detail describe the problem. The following is one of the student's answers.

2. Pak Herman menggunakan motornya untuk aktivitas sehari-hari. Pada spedometer motor Pak Herman tertera bilangan 120 yang berarti motor tersebut telah menempuh jarak 120 km. Hari-hari berikutnya Pak Herman mencatat bilangan yang tertera pada spedometer motornya sebagai berikut: 160, 200, 240, 280, 320, 360, ···. Jika Pak Herman harus menservis motornya setelah menempuh jarak 2.000 km, dapatkah ditentukan waktunya?

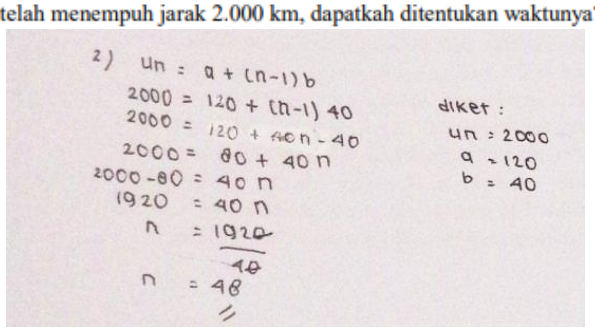


Figure 5. Question No.2 and Answers of S-1 Students

Figure 5. shows that undergraduate students are incomplete in writing down the information asked. S-1 students make the same mistakes as S-5 students. Researchers conducted interviews with undergraduate students, it was found that students were incomplete in making information known and asked because students were in a hurry to answer questions. Nurussafa'at et.al (2016) in his research also found that students were wrong in answering questions because they were in a hurry and were not detailed in writing down the information asked in the questions.

2) Process on Pattern Recognition Skills

Based on the student's answer sheet on the pattern recognition indicator, the success rate was 33.5%. The student's error is due to wrongly finding the pattern of the sequence so that the student is not able to solve the given problem. The following is one of the student's answers.

1. Tentukan rumus suku ke-n dari barisan berikut.
   a. $8, 12, 16, 20, \ldots$
   b. $\frac{1}{4}, \frac{1}{2}, 1, 2, \ldots$

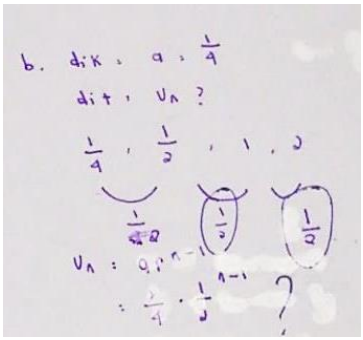


Figure 6. Question No.1b and Student Answers S-14

From Figure 6. it can be seen that the S-14 students in answering question No.1b, have not been able to correctly determine the pattern formed from the problem. According to the results of interviews with S-14 students, students were wrong in determining the pattern because they were confused about the ratio of the problem. The ratio in this problem should be 2 while the S-14 students write down the ratio. In line with research Wulandari & Setiawan (2021) that students have been able to write down the information that is known on the problem but cannot determine the ratio of the geometric sequence so that the solution is less precise.

3) Process on Abstraction Skills
Based on the student's answer sheet on the abstraction indicator, the success rate was 62%. Students are wrong in writing abstractions or distinguishing between ratios in geometric sequences or different in arithmetic sequences. The following is one of the student's answers.

1. Tentukan rumus suku ke-n dari barisan berikut.
   a. 8, 12, 16, 20, ...
   b. $\frac{1}{4}, \frac{1}{2}, 1, 2, \ldots$

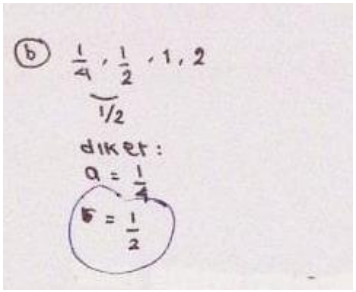


Figure 7. Question No.1b and Answers of S-1 Students

Figure 7. shows that the undergraduate students have not been able to determine the general formula in question N0.1b. S-1 students were interviewed so that it was known that students were wrong in the abstraction process because students were confused about whether what was meant by the question was a difference in an arithmetic sequence or a ratio in a geometric sequence. Damayanti & Kartini (2021) in his research also found that students are often wrong in identifying questions, whether the questions are included in arithmetic sequences and series or geometric sequences and series.

4) Process on Algorithmic Thinking Skills
Based on the student's answer sheet, the success rate was 39%. Student error due to wrong in mathematical calculations. The following is one of the student's answers.

