PARADIKMA JURNAL PENDIDIKAN MATEMATIKA
ISSN: 1978-8002 (Print)
ISSN: 2502-7204 (Online)

Analysis of Students' Mathematical Pattern Thinking Ability Through Problem Based Learning Model Using Geogebra Software

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Article History:
Received : 27-05-2023
Revised : 28-08-2023
accepted : 06-05-2024
On line : 06-05-2024

Keywords:
Mathematical Patterns Thinking Ability;
Problem Based Learning;
Geogebra;
Qualitatitve Research

ABSTRACT

This study aims to determine: (1) The level of students' ability to think mathematical patterns through problem based learning model by using software geogebra, (2) The process of student answer sheets in solving pattern thinking problems through learning models problem based learning by using software geogebra, (3) Difficulties in solving problems that require the ability to think patterns in learning problem based learning by using software geogebra. This research is a qualitative research with a descriptive approach. Based on the research data, it was found that: (1) The level of students' ability to think mathematical patterns through learning models Problem Based Learning by using software geogebrais at a moderate level. Of the 19 students, 4 students had a 'high' level of mathematical thinking ability, 12 students had a 'moderate' level of mathematical thinking ability, and 3 students had a 'low' level of mathematical thinking ability. (2) The process of student answer sheets in solving pattern thinking through learning problems based learning models problems by using geogebra software found that the errors that appear more often are errors in differentiating concepts between arithmetic sequences and series, (3) Difficulty in pattern thinking skills in learning problem based learning by using geogebra software including difficulties in exploring and identifying, extending and reproducing, comparing, representing and describing.

A. INTRODUCTION

Developments in the field of Science and Technology (Science and Technology) as well as modernization that are increasingly fast nowadays, demand that people balance this with various aspects of competence that must be possessed, one of the ways that can be done is through education. Education plays a very important role in building change, progress and a better future. Education is also an important thing for human life, because education will be able to improve the quality of human resources. According to Sepriyanto (2017: 49) states that "Education has a responsibility in realizing quality human resources, especially preparing students as future development successors who are competent, independent, critical, creative and able to solve the problems they face".

The rapid progress of Science and Technology (IPTEK) cannot be separated from the role of mathematics. Mastering and creating technology in the future requires strong mathematics from an early age. This statement is supported by Nasution, Surya, Syahputra (2015: 2) in his research stating that mathematics is one of the basic sciences that plays an important role in the development of science and technology (IPTEK).

Mathematics is a universal science that underlies the development of technology, and mathematics plays an important role in shaping the mindset of students, besides that mathematics is also a means of communication in various fields of science to form creative, innovative, critical, and logical mindsets that students really need to form highly competitive human resources. This is also in line with Aisyah's opinion (2007: 85) which states that, "mathematics is a universal science that underlies the development of modern technology, has a role in various disciplines and advances human thinking power".

According to Bochori (2015: 371), mathematics is one of the sciences that plays a crucial role in preparing students to be development successors in the future. It is evident from this description that mathematics is crucial to acquire, develop, and master in education.

By studying mathematics, students are expected to improve thinking skills such as the ability to think logically, analytically, systematically, critically, creatively, reasoning, connections, problem solving, and the ability to think mathematical patterns and be able to solve problems in everyday life, because mathematics is so closely related to real-world situations. This is supported by Hasratuddin (2018: 37), who asserts that mathematics is the result of human intellectual thought. Intellectual thought can be stimulated by both simple thinking problems and ordinary problems. In this fashion, mathematics is also referred to as human life and a method for training the mind.

According to Sumarmo (2004: 2), mathematics education essentially has two directions of development, namely to meet present demands and future needs. Thus, mathematics is necessary both now and in the future.

However, the high demand for mathematics mastery is not directly proportional to student achievement in mathematics, indicating that mathematics learning outcomes are still inadequate. From the results of the biennial TIMSS (Trends in International Mathematics and Science Study) survey, which was conducted in 1995, 1999, 2003, 2007, 2011, and 2015, respectively. Indonesia is one of the four countries examined by TIMSS over the past four cycles. Based on the results of the TIMSS 2003 study, Indonesia ranks 35th out of 46 participating countries with an average score of 411, whereas the international average score is 464.

