Journal ofMathematical Education
*Website:*http://usnsj.id/index.php/JME
E-mail:managerjme@gmail.com
p-ISSN 2528-2468; e–ISSN 2528-2026

DOI:https://doi.org/10.31327/jme.v8i2.1972

ANALYSIS OF MATHEMATICAL CONNECTION ABILITY IN SOLVING HOTS QUESTIONS ON ARITHMETIC SEQUENCE

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Article Info

Article History:

Received Jun 27, 2023
Revised Sept 12, 2023
Accepted Dec 20, 2023

Keywords:

Analysis
Mathematical connection
HOTS
Arithmetic progression

ABSTRACT

Mathematical connection ability needs to be analyzed so that teachers can get an overview of students' mathematical connection abilities and develop learning strategies to improve students' mathematical connection abilities. This study explores the mathematical connection abilities of class XI MAN 2 Kota Palu students in solving HOTS arithmetic sequence problems. The type of research is qualitative and uses student interview results as data. The results of this research show that mathematical connections high-ability students demonstrate strong connections between arithmetic series and algebra, exponents, and roots, and apply these concepts in real-life and economic contexts. Moderately skilled students link arithmetic sequences to algebra but struggle with economic connections. Low-ability students face challenges linking mathematical concepts, applying arithmetic series to daily life, and connecting it with economics. Understanding these abilities helps teachers tailor strategies to enhance students' mathematical connections, aiding their problem-solving skills.

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How to Cite:

Sukmayanti,etc. (2023). Analysis Of Mathematical Connection Ability In Solving Hots Questions On Arithmetic Sequence. *JME: Journal of Mathematics Education*, ***8***(2), 188-198.

1. INTRODUCTION

Mathematics is one of the scientific disciplines studied at educational levels ranging from elementary school to tertiary education. Mathematics is essential to teach to students because mathematics is closely related to everyday life and relies on thinking processes in solving problems. As Bernard et al., (2018) expressed, mathematics has a vital role in living things that can be used in everyday life. Mathematics is generally known as a science with hierarchically interrelated concepts, so learning mathematics must be structured and

systematic. This is in accordance with Sumarmo (2013) who said that mathematics is a science that has characteristics as a structured, hierarchical, and systematic science, which implies that the concepts and principles in mathematics are interrelated with one another. In other words, when students learn mathematical ideas or concepts, they need previous ideas or knowledge and even have to learn previous concepts related to the concepts to be studied or the problems encountered so they can quickly solve them.

In mathematics, linking mathematical ideas or concepts is called mathematical connection. The understanding of mathematical connections expressed by Putri & Riwayati, (2017) that mathematical connection is associating a mathematical concept with other mathematical concepts, with other subjects, and with applications in everyday life. Ausubel (Hasbi & Inayah, 2016) states that if students learn to understand a new knowledge based on what they already have it means they can connect a concept that is being studied. There are three indicators of mathematical connection ability formulated by NCTM (2000) namely: 1) Recognizing and connecting between mathematical ideas; 2) Recognize and apply mathematics in contexts outside mathematics and 3) Demonstrate the interconnection of mathematical ideas and build on each other to produce a unified whole of knowledge.

Mathematical connection skills are very necessary for students because mathematics is a unified whole, where one concept is interconnected with other concepts, or in other words, studying certain concepts in mathematics requires prerequisites from other concepts (Septian & Komala, 2019). Regarding the importance of learning mathematics, NCTM (2000) argued that one of the importance of learning mathematics, namely learning to associate ideas. Apart from that, mathematical connection skills can also support improving thinking abilities, including high-level thinking abilities. If students can find connections between mathematical concepts and the relationship between mathematical concepts and everyday life, this can give rise to new thoughts or ideas in solving mathematical problems such as Higher Order Thinking Skills (HOTS) questions.

The HOTS questions in question are an instrument that can assess students' high-level thinking abilities so that students do not just remember or restate, but students are expected to be able to develop their ideas (Giani et al., 2015). Higher-order thinking is an analysis of understanding new questions or information by using and applying previous experience, to obtain an answer in a difficult situation and achieve a goal (Amalia & Hadi, 2020). Thus students' mathematical connections can be trained by solving HOTS questions because these questions indirectly require students to be able to connect and develop ideas in solving them.

In the 2013 curriculum, HOTS type questions began to be developed because the 2013 curriculum requires students not only to have the ability to solve low-level questions, but students must be able to use their thinking skills at a higher level and use mathematical forms to solve problems related to everyday life. . In the 2013 curriculum, students are also required to master HOTS questions (Kusuma & 'Adna, 2021).