2. Pak Herman menggunakan motornya untuk aktivitas sehari-hari. Pada spedometer motor Pak Herman tertera bilangan 120 yang berarti motor tersebut telah menempuh jarak 120 km. Hari-hari berikutnya Pak Herman mencatat bilangan yang tertera pada spedometer motornya sebagai berikut: 160, 200, 240, 280, 320, 360, ···. Jika Pak Herman harus menservis motornya setelah menempuh jarak 2.000 km, dapatkah ditentukan waktunya?

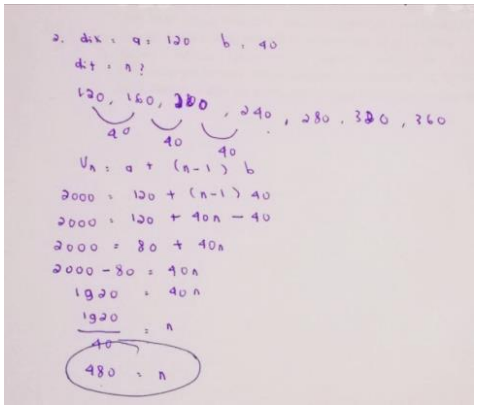


Figure 8. Question No.2 and Answers of S-14 Students

Figure 8. shows that S-14 students made a mistake in calculating the value of n, which should be 48 but students wrote it down 480. The results from interviews with S-14 students showed that students were wrong in the calculations because they were in a hurry in the mathematical calculation process. In line with research Hidayat & Pujiastuti (2019) that the error in the calculation process is because students are in a hurry and are not careful in the mathematical calculation process.

C. Computational Thinking Process of Low Ability Students

1) Process on the Decomposition Skill

Based on the student's answer sheet on the decomposition indicator, the success was 38.3%. Student errors due to incorrectly describing the problem. S-11 students are wrong in recognizing the information that is known on the problem which causes errors in problem solving. The following is one of the student's answers.

2. Pak Herman menggunakan motornya untuk aktivitas sehari-hari. Pada spedometer motor Pak Herman tertera bilangan 120 yang berarti motor tersebut telah menempuh jarak 120 km. Hari-hari berikutnya Pak Herman mencatat bilangan yang tertera pada spedometer motornya sebagai berikut: 160, 200, 240, 280, 320, 360, ···. Jika Pak Herman harus menservis motornya setelah menempuh jarak 2.000 km, dapatkah ditentukan waktunya?

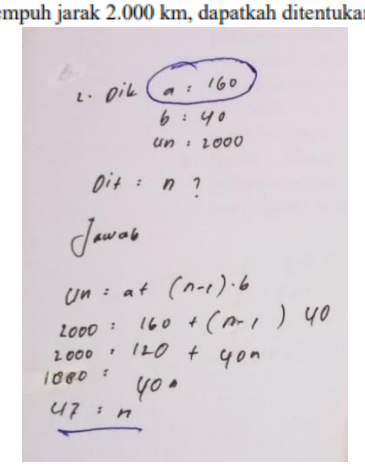


Figure 9. Question No.2 and Answers of S-11 Students

Figure 9. shows that the S-11 students were wrong in writing the first term in the arithmetic sequence. Students make mistakes in reading the questions given. The first term in the row should have been 120 but students wrote 160. Researchers interviewed S-11 students, it was found that students were not careful in reading and understanding the problems in the questions that caused students to write down the information they knew wrong. Study Fitri et.al (2022) also found that the biggest error in understanding the problem was an error in writing what was known and asked in the question.

2) Process on Pattern Recognition Skills
Based on the student's answer sheet on the pattern recognition indicator, the success rate was 11.67%. Students do not make patterns in the process of solving problems. The following is one of the student's answers.

3. Perusahaan keramik menghasilkan 5.000 buah keramik pada bulan pertama produksi. Dengan adanya penambahan tenaga kerja, maka jumlah keramik juga meningkat sebanyak 300 buah setiap bulannya. Jika perkembangan produksinya konstan setiap bulan, berapa jumlah keramik yang dihasilkan selama satu tahun pertama?

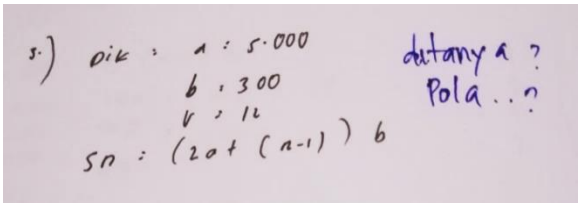


Figure 10. Question No. 3 and Answers of S-11 Students

Figure 10. shows that S-11 students did not write down the pattern for the problem solving problem No.3 and did not make a pattern for solving other questions. From the results of interviews with S-11 students, it is known that in solving problems, students do not use patterns but directly determine the information that is known in the questions. Even though they have written down the known information, students are not able to solve the problem until the calculation process or algorithm thinking indicator.

