AlphaMath
Journal of Mathematics Education, 11(1) May 2025
p-ISSN 2477-409X, e-ISSN: 2549-9084
Available online: https://jurnalnasional.ump.ac.id/index.php/alphamath/

Learning Independence as a Key to Mathematical Connections in Sequences and Series

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http://dx.doi.org/10.30595/alphamath.v11i1.26290

ABSTRACT

The ability to make mathematical connections is a critical skill that enables students to relate various mathematical concepts and apply them in diverse contexts. However, many students continue to struggle with this skill, indicating a significant gap in mathematical understanding. This study aims to describe students' mathematical connection ability through the lens of learning independence—an intersection that has received limited scholarly attention. Employing a qualitative descriptive method, the research involved 25 tenth-grade students, from whom six were selected based on stratified levels of mathematical connection ability (high, middle, and low). Data were collected through a written test focused on arithmetic sequences and series, guided by indicators of mathematical connection adopted from the national high school mathematics textbook. Complementary interviews were conducted to assess aspects of learning independence. The findings reveal that students with high learning independence demonstrated stronger mathematical connection ability, while those in the middle and low categories showed frequent conceptual errors and imprecise reasoning. The novelty of this study lies in its integrated analysis of cognitive and affective dimensions, offering new insights into how learning independence supports mathematical understanding.
Keywords: Arithmetic rows and series, Learning independence, Mathematical connection ability

ABSTRAK

Kemampuan membuat koneksi matematika merupakan keterampilan penting yang memungkinkan siswa untuk menghubungkan berbagai konsep matematika dan menerapkannya dalam konteks yang beragam. Akan tetapi, banyak siswa yang terus berjuang dengan keterampilan ini, yang menunjukkan kesenjangan yang signifikan dalam pemahaman matematika. Penelitian ini bertujuan untuk menggambarkan kemampuan koneksi matematika siswa melalui sudut pandang kemandirian belajar—sebuah titik temu yang kurang mendapat perhatian ilmiah. Dengan menggunakan metode deskriptif kualitatif, penelitian ini melibatkan 25 siswa kelas sepuluh, yang enam di antaranya dipilih berdasarkan tingkat kemampuan koneksi matematika yang bertingkat (tinggi, sedang, dan rendah). Data dikumpulkan melalui tes tertulis yang difokuskan pada deret dan deret aritmatika, yang dipandu oleh indikator koneksi matematika yang diadopsi dari buku teks matematika sekolah menengah nasional. Wawancara pelengkap dilakukan untuk menilai aspek-aspek kemandirian belajar. Temuan tersebut mengungkapkan bahwa siswa dengan kemandirian belajar yang tinggi menunjukkan kemampuan koneksi matematika yang lebih kuat, sementara mereka yang berada dalam kategori sedang dan rendah menunjukkan kesalahan konseptual yang sering terjadi dan penalaran yang tidak tepat. Kebaruan penelitian ini terletak pada analisis terpadu dimensi kognitif dan afektif, yang menawarkan wawasan baru tentang bagaimana kemandirian belajar mendukung pemahaman matematika.
Kata kunci: Barisan dan deret aritmetika, Kemampuan koneksi matematis, Kemandirian belajar

Received : May 1, 2025
Accepted : May 14, 2025
Published : May 15, 2025

Introduction

Mathematics is still considered difficult by students. Mathematics has abstract concepts that make students find it difficult to learn mathematics so they are less likely to like this lesson (Leonard et al., 2022). In addition to its abstract concepts, mathematics also has concepts that are interrelated with other concepts. Basically, mathematics is a science that can be used to solve various problems, not only in mathematics but in other sciences and also in daily life problems. Humans will always intersect with mathematics because every concept in mathematics can be found anywhere. According to Defitriani (Indriani & Noordyana, 2021) mathematics must be matched with science in other fields in daily life to be more meaningful. Therefore, students must have the ability to connect the relationship between math concepts and existing objects. The ability to connect or relate concepts in mathematics is called the ability to connect (Muharomi & Afriansyah, 2022).