The Ministry of Education and Culture (2017) explains that HOTS questions are a measurement instrument used to measure high-level thinking abilities, namely thinking abilities that do not just remember, restate, or refer without processing (recite).(Fikriani & Nurva, 2020). In line with opinion Giani et al., (2015) that the HOTS question in test is an instrument that can assess students' high-level thinking abilities so that students do not just remember or restate, but students are expected to be able to develop their ideas and concepts. In preparing HOTS questions, operational verbs are needed. The choice of operational verbs must be appropriate and appropriate to the realm of intellectual ability that you want to measure. So the HOTS questions referred to in this research are questions that do not just remember, understand and apply but require students to be able to analyze questions or information and be able to develop ideas by connecting previously acquired mathematical concepts in solving problems.

Based on previous research conducted by (Ully & Jahring, 2021) shows that the mathematical connection abilities of students in class IX of SMP Negeri 1 Tanggetada are still relatively low. According to the results of an initial interview with a mathematics subject teacher at one of the secondary schools, it was discovered that the majority of students had difficulty connecting the material currently being studied with previous material, and students even tended not to be able to answer questions related to material outside mathematics and students were also unable to complete it. story problems related to everyday life because they are confused about connecting these questions with mathematical concepts and procedures (Ully & Jahring, 2021).

Based on this, students' mathematical connections still need to be improved, considering the importance of developing mathematical connections in students, especially in secondary school. A similar problem was also found in one of the schools which is equivalent to a secondary school, namely MAN 2 Palu City. After conducting interviews with mathematics teachers at the school, information was obtained that students in class So the teacher must re-teach previous concepts related to the concept to be studied. Apart from that, students also have difficulty using mathematical concepts in working on questions that require a description of concepts such as HOTS questions. Students are not used to working on HOTS questions so they have difficulty solving them. Most students can remember the formula but sometimes do not know when and how to apply the formula. Students also have difficulty associating mathematical concepts with other fields.The difference between previous studies was examining students' mathematical connection abilities based on the students' learning styles because in these schools there was still minimal information about learning styles, whereas this research will describe students' mathematical connection abilities in solving HOTS questions because based on interviews conducted by researchers, teachers did not yet have them. an overview of students' mathematical connection abilities so that they have not received appropriate learning strategies to improve mathematical connections, both students with high mathematical abilities, students with moderate mathematical abilities and students with low mathematical abilities.

Of the many mathematical materials studied, arithmetic series is one of the materials whose concepts are interrelated with other mathematical concepts. This material also has an important role when applied to everyday life and can be used in other fields of science. Therefore, researchers are interested in conducting research on analyzing students' mathematical connection abilities in solving HOTS problems.The expected results of this research are to obtain a description of students' mathematical connection abilities in solving HOTS arithmetic series problems for MAN 2 Palu City Students.

2. METHOD

The method used in this research is a descriptive method with a qualitative approach. This research was conducted at MAN 2 Palu City. The research will be carried out in the 2022/2023 academic year, even semester. This research took 3 students as research subjects. To get these 3 people, they will be selected based on their final semester exam scores in mathematics subjects consisting of students with high abilities, students with medium abilities and students with low abilities. To categorize subjects, the following criteria are used.

Table 1. Student Ability Criteria

Category	Criteria
High ability	n + SD$\geq \bar{x}$
Moderate ability	$\bar{x}$ −SD n + SD$\leq <\bar{x}$

Low ability	n SD< $\bar{x}$ −

Arikunto (2013)

In this research, the material used is arithmetic series.The research instrument uses written assignments in the form of HOTS questions and interviews to measure students' mathematical connection abilities based on mathematical abilities which are categorized into 3, namely high, medium and low abilities.Indicators of mathematical connection abilities used in this research can be seen in the following table.

Table 2. Mathematical Connection Capability Indicator

Mathematical Connection Capability Indicator	Activities carried out
1. Relate one mathematical concept to other mathematical concepts	Relate the concept of arithmetic sequences to algebraic calculation operations and the concept of exponents
2. Relate mathematical concepts to everyday life	Relate the concept of arithmetic series to everyday life
3. Relate mathematical concepts to other fields	Relate the concept of arithmetic series in economics

3. RESULTS AND DISCUSSION

3.1. Results

Based on the students' semester exam scores, 3 research subjects were obtained as follows.