Sequences and series in arithmetic are one of the topics covered in class X of high school mathematics. The study of sequences and series is a subfield of mathematics that focuses on numbers. Sequences and series content is advanced mathematics content from junior high school, specifically number sequences and series. Includes arithmetic sequences and series, geometric sequences and series, infinite geometric series, and the application of sequences and series to contextual problems (Lin et al., 2020). Even according to Ferrara, et al (in Nurdin 2011: 2), the concept of sequences can be used to help find patterns, develop critical thinking skills, and prove a mathematical conjecture. Given the significance of the topic of sequences and series, students must have a firm grasp of the concept of sequences and series.

Learning sequences and series in mathematics requires pattern intelligence. When studying arithmetic sequences and series, the objective of the learning process is to equip students with patterns of sequences and series that can be used to solve context-based problems involving sequences and series, which have numerous applications in everyday life as well as various fields of science and technology. (Masjudin, 2017: 77) Learning sequences and series in arithmetic necessitates a suitable strategy in order for students to comprehend the concept of this material. Students' comprehension of arithmetic sequences and series can be enhanced through the concept of sequence and series patterns. Therefore, we require a method for training and developing pattern thinking.

In mathematics, patterns have been a topic of interest for many years. According to Zaskis and Liljedahl (2002), "Patterns are the heart and soul of mathematics", which means that patterns are the heart and soul of mathematics. One of the most well-known researchers, Steen (1988), stated, "Who described patterns as the language and science of mathematics, because one is constantly searching for patterns not only in mathematics but also in the world" Professor of mathematics at Illinois State University Thorton (1977) observes that children begin to recognize patterns at an early age and that pattern recognition is an essential foundational skill for the development of mathematical skills and concepts.

Based on the preceding explanation, it is evident that students' ability to think mathematical patterns plays a significant role in learning arithmetic sequences and series; therefore, instructors are required to pay close attention to students' ability to think mathematical patterns in the classroom. However, in practice, the teacher still pays less attention to students' capacity to think in mathematical patterns.

This can be seen from the results of initial observations through the provision of questions that measure the ability to think mathematical patterns in the Arithmetic Rows and Series material given to 19 class X students of Jambi Private Vocational School Jambi Medan for the 2022/2023 Academic Year showing that students' ability to think mathematical patterns is low. Of the 19 students who took the test, only 5 students passed (26%) and 14 students did not complete (74%).

With the percentage of each indicator with a percentage value of 39.6% of students low on the indicator of exploring and identifying, 49.6% of students low on the indicator of expanding and reproducing, 39.6% of students low on the indicator of comparing, and 35.4% of students low on the indicator of representing and describing.

Determine the 14th term of the arithmetic sequence 2, 6, 10, ….!

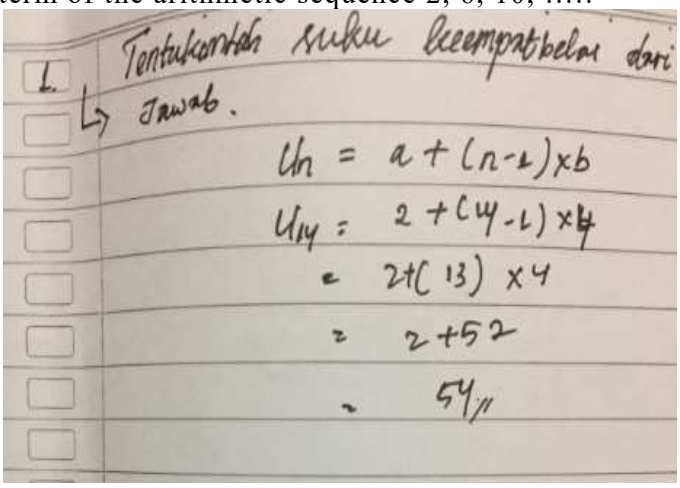

Figure 1 Student Completion Sheet for Item Number 1

From the student responses in Figure 1, it can be concluded that students obtain the final results, but are unable to investigate and identify the given problems. In arithmetic sequence problems, students do not record what they know and what is requested. In addition, students are unable to represent and describe the obtained results.