According to the National Council of Mathematics Teachers, mathematics is the relationship between mathematics topics, mathematics with other subjects, and mathematics with the real world or everyday life (Romli in Nasution et al., 2021). NCTM emphasizes that the ability to build mathematical connections is essential in the learning process. The ability to connect concepts with real life, to learn interconnected mathematical concepts, and the goal that learning can be adequately achieved so that students are able to solve the problems given (Susanti & Faradiba, 2022). With the existence of mathematical connections, students not only learn about mathematics, but also learn how to apply it in various fields. The ability to make mathematical connections allows students to understand the relevance of the math material they have studied (Mahendra et al., 2023).

There are so many benefits if students have mathematical connection ability, but the facts show that students' mathematical connection ability are still low. The results of the observations made by the researcher are, students are often confused in solving mathematical problems. This statement is supported by the results by Yusuf et al., (2022) research which states that students' mathematical connection skills are still lacking with a percentage of 33.94%. None of the three indicators used in the study touched the 50% percentage. The low results are because students always feel confused when solving the given problems. Not understanding the given issues, lack of precision, and lack of understanding of mathematical concepts are the causes. Supono et al. (2024) also show that students still have low mathematical connection ability.

Students who experience low mathematical connections can be caused by several factors, including students not fully understanding the previous material and the material being taught (Mufidah & Machromah, 2023). The low curiosity of students in

depth about mathematics who think that mathematics is not related to each other and the lack of practice questions and its application in daily life are also factors that cause it. In order to describe the mathematical connection ability of students, an indicator of students' mathematical connection ability is used. The indicators used in this study are indicators of mathematical connection ability presented by NCTM (2000) in (Salsabila et al., 2022) are used, namely 1) Recognizing and using the relationship between mathematical ideas, 2) Understanding how ideas in mathematics are related to each other and produce a complete unity, 3) Recognizing and applying mathematics to contexts outside mathematics.

In the learning process, there are several factors that affect student learning. Hendrian (Muharomi & Afriansyah, 2022), said that learning is a cognitive process that is influenced by several factors such as individual circumstances, attitudes, individual views, ways of presentation, and prior knowledge. Individual circumstances are one of the important factors that can affect learning, namely learning independence. Zimmerman (2002) Learning independence is not a specific mental or academic skill like reading fluency, a self-management process as the process of turning mental skills into specific academic skills. In addition, according to Sundayana (Millaty, 2021), student learning independence can affect the mathematical ability possessed by students.

Independence in learning is very important for every student. To achieve learning goals, students need to develop their abilities independently in order to achieve the desired results (Arista et al., 2022). Students who have high learning independence will not give up easily and show behavior in solving problems well, on the other hand, students who have low learning independence tend to give up easily (Afidah et al., 2024; Aprila & Fajar, 2022). Learning independence has indicators or characteristics that have been developed by Zimmerman (Permatasari et al., 2022), namely metacognitive, motivational and behavioral. (1) Metacognitive which includes the dimensions of planning and determining learning goals, organizing, monitoring self-development and evaluating learning activities; (2) Motivational which includes having high self-efficacy and self-attribution, intrinsic interest in tasks, and students showing their hard work and perseverance in learning; and (3) Behaviors that include selecting, structuring and creating a conducive environment that can optimize their learning process. Using the learning independence indicator, the description of students' mathematical connection abilities can be done in a more targeted and effective way.

Basically, mathematical connections and learning independence are are skills and affective behaviors that are very important for students who are studying mathematics

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p-ISSN 2477-409X, e-ISSN: 2549-9084

to have. If students are independent in learning, they can connect mathematics in their own way. Mathematical connection ability and learning independence are two important factors that need to be considered to achieve mathematics learning goals (Nurhayati et al., 2022). This research is important because it discusses how students' ability to connect mathematical concepts and their learning independence. This research also serves as a material for educators' evaluation in understanding students in the learning process, especially in arithmetic row and series material. The novelty of this research lies in the analysis of students' mathematical connection abilities in arithmetic row and series materials reviewed from learning independence, not through a learning model like previous research. Therefore, the idea was to analyze the mathematical connection ability of SMK class X students in arithmetic row and series material reviewed from learning independence.