Table 3. Student Ability Criteria

Subject	Mark	Criteria
ST	95	Tall
SS	81	Currently
SR	70	Low

The three research subjects were given written tests or assignmentsin the form of HOTS arithmetic series questions created by the researcher himself with two questions. After that, the subject was interviewed to obtain accurate data regarding mathematical connection abilities. Based on data analysis carried out on the subject, the following research results were obtained.

Indicators Link One Mathematical Concept to Other Mathematical Concepts

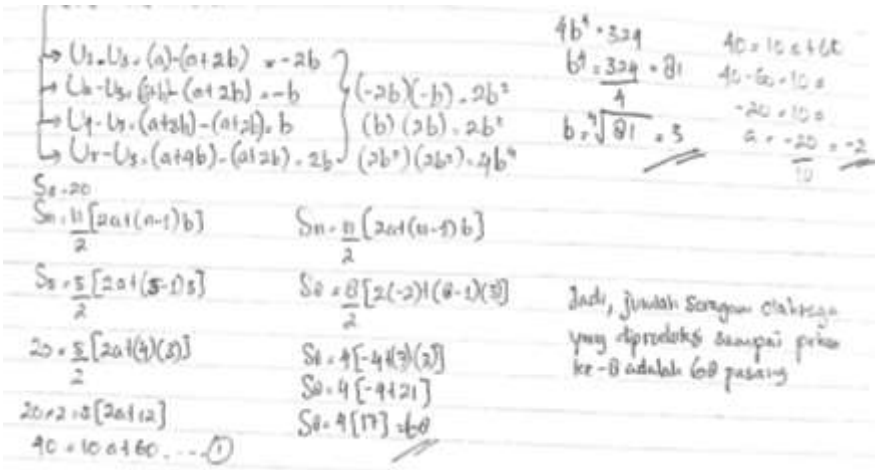

Figure 1. ST's Answer to Question Number 1

The picture above is the answer of a high-ability subject in which the subject was asked to determine the number of sports uniforms produced until the 8th week where it was known that the number of sports uniforms in the 5th week was 20 pairs with the condition that the number of sports uniforms in the 1st week , 2nd, 4th, and 5th minus week 3, then the product of the number of uniforms in weeks 1, 2, 4, and 5 is 324 pairs. Based on ST's answers and interview results, it shows that ST links several mathematical concepts in solving problems. Among them is the concept of arithmetic sequences, that is, and according to the ST question instructions, it is explained using the arithmetic operations of addition and subtraction, namely onwards. ST links the concept of exponents and root form, namely dividing by 4 and rooting both sides so . ST also correctly uses the concept of arithmetic series to obtain the value of a.$U_1 = a, U_2 = (a + b), U_3 = (a + 2b), U_4 = (a + 4b) U_5 = (a + 5b)(a) - (a + 2b) = -2b, (a + b) - (a + 2b) = -b 4b^4 = 324 b^4 = 81 = \sqrt[4]{81} = 3$

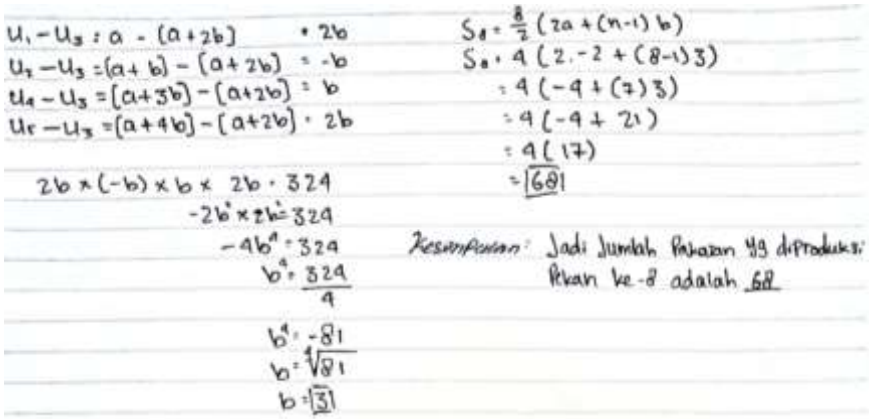

Figure 2. SS's answer to question number 1

In the picture above is the answer of a moderately capable subject which shows that the subject can write down the steps for solving problems using several concepts in mathematics, namely the concept of arithmetic sequences and linking them to the concept of addition and subtraction arithmetic operations. SS also uses the concept of exponents and roots, namely and . as well as using the concept of an arithmetic series to determine the number of clothes produced in the 8th week, namely $.U_1 = a, U_2 = (a + b), U_3 = (a + 2b), U_4 = (a + 4b) U_5 = (a + 5b) 4b^4 = 324 b = \sqrt[4]{81} = b S_8 = \frac{8}{2}(2a + (n - 1)b)$