Based on the results of interviews with researchers conducted at the time of initial observation, it was determined that a number of factors contributed to the low ability of students to think in mathematical patterns, including the ongoing process of learning mathematics in which the teacher is the focal point of student activity, whereas students tend to be passive during learning activities. Without learning the concept of patterns, students only attend to everything that is explained by the instructor, record the provided material, and complete everything that the teacher instructs. During the learning process, students receive ready-made materials and are not required to generate them on their own. In spite of the fact that the concept of arithmetic sequences and series necessitates the ability to recognize patterns in order to comprehend patterns derived from arithmetic sequences and series, this causes students to lack the ability to recognize patterns. Students' ability to recognize mathematical patterns is consequently hindered and underdeveloped.

According to Fathurrohman (2015: 29), the learning model is a conceptual framework that describes systematic procedures in organizing learning and learning experiences to achieve specific learning goals and functions as a guide for teachers in implementing learning activities. This is consistent with Ngalimun's (2014:28) assertion that with a learning model, teachers can help students acquire information, ideas, skills, modes of thinking, and methods of expressing their own ideas in order to teach them how to learn. In order to develop the ability to think in patterns when learning mathematics, the learning process involves undertaking a variety of activities or actions in addition to absorbing information from the teacher. Davis (in Rusman, 2011, p. 229) suggests that a common oversight is forgetting that student learning, not instructor instruction, is the essence of education. Teachers must be able to select learning activities that encourage student engagement in the educational process. Problem-Based Learning (PBL), also known as problem-based learning (PBM), is a model of instruction that encourages the growth of pupils' mathematical thought processes.

Problem-Based Learning was first implemented at the Canadian Faculty of Medicine at McMaster University in the early 1970s. According to Mufarokah (2013, p. 243), one of the benefits of this problem-based learning model is that it fosters the development of students' critical thinking so that they can solve problems effectively. The Problem-Based Learning (PBL) model is an alternative paradigm that can assist students in recognizing mathematical patterns when solving problems. This model gives students the opportunity to solve problems in their own

way. Students are trained to develop their ability to recognize mathematical patterns using their own methods.

Other than that, in addition to the problem-based learning model, a computer technology-based mathematics learning process must also be implemented. The purpose of instructional materials is to facilitate communication instruction with students. This is supported by Daryanto's (2013) claim that teaching and learning is fundamentally a communication process involving the transmission of messages from students to recipients. Researchers have noted that instructors at Jambi Medan Private Vocational School do not use software-assisted computer technology. Permendiknas Regulation No. 16 of 2007 emphasizes that one of the pedagogical competencies that mathematics instructors must possess is the ability to use information and communication technology (ICT) for the benefit of learning.

Sampurno (in Santoso, 2018: 170) argues that the development of Information and Communication Technology (ICT) necessitates the world of education to continue to experience quality enhancements, specifically modifications to the use of ICT in the learning process. Thus, learning mathematics can be made more accessible and engaging at any time. Software is one of the innovative media that can present understandable and observable abstract objects.

In the current technological era, according to Rahmawati (2018: 381), there are numerous portable software and applications that can be used for learning mathematics. Including, among others, Matlab, GeoGebra, GeoEnzo, Microsoft Mathematics, Speq Mathematic, and Adobe Flash. The use of technology in mathematics education can increase students' interest in learning and familiarize them with technology, in addition to serving as a visual aid.

Geogebra Software is therefore one of the computer programs that can be used to study mathematics. Markus Hohenwarter from Austria created Geogebra in 2001 as a free program for learning mathematics. Geogebra software is simple, straightforward, user-friendly, and simple for students to observe in order to construct their own knowledge.

B. RESEARCH METHODS

The type of research used in this research is descriptive qualitative research. This study aims to describe students' ability to think mathematical patterns through problem-based learning models using geogebra software. The resulting data describes the results of the research in written words resulting from interviews, observations, and documentation studies. In this study, all facts, both written and verbal, were sourced from human data that had been observed and other related documents were described as they were and studied to answer problems.

This research was conducted at Jambi Medan Private Vocational School, class X in the 2022/2023 Academic Year, with a schedule coordinated with school activities. The reasons for the researchers choosing this school were: (1) There was no similar research conducted at Jambi Medan Private Vocational High School (2) The researcher wanted to find out how the level of students' mathematical pattern thinking ability, the process of answering students' mathematical pattern thinking ability tests and the difficulties experienced by students in problem based learning using geogebra software.