Research Methods

The method used is descriptive qualitative to explain the ability of mathematical connections reviewed from learning independence. Descriptive research is a research that produces reports containing data and then delivered in the form of words, images, not numbers (Moleong in Fatmasari et al., 2024). The subjects were taken as many as 25 students in class X of Pharmacy of SMK Kesehatan Logos who were given test questions about rows and series of arithmetic sourced from the book Mathematics for High School/Vocational School Class X First Edition, 2021 published by the Ministry of Education, Culture, Research, and Culture. The test questions consist of three questions which in each question contains an indicator of mathematical connection ability. The indicators used as stated by National Council of Teacher of Mathematic (NCTM, 2000) are 1) Recognizing and using the relationships between mathematical ideas, 2) Understanding how the ideas in mathematics relate to each other and produce a complete unity, 3) Recognizing and applying mathematics in contexts outside mathematics. Then the six people were reviewed on their learning independence. Question item number one contains the first indicator, question item two contains the second indicator, and question item three contains the third indicator.

Furthermore, six of the 25 students will be selected as subjects and grouped into three categories, namely high, middle, and low. The six students were selected based on the results of the analysis that had been carried out based on indicators of mathematical connection ability. They will be reviewed on their learning independence based on indicators developed by Zimmerman (Permatasari et al., 2022), namely metacognitive, motivational, and behavioral. (1) Metacognitive which includes the dimensions of planning and determining learning goals, organizing, monitoring self-development and evaluating learning activities; (2) Motivational which includes having high self-efficacy and self-attribution, intrinsic interest in tasks, and students showing their hard

work and perseverance in learning; and (3) Behaviors that include selecting, structuring and creating a conducive environment that can optimize their learning process. The review was carried out by asking direct questions or short simple interviews by indicators of learning independence.

Result and Discussions

Based on the results of calculating students' answer scores using Microsoft Excel, an average score of 81.43 was obtained from 25 students on math row and series material. Then from the score, it is recalculated to do grouping. The grouping is categorized into three groups, namely high, middle, and low categories using measures according to Arikunto (Amieny & Firmansyah, 2021) based on average scores and standard deviations (Table 1).

Table 1. Distribution of Categorization of Students' Mathematical Connection Ability

Score	Frequency	Category
$x > 88.99$	3	High
$73.87 \leq x \leq 88.99$	17	Middle
$x < 73.87$	14	Low

This grouping is carried out to determine the interview subject in order to obtain information and verification about learning independence based on the results of the test answers. Then the results will be used as a reference to analyze students' mathematical connection abilities reviewed from learning independence. Then six subjects were taken from each category with two high categories, two middle categories, and two low categories. The high category is named with the codes Tg1 and Tg2, the middle category with Sd1 and Sd2, and the low category with Rd1 and Rd2.

Mathematical Connection Ability

The ability to connect is one of the basic skills that students need to master. National Council of Teachers of Mathematics (NCTM) menyatakan bahwa mathematical connections are the relationships between mathematics topics and other subjects, and between mathematics and the real world or everyday life (Romli in Nasution et al., 2021). For high school students who have passed the elementary school phase, of course, they have quite a lot of basic knowledge of mathematics that will be reused, so that students will not only know when learning but will continue to be used and interconnected, this shows that students must have basic mathematical skills (Dinata et al., 2023).

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To describe how the mathematical connection ability of students is, the indicator of mathematical connection ability is used. The indicators used are based on the National Council of Teachers of Mathematics (NCTM, 2000) including, 1) Recognizing and using the relationships between mathematical ideas, 2) Understanding how the ideas in mathematics are related to each other and produce a complete unity, 3) Recognizing and applying mathematics to contexts outside mathematics. The following is a discussion of students' mathematical connection abilities in arithmetic row and series material from the results of students' answers.