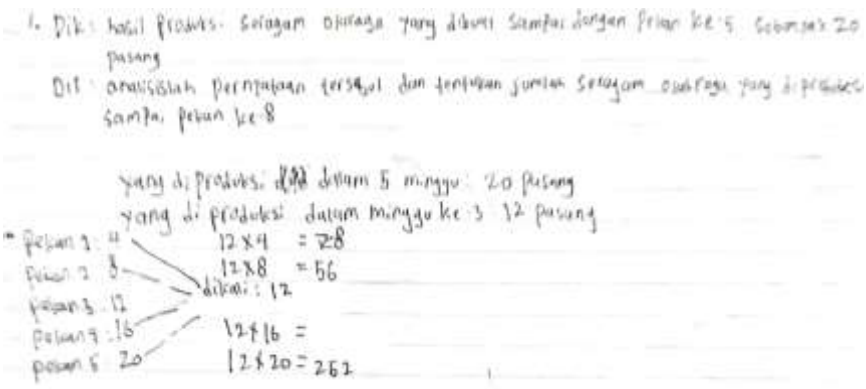

Figure 3. SR's answer to question number 1

From answer, SR is known that SR is not able to associate the concept of arithmetic sequences and series with other concepts. In the interview, SR also stated that he didn't really understand the questions given, but only knew what he knew and was asked about the questions, then SR also didn't know what material was involved in the questions and couldn't solve the questions correctly.

Indicator Linking Mathematical Concepts with Everyday Life

On the indicator of linking mathematical concepts to everyday life, data were obtained from subject interviews. Based on the results of the interview, it is known that ST can associate the concept of arithmetic series with everyday life. ST said that he had encountered the concept of arithmetic series in everyday life so he could give a simple example, namely for example in the first month I saved 10,000 then the next month it increased by 2,000 and so on until the tenth month. So to determine the amount of savings for 10 months, you can use the arithmetic series formula$S_n = \frac{n}{2}(2a + (n-1)b)$.

Based on the results of interviews conducted with SS subjects, it is known that SS can relate the concept of arithmetic series to everyday life. SS mentioned that the concept of arithmetic series can be used in everyday life, then SS said that arithmetic series are usually used to determine the number of chairs in a hall and SS can give concrete examples.

The results of interviews conducted with SR showed that SR was unable to relate the concept of arithmetic series to everyday life. From the interview it can be seen that SR does not understand the concept of arithmetic series and cannot provide simple examples regarding the use of the concept of arithmetic series in real life.

Indicators Link Mathematical Concepts in Other Fields

Figure 4. ST's answer to question number 2

In question number 2, the subject is asked to determine the amount of profit during the first year of his business activities, where it is known that the profit was IDR 700,000 in the fifth month and the total profit for seven months was IDR 4,620,000. Based on the answers and results of interviews with ST, it is known that ST can use the concept of sequences and arithmetic series as well as the SPLDV concept in solving problems in the field of economics. In the interview, ST said that the first concept that was linked was an arithmetic series to determine the first equation and then used the concept of an arithmetic series$U_n = a + (n-1)bS_n = \frac{n}{2}(2a + (n-1)b)$ to create the second equation [STM1 062]. Next, to obtain the values a and b, ST uses the SPLDV concept with the substitution and elimination method.

