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ANALYSIS OF MATHEMATICAL REASONING ABILITY IN TERMS OF STUDENTS' MATHEMATICAL LEARNING INDEPENDENCE

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ABSTRACT
Mathematical reasoning is one of the important mathematical abilities possessed by students. This ability can be improved through mathematical learning independence. Mathematical learning independence is currently not visible in conventional learning from teachers. Low mathematical learning independence makes students' mathematical reasoning abilities also not realized properly. The purpose of this study was to describe students' mathematical reasoning abilities in terms of mathematical learning independence of MAN 2 Pekanbaru students. The research method is a qualitative approach with data collection techniques in the form of mathematical reasoning ability tests and mathematical learning independence questionnaires. This study found that the mathematical reasoning abilities of students with high mathematical learning independence were better than students with medium and students with medium mathematical learning independence were better than students with low mathematical learning independence.
Keywords: Mathematical Reasoning, Mathematical Learning Independence, Sequence And Series

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PRELIMINARY

Students need to be well-prepared to face the world. According to Amir, preparing students to be able to face world changes is the goal of learning school mathematics (Amir, 2015). This reason is that mathematics is felt to be able to encourage students to be more systematic in thinking and develop logical thinking (Nurfadhillah et al., 2021). This way of thinking makes mathematics the basis of knowledge related to the expansion of other fields of study so it is very influential in the progress of science and technology (Zulkarnain & Rahmawati, 2014). This reason also means that mathematics is an important subject that must be mastered by students.

Students can be said to be successful in learning mathematics when they achieve the vision of learning mathematics, which aims to foster a way of thinking with a reasoning abilities. It was explained that mathematical reasoning ability plays an important role in students because it encourages each individual to be able to provide conjectures on the experiences they have (Hendriana et al., 2017). Improved mathematical reasoning ability not only improves students' performance in mathematics, but also leads to increased application of mathematical knowledge to real-world experiences (Mukuka et al., 2021).

The existence of mathematical reasoning ability is a necessity for students to understand mathematical concepts and without mathematical reasoning ability makes it is difficult for students to solve mathematical problems (Izzah & Azizah, 2019). When learning mathematics, the capacity to think mathematically plays a crucial role and has a significant impact on how a problem is solved (Rosyid et al., 2018). Mathematical reasoning ability is also the ability of students to find a way to develop and convey creativity in the form of mathematical ideas from the broad range of mathematical phenomena they face (A. S. Lestari et al., 2018). This means that it is important for students to have mathematical reasoning ability as well as being the main characteristic in learning mathematics (Khaeroh et al., 2020; Kotto et al., 2022; Romadhina et al., 2019).

Mathematical reasoning ability can be developed in a student by paying attention to the learning process with activities in which students are trained to produce a mathematical conjecture and attempt to manipulate mathematics as a strategy for solving mathematics. The ultimate goal is to make students with their mathematical reasoning abilities able to draw a valid conclusion as a solution to a mathematical problem. Sri Wardhani explained several indicators that became the realization of students' mathematical reasoning ability, namely (1) students could propose a hypothesis, (2) students could perform mathematical manipulation of the problems encountered, (3) students could draw a conclusion accompanied by reasons and evidence which is the basis for concluding, (4) students conclude a statement submitted, (5) students examine the truth of a statement submitted, and finally (6) students are required to be able to find patterns or characteristics of existing mathematical symptoms and make it generalized (Hendriana et al., 2017).

Referring to the six indicators that students must have as part of mathematical reasoning ability, then comparing it with the current conditions of learning mathematics, it can be concluded that it has not been realized properly and is classified as low (Khainingsih et al., 2020). This assertion is supported by the findings of TIMSS research, which revealed that 17% of students on average had cognitive domains with the lowest degree of mathematical reasoning ability, which is the lowest level ever recorded in Indonesia (Rosnawati, 2013). The results of this research continue with field facts that provide reasons for the low mathematical reasoning ability of Indonesian students because the learning process is not precise and does not facilitate students' mathematical reasoning ability. A similar claim holds that Indonesia's low levels of mathematical reasoning ability are the result of conventional education's failure to recognize students' mathematical reasoning abilities, which has a negative impact on both the quality of students' learning and school achievement (N. Lestari et al., 2016). Learning that makes pupils passive when they should be the focal point and major characters of the lesson leads to ineffectiveness.

Making students the center of learning will require students to have independence in learning mathematics. The mathematical learning independence possessed by a student will be able to give birth to the nature and personal responsibility of students to organize and discipline themselves when studying (Afiani, 2017). The sense of responsibility and discipline born from mathematical learning independence will also hone students' mathematical abilities, especially in reasoning to find valid strategies for mathematical problems. Mathematical learning independence will also make students have more effort in finding and achieving learning goals (Isnaeni et al., 2018).

Mathematical learning independence in students can be seen from the indicators of mathematical learning independence in the form of (1) the existence of initiative and intrinsic learning motivation, (2) diagnosing the need for self-study to become a habit of students, (3) the existence of a vision and mission in the form of learning goals/targets, (4) can monitor, organize, and control learning, (5) mathematical difficulties are seen as a challenge that must be faced, (6) there is an effort to find learning resources and utilize relevant learning materials, (7) can sort and choose a learning strategy to be applied, (8) being able to evaluate learning processes and outcomes, and (9) having self-efficacy or self-concept (Ariyanti, 2019). Nine indicators of mathematical learning independence applied by a student can produce a positive attitude toward learning. The positive attitude that is born will have a good impact on the students' mathematics learning process. The learning process with a positive attitude can result in a growing sense of caring for students to learn better. This will later develop students' mathematical abilities in terms of logical thinking making students' mathematical reasoning ability realized well.