The ability of mathematical connections in indicators to recognize and use relationships between mathematical ideas

In the indicator of recognizing and using the relationship between mathematical ideas, students are expected to solve test problems by using the relationship of mathematical ideas by connecting arithmetic rows with a two-variable linear prediction system by converting known tribes into equations. This indicator is in question item number one. The following are the results of the completion on the subjects.

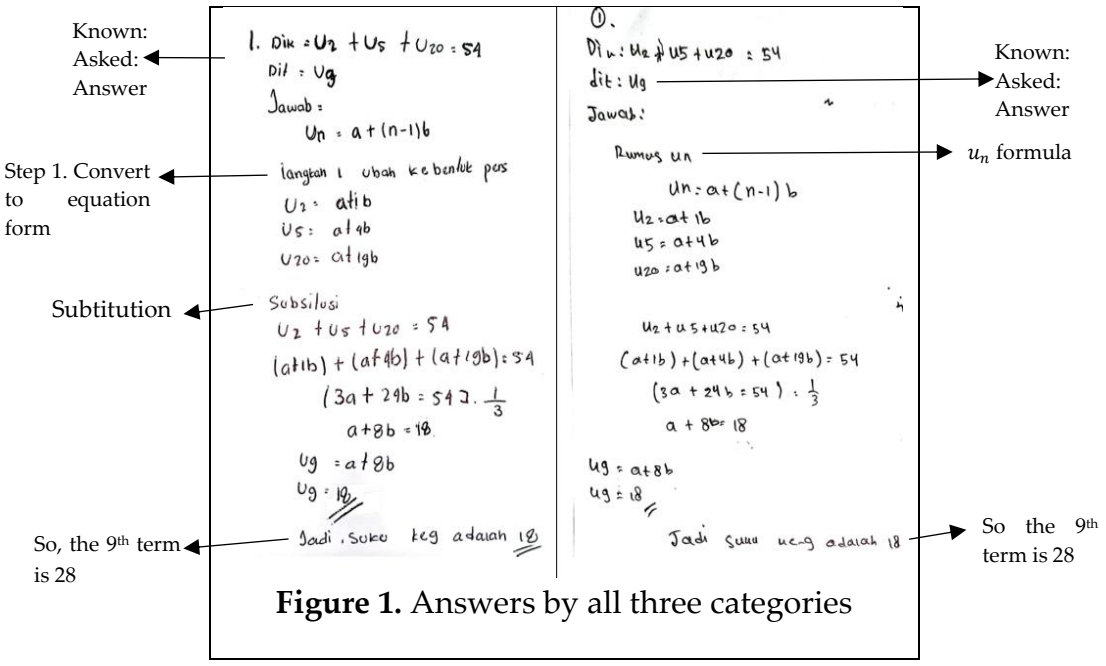


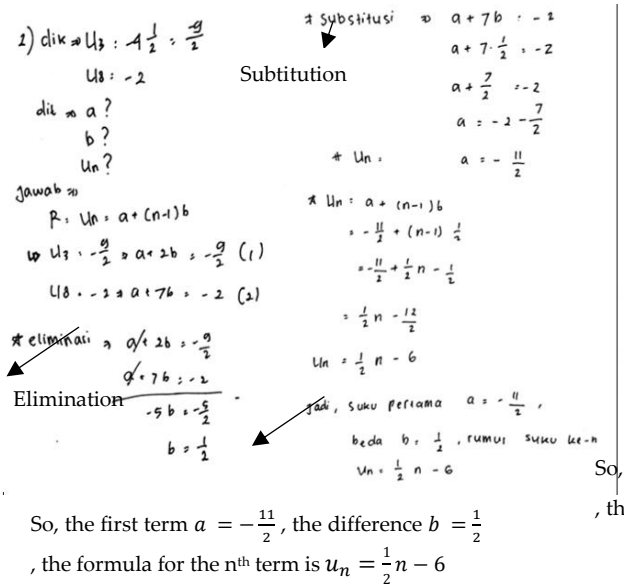
Figure 1. Answers by all three categories