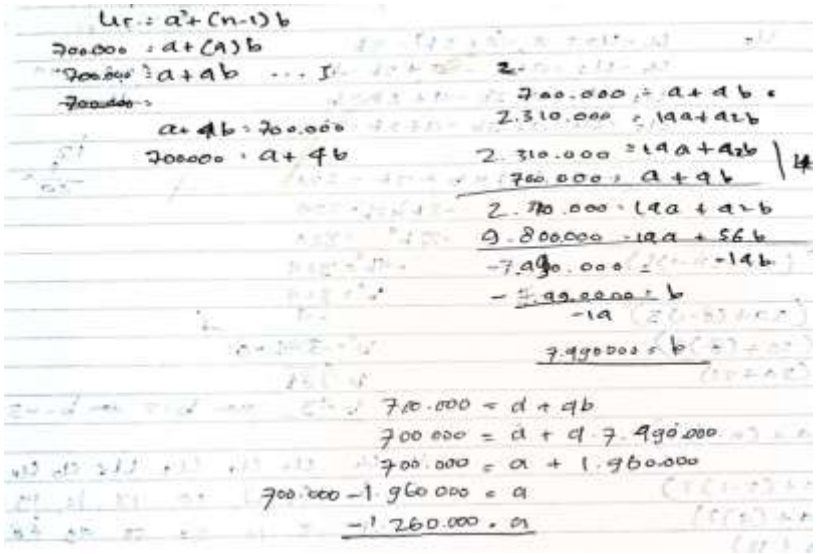

Figure 5. SS's answer to question number 2

Fromthe results of the answers and interviews conducted with SS found that SS was quite good at relating mathematical concepts in the field of economics, namely SS linked the concept of arithmetic sequences to make the first equation then linked the concept of arithmetic series to make the second equation [SSM1 054] and linked the SPLDV concept using the elimination method and substitution. However, SS cannot use algebraic arithmetic

operations properly so that it is wrong in solving the problem and unable to solve the problem correctly.$U_n = a + (n-1)b$

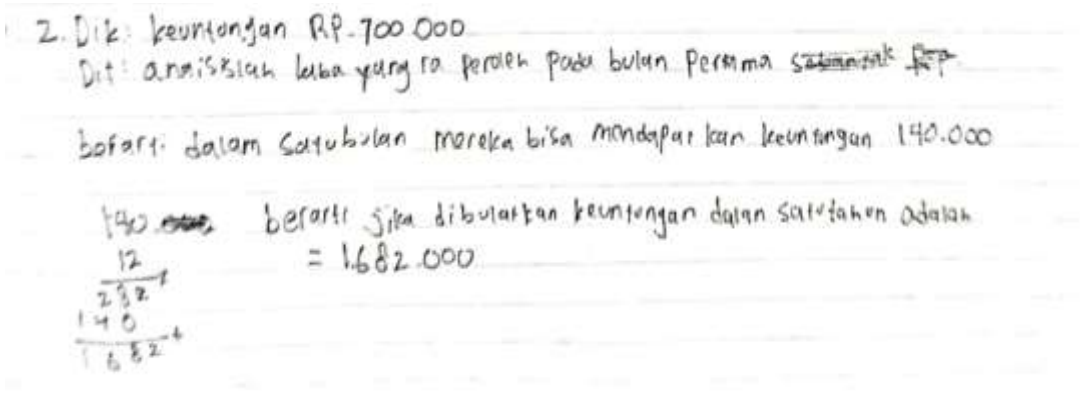

Figure 6.S R's answer to question number 2

Based onThe results of answers and interviews with SR revealed that SR was unable to relate the concept of arithmetic series to the field of economics. From the interview, SR stated that he did not understand how to do the questions and only wrote down what he knew and asked in the questions.

3.2 Discussion

a. Subject ST

In terms of indicators of linking one mathematical concept to another, ST is good at linking the concept of arithmetic series with the arithmetic operations of addition and subtraction, linking the concept of exponents and root forms and correctly using the concept of arithmetic series in solving problems. This shows that ST understands the relationship between mathematical concepts well so that they can use them in solving HOTS level questions. In line with Hurst's opinion in Rismawati et al., (2016) that concepts in mathematics are related to one another, therefore in solving mathematical problems a person can relate one concept to another concept.

Furthermore, the second indicator is linking mathematical concepts to everyday life. ST stated that he had encountered arithmetic series in everyday life and could provide simple examples of the use of arithmetic series concepts in real life. for the third indicator, ST is good at linking several mathematical concepts in solving problems in the field of economics, namely ST links the concept of arithmetic series to obtain equation (1) and arithmetic series to obtain equation (2). ST also links the SPLDV concept using the elimination and substitution method to determine the values a and b in the problem solving step. This shows that ST can understand and master the concepts used and can explain them well when interviewed. This is in accordance with opinion Rohmah & Warmi (2021) which states that mathematical connection skills help students master understanding concepts through connections between mathematical concepts and with concepts outside mathematics.