The subject of this study involved students of class X (RPL) at Jambi Medan Private Vocational School who were treated with a problem-based learning model using geogebra software in the even semester of the 2022/2023 academic year. Then students are given a test of students' ability to think mathematical patterns and finally taken the subject to be interviewed.

C. RESULTS AND DISCUSSION

The data for this research came from students at the Jambi Medan Private Vocational School, class X in the 2022/2023 Academic Year using a questionnaire and an answer model in the form of a Likert scale. Questionnaires were given to students after they carried out teaching and learning activities in the field of mathematics, so that researchers made direct observations of the implementation of activities. The following can be seen the results of data processing, namely:

The Level of Ability to Think Mathematically Patterns of Students through the Problem Based Learning Learning Model using Geogebra Software

After learning the material for arithmetic sequences and series utilizing the problem-based learning model and GeoGebra software, a pattern-thinking aptitude test is administered. This study employs a

pattern thinking ability test in the form of an essay containing four questions designed to collect data on the mathematical pattern thinking ability of students, which were then processed and analyzed. Class ten students at RPL Jambi Medan Private Vocational School were evaluated on their capacity to think in mathematically structured patterns.

Table 1 Test Results for Students' Mathematical Pattern Thinking Ability

The number of students	Maximum Score	Minimum Score	Average Score	Category
19	86	20	62,83	Currently

Table 1 is a table of students' mathematical pattern thinking ability test results which shows that the highest score obtained by students is 86 and the lowest is 20 with an average score of 62.83 in the medium category. The results of the categorization of the ability to think mathematical patterns grouped into 3 levels are as follows:

Table 2 Levels of Students' Mathematical Pattern Thinking Ability

Category	Score Range	The number of students	Percentage
Tall	> 83.80	4	21.05%
Currently	41.86 ≤ Score ≤ 83.80	12	63.15%
Low	< 41.86	3	15.80%
Amount		19	100%

The diagram of the level of students' ability to think mathematical patterns is:

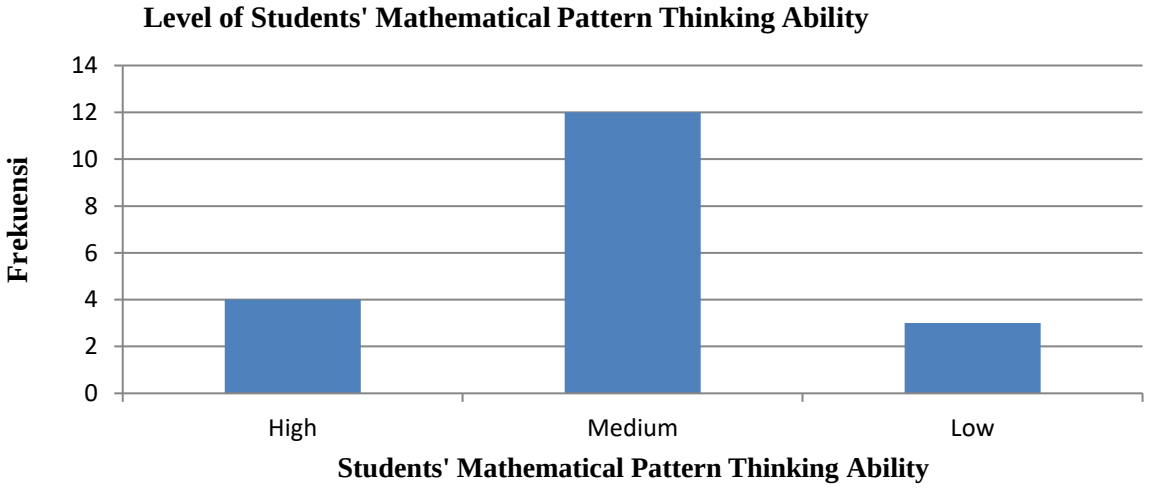

Figure 2 Level of Students' Mathematical Pattern Thinking Ability

The Process of Answering Students' Mathematical Pattern Thinking Ability Test through the Problem Based Learning Learning Model using Geogebra Software

The answer process is the method, procedure or steps used to solve math problems in order to see student errors in solving the given test questions. The process of student answers is selected from each level of students' ability to think mathematical patterns, namely high, medium, and low.