In question number one, the subjects of the three categories had the same solution (Figure 1). They are able to make modeling from the formula u_n into the form of a two-variable linear equation (it can also be said that it is a formula of u_n) which is then operated by summing according to the existing information. After doing the addition, they found an equation model that is $a + 8b = 18$ and they understood the concept. According to Arnidha (Angelina & Effendi, 2021), if students can solve the problem with the right steps, then students can define what is contained in the problem into a

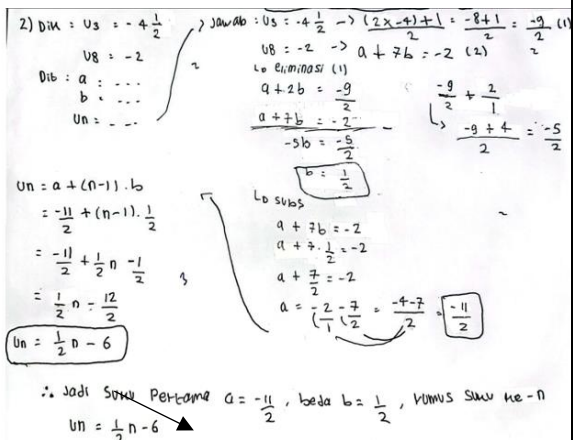
mathematical model. From this understanding, they can conclude that the equation can be interpreted as the 9th or u_9. So that, u_9 was obtained is 19. From this explanation, it can be concluded that they understand to use interconnected mathematical concepts or ideas. From the three answers, it can be said that the subject meets the indicators of recognizing and using the relationship between mathematical ideas.

The ability of mathematical connections in indicators to understand how ideas in mathematics relate to each other and produce a whole unity

In the indicator of understanding how ideas in mathematics are related to each other and produce a complete unity, students are expected to be able to solve these problems by using ideas in mathematics in solving them so that they get the right results. This indicator is in question item number two and is asked to look for the first syllable, different, and nth syllable formula. To find the first difference and syllable, the concept of a two-variable linear equation system and fractional number operation is required. The following are the results of the completion on the subjects that have been grouped.



So, the first term $a = -\frac{11}{2}$, the difference $b = \frac{1}{2}$, the formula for the nth term is $u_n = \frac{1}{2}n - 6$



So, the first term $a = -\frac{11}{2}$, the difference $b = \frac{1}{2}$, the formula for the nth term is $u_n = \frac{1}{2}n - 6$

Figure 2. Answers by Tg1 and Tg2

The solution done by Tg1 and Tg2 is the same (Figure 2). They are able to use the concept of mixed fractions, which is to convert mixed fractions into ordinary fractions, $-4\frac{1}{2} \rightarrow -\frac{9}{2}$. As you can see, there are two known pieces of information and they convert it into a two-variable linear equation form (it can also be said that it is a formula of u_n) so that two equations are obtained. From the two equations, they used the concept of a two-variable linear equation system by performing elimination and substitution methods to obtain the first and different terms. Once obtained, they use it

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to obtain the formula u_n and perform mathematical operations up to the formula of the first quarter (u_n) is found. They also solved it by using the concept of fractional operation. The ability of Tg1 and Tg2 to connect fractional concepts, two-variable linear equation systems, fractional operation, and arithmetic row formulas shows that they understand how mathematical ideas are interrelated and form a whole unit in problem solving. From this statement, it is said that Tg1 and Tg2 can see mathematics as a whole (Maulida et al., 2019) and understand that ideas in mathematics are interrelated with each other. From this explanation, the high category is declared to meet these indicators.