3) Process on Abstraction Skills
Based on the student's answer sheet on the abstraction indicator, the success was 33.3%. Students are wrong in the abstraction of the problem. The following is one of the student answer sheets.

1. Tentukan rumus suku ke-n dari barisan berikut.
   a. 8, 12, 16, 20, ...
   b. $\frac{1}{4}, \frac{1}{2}, 1, 2, \ldots$

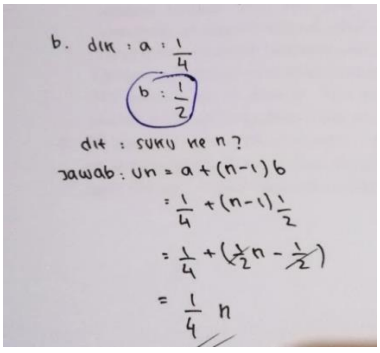


Figure 11. Question No.1b and Student Answers S-10

Figure 11. shows that S-10 students are wrong in determining problem No.1b including arithmetic or geometry. The problem in question is the concept of a geometric sequence, while what students write is an arithmetic sequence. Researchers conducted interviews with S-10 students. It was found that students' errors were due to not being able to distinguish whether they were arithmetic sequences or geometric sequences. In line with research Mardhayanti et.al (2020) that the mistakes made by students were due to the wrong concept to distinguish between arithmetic sequences and geometric sequences. By not knowing whether the sequence is arithmetic or geometric, students cannot determine whether what is known is a difference or a ratio. So that students are wrong in the process of abstracting the problem.

4) Process on Algorithmic Thinking Skills

Based on the student's answer sheet on the algorithm thinking indicator, the success was 21.7%. Students are not able to solve problems, students' abilities are only in writing information that is known and asked and recognizes the patterns in the questions. The following is one of the student answer sheets.

3. Perusahaan keramik menghasilkan 5.000 buah keramik pada bulan pertama produksi. Dengan adanya penambahan tenaga kerja, maka jumlah keramik juga meningkat sebanyak 300 buah setiap bulannya. Jika perkembangan produksinya konstan setiap bulan, berapa jumlah keramik yang dihasilkan selama satu tahun pertama?

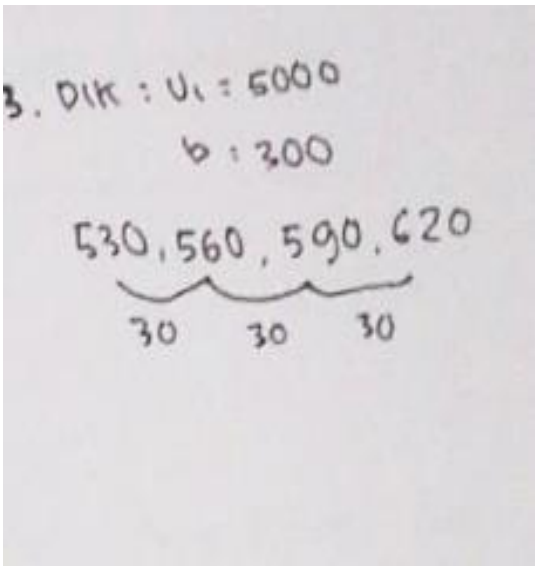


Figure 12. Question No. 3 and Answers of S-10 Students

Figure 12. shows that students have not been able to complete the problem calculation process. S-10 students were interviewed so that it can be seen that students are not able to do mathematical calculations because they are confused in solving problems and running out of time to be able to answer the questions. Previous research conducted by Amalia (2017) that one of the students' mistakes in solving problems is confused in determining the steps in solving the problem and running out of time to solve the problem. Low-ability students are only able to answer questions up to number 3. Whole numbers 4 and number 5, students do not write down any answers on the answer sheet.

4. CONCLUSION

Based on the results of the analysis of the computational thinking ability test, it can be concluded that high-ability students can be categorized as good on each indicator. The highest achievement was on the abstraction indicator of 97.5% and the lowest was on the pattern recognition indicator of 50%. For students with moderate abilities, it can be categorized as sufficient with the highest achievement on the abstraction indicator of 62%, while for students with low abilities it is categorized as low on three indicators and very low on the pattern recognition indicator.

Errors made by students on the decomposition indicator are lacking in detail in describing the information that is known and asked in the question. In the pattern recognition indicator, students are wrong in finding patterns and wrong in determining whether the sequence is a difference in an arithmetic sequence or a ratio in a geometric sequence. For abstraction indicators, high and medium ability students are good, but low ability students cannot carry out the abstraction process properly. On the indicators of thinking algorithms, students are careless and less thorough in the mathematical calculation process.

The results of this study indicate that the students' computational thinking ability is still low. These results can be used as input for teachers to design learning according to the stages of students' computational thinking processes, for example by giving challenging questions to train students' computational thinking skills in solving math problems.

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