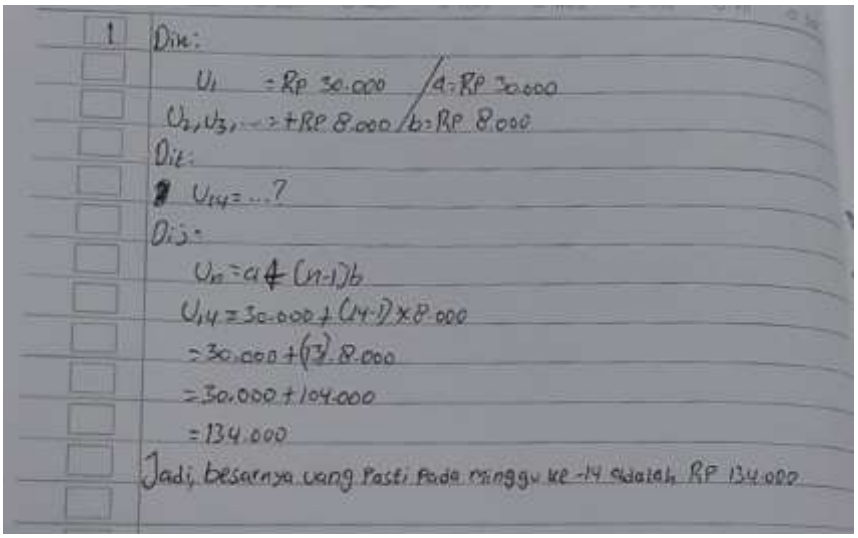

Figure 3 Process of Answering Question Number 1

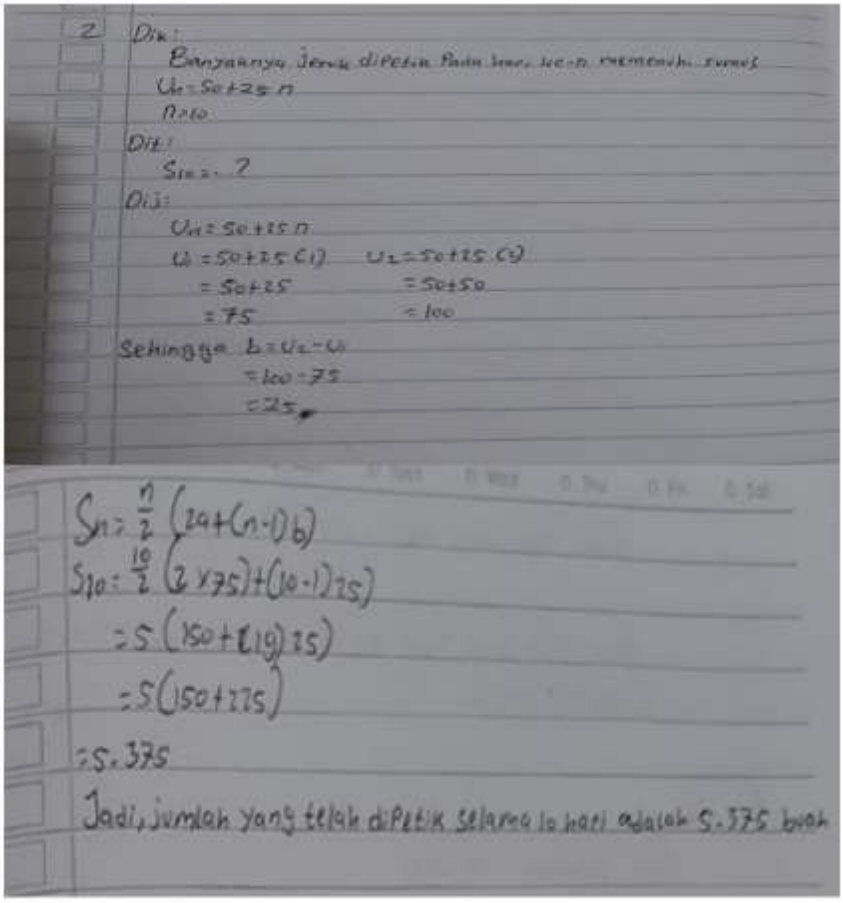

Figure 4 Process of Answering Question Number 2

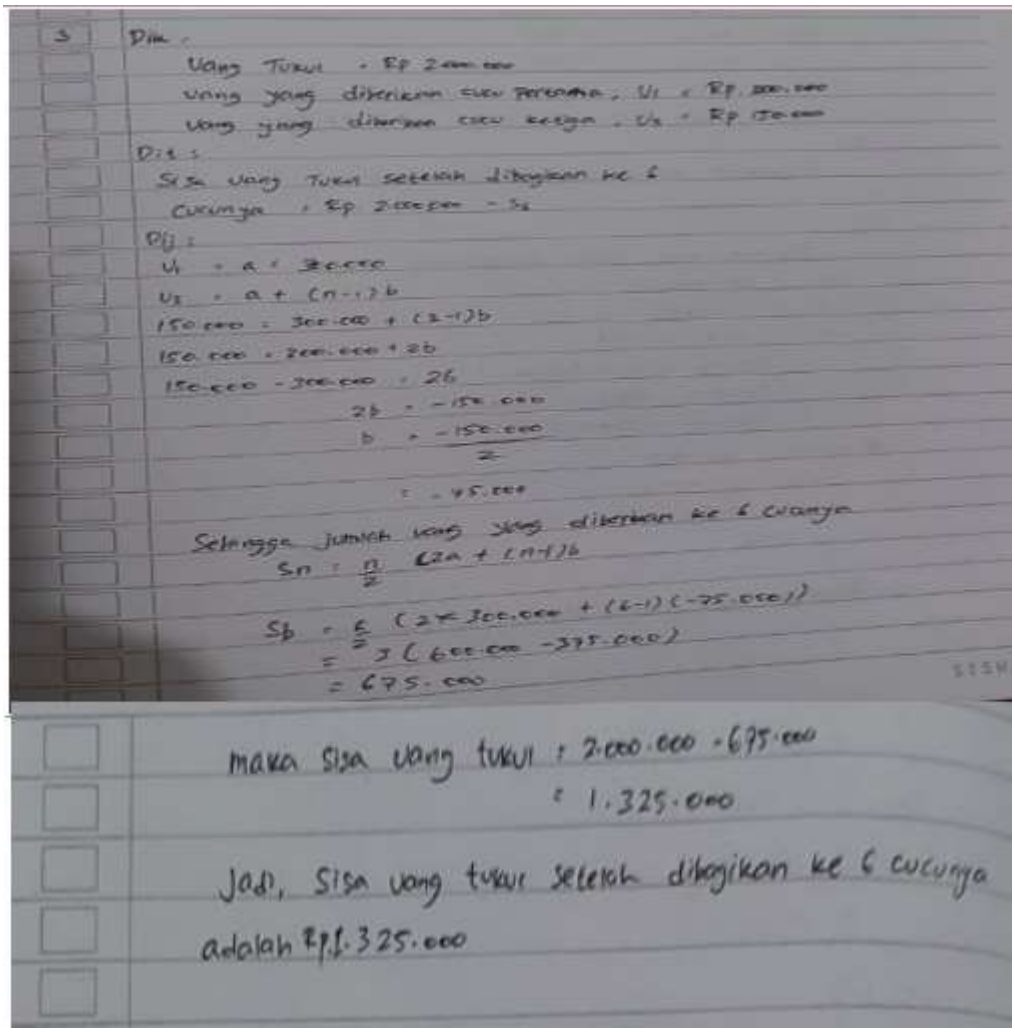

Figure 5 The Process of Answering Question Number 3

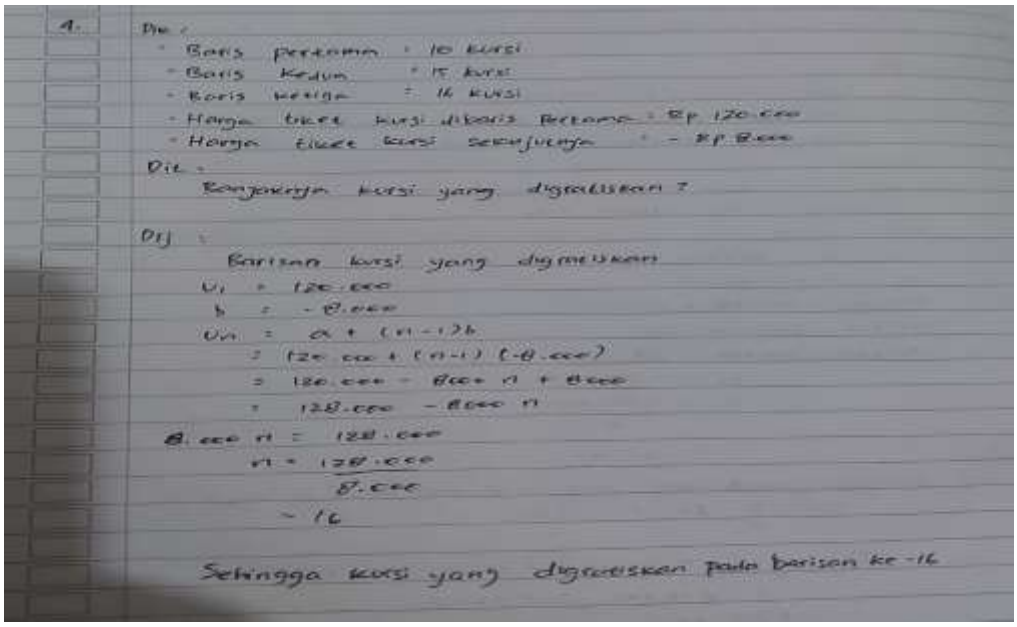

Figure 6 The Process of Answering Question Number 4

The difficulty of pattern thinking is a condition or situation where students are unable to understand the steps in solving mathematical problems properly. These difficulties are not only experienced by groups of students with 'low' mathematical pattern abilities, groups of students with 'high' mathematical pattern abilities can also experience them. Here are some excerpts from the interview:

Question number 1

P : Do you understand the meaning of question number 1?
S-09 : Yesunderstand mom.
P : Then what information is known from question number 1?
S-09 : Rasti saves money in the school cooperative. The first week, Rasti saved IDR 30,000. second week andso on, increase IDR 8,000.