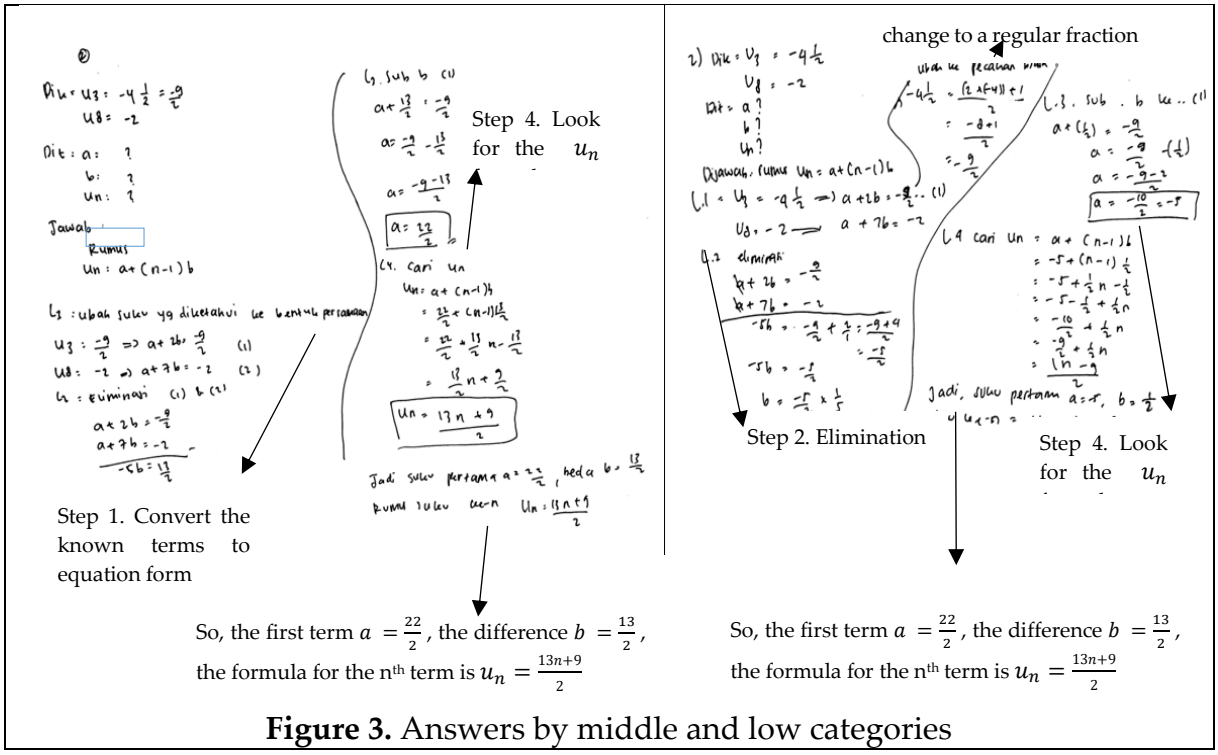

Figure 3. Answers by middle and low categories

The completion made by this middle category is actually the same as the high category, but they have errors in the process (Figure 3). They used the concept of a two-variable linear equation system with elimination and substitution methods, the concept of mixed fractions, fractional operations, and arithmetic rows. Let's look at the fractional operation Sd1 when performing an elimination to look for b, i.e. $-\frac{9}{2} - (-2) = \frac{13}{2}$, it ignores the negative sign on the fractional number. This continues in the next process, which is to find a so that the final result obtained is not correct. This is also due to a mistake in writing the equation that will be used as a substitution place for the value b. Similar to what Sd2 and low category do. Most of these mistakes occur because they do not understand the concept and how to calculate. As said by Syakur et al., (2021) that students do not understand mathematical concepts, students do not understand the concept of division, and students are also less thorough or careless in calculating.

Based on these results, it can be said that the middle and low category students have not met this indicator because of the mistakes they made in completion.

The ability of mathematical connections in indicators to recognize and apply mathematics in contexts outside of mathematics

In the indicator of recognizing and applying mathematics in contexts outside mathematics, students are expected to be able to apply mathematics to contexts other than mathematics. This indicator is in question item number 3 and presents problems in the real world with the hope that students will be able to understand them and turn them into mathematical models. In daily life, humans are inseparable from mathematics, so every human needs to learn mathematics not only in the classroom but its application in real life. In mathematics learning, students are expected to be able to apply problems, apply concepts, and mathematical formulations in problems related to daily life (Supriyadi et al., in Rohmah & Warmi, 2021). The following are the results of the completion on the subjects.