b. Subject SS

In linking one mathematical concept with other mathematical concepts, SS is good at linking several concepts in mathematics, namely the concept of arithmetic sequences$U_1 = a, U_2 = (a+b), U_3 = (a+2b), U_4 = (a+4b)$ $U_5 = (a+5b)$with the arithmetic operations of addition and subtraction, the concept of powers and root forms, namely$4b^4 = 324$ And$b = \sqrt[4]{81} = b$ and using the concept of arithmetic series to determine the number of clothes produced in the 8th week, namely$S_8 = \frac{8}{2}(2a + (n-1)b)$. SS is also good at

explaining the use of mathematical concepts in solving problems because he can understand the meaning of the questions and understand the interrelated concepts.In relating mathematical concepts to everyday life, SS stated that the concept of arithmetic series can be used in everyday life and is usually used to determine the number of chairs in a hall. SS is also able to explain and provide concrete examples regarding the application of the concept of arithmetic series in everyday life. In the third indicator SS is quite good at linking mathematical concepts with economics because in solving problems SS is only able to link the concept of arithmetic sequences to create equation 1, namely$U_5 = a + (n-1)b$then the equation is obtained. SS uses$700.000 = a + 4b$SPLDV concept but cannot relate to the concept of arithmetic series because they are confused about the next step to solve a problem that is slightly different from before. This is in accordance with the statement(Rohmah & Warmi, 2021)that students tend to get confused and have difficulties when they find problems that are presented differently. Even though SS was correct in using the concepts of arithmetic sequences and SPLDV, SS was unable to use algebraic calculation operations correctly so he solved the problem incorrectly and was unable to continue solving the problem because he did not understand the meaning of the problem. In accordance with Sudirman's opinion in Rohmah & Warmi (2021) stated that student errors occur because students forget the concepts studied before and do not understand the meaning of the questions.

b. SR Subject

In associating one mathematical concept with another, SR was unable to relate the concept of arithmetic sequences and series to other concepts. SR also stated that he did not really understand the questions given but only knew what he knew and was asked about the questions. It is possible that what happened was that SR forgot about the material for arithmetic sequences and series that he had studied and did not understand mathematical concepts well so that SR had difficulty working on questions that required high analysis such as HOTS questions. In accordance with the results of research conducted by Kempirmase et al. (2019) that students often forget the concepts related to the questions, making it difficult for them to complete questions, especially questions in the form of HOTS questions which are more contextual in nature and require high ability to analyze and evaluate. Furthermore, SR was not good at relating the concept of arithmetic series to everyday life and stated that he did not understand the concept of arithmetic series and could not provide simple examples regarding the use of the concept of arithmetic series in everyday life. This is because SR does not have a good conceptual understanding of mathematics so SR is often silent when interviewed. Meanwhile, in relating mathematical concepts to other fields, SR is not good at relating the concept of arithmetic series to the economic field. SR said he didn't understand how to do the questions correctly and only wrote down what he knew and asked in the questions. Thus it can be said that SR is not good at relating mathematical concepts to other fields.

4. CONCLUSION

The mathematical connection abilities of students with high mathematical abilities in solving HOTS questions series fulfil 3 indicators of mathematical connection ability. Namely, students who have high mathematical abilities (ST) and are good at relating the concept of arithmetic series to the arithmetic operations of addition and subtraction, relating the concept of exponents to the concept of roots, and relating the concept of arithmetic series to algebraic arithmetic operations, able to relate the concept of arithmetic series to everyday life. Then, the student correctly linked the concept of arithmetic series in economics. Students who have moderate mathematical ability (SS) meet two indicators of mathematical

connectivity ability, namely, linking the concept of arithmetic series with the arithmetic operations of addition and subtraction, linking the concept of exponents with the concept of root forms, linking the concept of arithmetic series with algebraic arithmetic operations. Then, he is good at relating the concept of arithmetic series to everyday life but cannot relate the concept of arithmetic series to the field of economics. The mathematical connection abilities of students with low mathematical abilities do not meet the three indicators of mathematical connection abilities. The indicators link one mathematical concept with other mathematical concepts for low-ability students who are good at linking the concept of arithmetic sequences and series with algebraic calculation operations and the concept of exponentiation with root forms. These students can also not relate the concept of arithmetic series to everyday life. They are not good at relating the concept of arithmetic series to economics.

SUGGESTION

It is best for students to practice a lot on questions that require critical thinking, such as HOTS questions, so that students can practice their thinking skills in connecting various knowledge or concepts they have, both concepts between mathematical topics and outside mathematics. Then teachers should pay more attention to students' mathematical connection abilities and be able to think about appropriate strategies or learning models to use that can improve students' mathematical connection abilities because having this ability can make it easier for students to solve problems. For other researchers who wish to conduct research on mathematical connection abilities, it is possible to expand the research subjects at both middle and high school education levels which are not used in this research.

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