P : What do you understand from question number 1?
S-09 : Looking for Rasti's 14th week mom.
P : What are you doing to solve this problem?
S-09 : BecauseI was asked how much money Rasti had in the 14th week, I solved it using an arithmetic series formula. It is known that a = 30,000, because Rasti's money increases by 8,000 every week, so b = 8,000, and n = 14. So
$sn = \frac{n}{2}(2a + (n-1)b)$
And calculated to get the result ma'am.
P : Why do you use the arithmetic series formula?
S-09 : BecauseI want to add up Rasti's money until the 14th week, ma'am.
P : TryYou look back at the problem, isn't it what Rasti asked about the amount of money in the 14th week? You should use the formula for an arithmetic sequence.
S-09 : Ithink using the arithmetic series formula ma'am.

Question number 2

P : Do you understand the meaning of question number 2?
S-07 : YesI understand, ma'am.
P : Then what information is known from question number 2?
S-07 : A garden picker picks his oranges every day, and records the number of oranges he picks. It turns out that the number of oranges picked on day n satisfies the formula Un = 50 + 25n.
P : What do you understand from question number 2?
S-07 : Iasked to countnumber of oranges picked during the first 10 days ma'am.
P : What are you doing to solve this problem?
S-07 : First,I'll look for U1 and U2 first, ma'am, so you know the b, ma'am
Un = 50 + 25n
u_1 = 50 + 25 (1)
Then
Un = 50 + 25n
u_2 = 50 + 25 (2)
SoI'm looking for the b, ma'am, namely
b = u_2 - U_1
= 25
Soafter getting the value b, I used the arithmetic series formula to calculate the number of oranges, ma'am
$sn = \frac{n}{2}(2a + (n-1)b)$
$S10 = \frac{10}{2}(2 \times 75 + (10-1) \times 25)$
P : Try to look again at your answer sheet, is the final result 5,375?
S-07 : Ohyes ma'am I haven't counted the multiplication, I think it has been calculated. This is 5 x 375 bu, so the result is 1,875 bu.

Question number 3

P : Do you understand the meaning of question number 3?
S-12 : A little confused ma'am.
P : Then what information is known from question number 3?