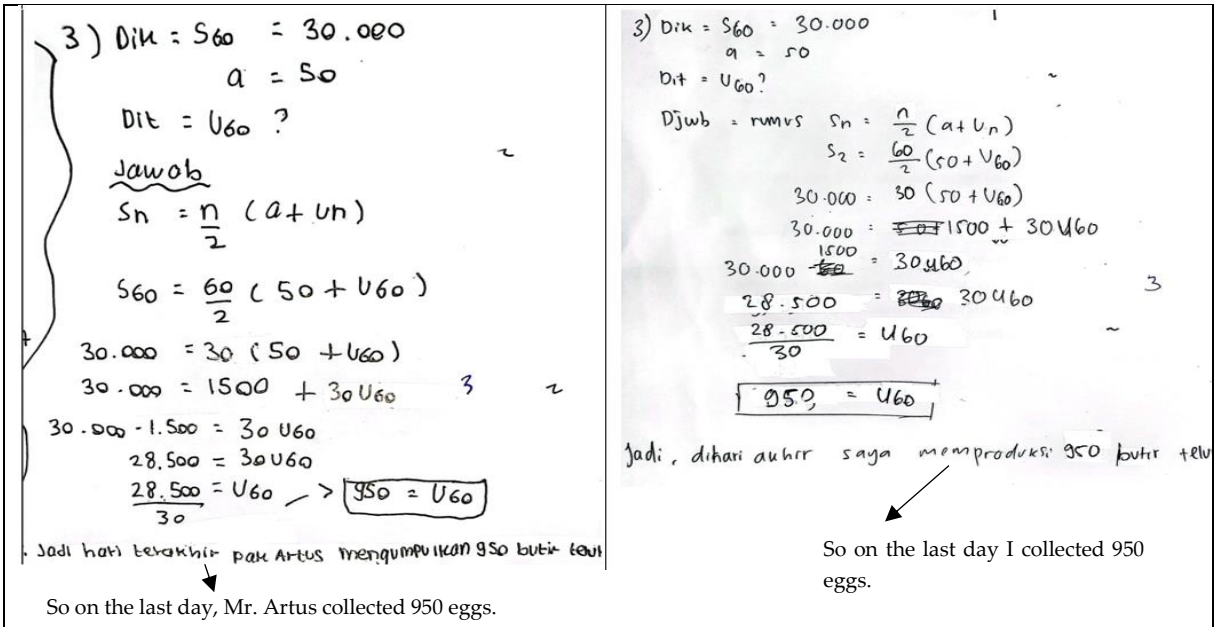

Figure 4. Answers by all three categories

In question number three, the subjects of the three categories had the same solution (Figure 4). They are able to turn everyday stories into mathematical models. Similarly, they understand what the question is aimed at, namely to find out how much egg production will be on the last day. Using the existing information, namely the first quarter and the number of n first quarters. From the available information, they use the concept of a formula $S_n = \frac{n}{2}(a + u_n)$. By substituting existing information and mathematical operations, they found u_{60} is 950 eggs. Judging from the results of the

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solution, ketiga kategori were able to solve the problem. So it can be said that the subject meets the indicators of recognizing and applying mathematics into a context outside of mathematics, because mathematics is often encountered in everyday life. As stated by Masamah (Rohmah & Warmi, 2021) that mathematical concepts and skills can be found and applied in various activities in human life.

Learning Independence

Learning independence is a behavior towards the desire to learn on one's own initiative by designing desires according to one's abilities without any coercion from others (Taufiqoh et al., 2023). Students can increase their motivation to continuously improve and update the way they learn. Students who can manage themselves in learning can see the development of their abilities, have a chance of succeeding academically, and look at their future optimistically. Therefore, independence in learning is very important for a person, having independence will cause confidence, individual self-ability, and control over the individual's own abilities (Fatah & Zumrotun, 2023). With learning independence, students are expected to be able to understand and respond well to their learning conditions (Arista et al., 2022).

Students have different learning independence. So to see this, the learning independence indicators developed by Zimmerman (Permatasari et al., 2022) are used, namely metacognitive, motivational, and behavioral. These three indicators describe how students manage their learning process independently and review how the level of learning independence relates to students' ability to make mathematical connections in solving arithmetic row and series problems. For this reason, the following is a discussion of student learning independence based on each indicator.

Learning Independence is a metacognitive indicator that includes the dimensions of planning and determining learning goals, organizing, monitoring self-development and evaluating learning activities

Based on the results of the interviews that have been conducted, subjects with high groups (Tg1 and Tg2) meet metacognitive indicators. They always make plans and determine their learning goals so that everything is neatly arranged. Always organize and monitor his development and always evaluate his learning activities. Meanwhile, subjects with middle (Sd1 and Sd2) and low (Rd1 and Rd2) groups only planned and determined learning goals without revealing themselves, so they did not know how far they had progressed.

Learning independence is a motivational indicator that includes having high self-efficacy and self-attribution, intrinsic interest in tasks, and students showing their hard work and perseverance in learning

Based on the results of the interviews that have been conducted, the subjects with the high group (Tg1 and Tg2) have efficacy in themselves that he can with real attribution. They are always interested in the tasks given because it will make their abilities continue to improve by always trying hard and diligent in learning. In contrast to the subjects in the middle group (Sd1 and Sd2) who were less interested in the tasks given because according to them it made them difficult, but they always had efficacy and attribution in them, as well as diligent in learning. The subjects in the group were tall and felt that if they made mistakes in doing the assignment because of a lack of effort to do them. Meanwhile, the subjects in the low group (Rd1 and Rd2) thought that the task made them difficult so that there was no effort to do the task. If it is wrong, they say they do not understand, do not understand, it is difficult so they do not believe in their own abilities. In line with Zagoto (2019), individuals who have high academic self-efficacy rate their failure in doing academic assignments to be due to lack of effort, while students with low self-efficacy rate their failure as due to lack of ability.

Learning Independence on behavioral indicators which include selecting, structuring and creating a conducive environment that can optimize their learning process
Based on the results of the interviews that have been conducted, these three groups of subjects always choose an environment that they think is conducive to learning because it will make them focus on learning. A no-distraction, comfortable, and safe environment to optimize the learning process. This is supported by the results of the questionnaire on this indicator (Ghassani et al., 2023) obtained an average of 64.8% with fairly good interpretation.

Basically, the ability to make mathematical connections and learning independence are essential affective skills and behaviors that need to be possessed and developed by students who study mathematics. If students are independent in learning, they can connect mathematics in their own way. Students with learning independence are able to learn better, due to the timing and responsibilities they have and are both metacognitive, motivational and behavioral (Sakinah & Hakim, 2023), so that they are able to solve mathematical connection problems. This is described in the results of the answers and interviews of students with a high group that meets all of these indicators.

Students who have high learning independence tend to learn better, are able to monitor, evaluate, and manage their learning effectively, manage learning and time efficiently, and obtain high scores (Anjarsari et al., 2021). In contrast to the middle and low groups that did not meet the indicators of mathematical connection ability and learning independence. They experience difficulties and errors in their completion. Based on the results of the interviews, they did not have high learning independence, as evidenced by the non-fulfillment of the learning independence indicators. This

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p-ISSN 2477-409X, e-ISSN: 2549-9084

shows that learning independence plays an important role in supporting students' mathematical connection ability.

Conclusion

Based on the results and discussion, the conclusion obtained is that students with the ability to make mathematical connections in the high group tend to have high independence also because they meet all indicators. Students with high learning independence do not make mistakes in answering questions. Meanwhile, students with mathematical connection ability in the middle and low groups tend to have less learning independence because they do not meet all indicators. They have errors and are less thorough in their solutions. This shows that learning independence plays an important role in supporting students' mathematical connection ability. Due to time and space limitations, it is suggested that further research can use a quantitative approach to examine mathematical connection ability and learning independence. In addition, the scope of material and research subjects is expanded to obtain diverse and unique discussions.

Acknowledgement

The author would like to thank the SMK Kesehatan Logos for providing opportunities and support in this research and also thank the lecture who have provided input in the preparation of this article.

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p-ISSN 2477-409X, e-ISSN: 2549-9084