S-12 : Tukul won a quiz prize of IDR 2,000,000. Tukul wants to give his 6 grandchildren with the younger grandson getting a smaller share than the older grandson. His first grandson was given IDR 300,000 and his third grandson IDR 150,000.
P : What do you understand from question number 3?
S-12 : Calculating how much Tukul's money is left after it is distributed to his 6 grandchildren, ma'am.
P : What are you doing to solve this problem?
S-12 : IFirst, write down what she knows, ma'am, namely the initial 2,000,000 Tukul is A, the money given to the first grandchild is 300,000 U1, the money given to the third grandchild is 150,000 is U3. From what is known, there is no b, so first look for the b value by entering the values of U1 and U3 using the arithmetic sequence formula

U1 = 300,000
U3 = a + (n-1) b
150,000 = 300,000 + (3-1) b
= 300,000 – 150,000 + 2b
= 150,000 +2b
-2b = 150,000
b = 75,000

Next, I used the arithmetic series formula to find out how much money Tukul gave for his 6 grandchildren

$sn = \frac{n}{2}(2a + (n-1)b)$

$S6 = \frac{6}{2}(2 \times 300,000 + (6-1)(75,000)$

Butma'am the result of the arithmetic series formula is greater than Tukul's money ma'am.
P : Try to look again at the answer you did earlier in this section = 300,000 – 150,000 + 2b, do you think it's correct?
S-12 : I think that's right ma'am.
P : Why don't you just move 300,000 + 2b to the left side.
S-12 : Ohso yes ma'am, I don't know ma'am.
P : Trydo it again like mom said earlier.
S-12 : *(Student reworks and gets the correct result)*
P : All right, kid, lots of talking about it, kid.

Question number 4

P : Do you understand the meaning of question number 4?
S-07 : YesI understand, ma'am.
P : Then what information is known from question number 4?
S-07 : In a theater room there are 20 lines. In the first row there are 10 seats, in the second row there are 13 seats, in the third row there are 16 seats, and so in the next row the difference in seats is always the same. The ticket price for a seat in the first row is IDR 120,000 and the ticket price for a seat in the next row is always reduced by IDR 8,000 until the price of a seat in a certain row is free.
P : What do you understand from question number 4?
S-07 : Iasked to countnumber of free seatsmom.
P : What are you doing to solve this problem?
S-07 : First, I looked for rows of seats with ticket prices that were starting to be freeusing the formula for an arithmetic sequence

Un = a + (n-1) xb
Means a = 120,000, b = -8,000, this is what you want to find
Un = a + (n-1) xb
= 120000 + (n – 1) (-8000)

The result is n = 16, meaning the free seats start from the 16th row to the 20th row.
Soto calculate the number of seats that are free of charge, use the arithmetic sequence formula as well, ma'am, so later I'll count the 16th to 20th rows, ma'am, I'll get the results later, ma'am.
P : Try to pay attention to the answer sheet number 4 that you have done, why don't you do a calculation of the number of seats that are free?
S-07 : YesMa'am, I don't have time to do it. It's already running out of time ma'am.
P : Alright, now mom give me time to continue solving question number 4.

S-07 : Already ma'am.
P : OK, your answer is correct. Thank you for your time.
S-07 : Yesma'am, you're welcome.

From excerpts from the interview onabove, it can be concluded that the completion of question number 4 shows that students do not understand the questions given at all. When the researcher asked what information was known from the questions, the students onlyread all question number 4,so the researcher explains how to solve it. Then the researcher gave another questionwith the same degree of difficulty, students are confused in determining the formula to be used because students cannot determine the problem of arithmetic sequences or arithmetic series. So S-15 experienced conceptual difficulties in understanding the questions.

D. CONCLUSIONS AND SUGGESTIONS

Based on the analysis of research data and the discussion that has been described, it can be concluded that the level of students' ability to think mathematically through the Problem Based Learning model using GeoGebra software is at a moderate level. Of the 19 students, 4 students had a 'high' level of mathematical thinking ability, 12 students had a 'moderate' level of mathematical thinking ability, and 3 students had a 'low' level of mathematical thinking ability:

ACKNOWLEDGEMENTS

On this space the authors want to express my deepest sincere thanks and biggest tribute to all those who have helped the author to finish this. First, to Prof. Dr. Bornok Sinaga, M.Pd as the 1st supervisor and Head of the Mathematics Education Study Program, Dr. Edi Syahputra, M.Pd as the 2nd supervisor, Dr. Mulyono, M.Si as head of the Mathematics Education Study Program, the principal and teachers and administrative staff of SMK Swasta Jambi Medan, and my family namely my brothers especially my mother and father.

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