Research by Dewi et al. suggests that mathematical learning independence has a good impact on learning outcomes in mathematics (Dewi et al., 2020). Research by Fajriyah et al. found that mathematical learning independence had a positive effect on students' mathematical reasoning ability by 46.6% (Fajriyah et al., 2019). A similar statement is that mathematical learning independence has a positive effect of 79% on students' mathematical reasoning ability (Cahya et al., 2021). It is said that students with weak reasoning tend to be less independent than students with strong reasoning (Isnaeni et al., 2018). It was also found that students with a high level of mathematical learning independence could fulfill the four indicators of mathematical reasoning, while students who had a low level of mathematical learning independence could not have complete mathematical reasoning indicators (Hidayati, 2020).

Based on the results of previous research which found valid decisions related to the effect of mathematical learning independence on mathematical reasoning ability, this research will describe students' mathematical reasoning ability in terms of students' mathematical learning independence. This study will analyze students' mathematical reasoning ability by reviewing students' mathematical independence learning based on ability level. The study's findings showed how MAN 2 Pekanbaru pupils' capacity to think mathematically was predicated on their ability to become more independence.

METHODS

This research is a qualitative descriptive research through case studies. A case study was conducted to describe students' mathematical reasoning ability in terms of mathematical learning independence. Case studies as a form of research collect data in the form of results of analysis of mathematical reasoning ability and mathematical learning independence.

The subjects of this research were 30 students of class XI at MAN 2 Pekanbaru. The research was conducted in class XI at MAN 2 Pekanbaru because they studied sequences and series material in the previous semester. The data collection technique is by giving tests and non-tests. Tests in the form of questions to measure mathematical reasoning abilities with sequences and series material. Non-tests in the form of a questionnaire to measure mathematical learning independence. The test used is a written test that contains questions with indicators of mathematical reasoning ability quoting from the modification of indicators spoken by Sri Wardhani, namely : (1) performing mathematical manipulations, (2) drawing conclusions from statements, (3) making conjectures, (4) finding patterns or characteristics of mathematical phenomena to make generalizations, and (5) checking the validity of a statement (Hendriana et al., 2017). The material for the questions used are sequences and series, namely arithmetic and geometric sequences and arithmetic and geometric series. The questions consist of 5 questions with each question containing one indicator of mathematical reasoning ability. The questions used have met the prerequisites for the due diligence as shown in Table 1 below.

Table 1. Results of the Question Feasibility Testv

No.	Validity		Reliability		Difference Power	Difficulty Level
	Results	Criteria	Results	Criteria		
1	Valid	Very High			Good	Easy
2	Valid	Very High			Good	Medium
3	Valid	Very High	Reliabel	High	Very Good	Medium
4	Valid	Very High			Good	Easy
5	Valid	Very High			Pretty Good	Easy

Subsequent data collection used a questionnaire sheet containing 13 positive statements and 9 negative statements of students regarding students' mathematical learning independence. The indicators of students' mathematical learning independence analyzed were: (1) initiative and intrinsic learning motivation, (2) diagnosing the need for self-study to become a habit for students, (3) vision and mission in the form of learning goals/targets, (4) being able to monitor, organize, and control learning, (5) mathematical difficulties are seen as a challenge that must be faced, (6) there is an effort to find learning resources and utilize relevant learning materials, (7) can sort and choose a learning strategy to apply, (8) being able to evaluate learning processes and outcomes, and (9) having self-efficacy or self-concept (Ariyanti, 2019). The questionnaire provided is valid and reliable. The results of student answers to the questionnaire will be processed using the following scoring guidelines.

Table 2. Guide to Scoring Questionnaire of Mathematical Learning Independence

Score	Positive Statement	Negative Statement
4	Strongly Agree	Strongly Disagree
3	Agree	Disagree
2	Disagree	Agree
1	Strongly Disagree	Strongly Agree

The scores that students get from each statement will later be added up to get the final score. The final values that have been found and processed will then be grouped according to the categories in Table 3 below.

Table 3. Category Level of Mathematical Learning Independence

Interval	Category
The Final Value ≥ Mean + SD	High
Mean - SD ≤ The Final Value < Mean + SD	Medium
The Final Value < Mean - SD	Low

(Eka & Yudhanegara, 2015)

There are 30 students in one class who will be tested regarding students' mathematical learning independence. 30 students will be divided into 3 classification levels of mathematical learning independence. There are three classifications of mathematical learning independence, namely high-level mathematical learning independence, medium-level mathematical learning independence, and low-level mathematical learning independence. For the high category, the score must be greater than and equal to the sum of the mean and standard deviation. For the low category, the score must be less than the difference between the mean and the standard deviation. While for the medium category, the score lies between the high and low categories. Subjects in the study will also carry out written tests in the form of sequence and series questions based on mathematical reasoning ability. Each item represents an indicator of mathematical reasoning ability. The results of written test questions with indicators of mathematical reasoning ability in students will be reviewed based on their independence in learning mathematics.

The analysis was conducted by examining students' mathematical reasoning skills at the level of their independence in their mathematical learning, along with pertinent research backing and preexisting theory. The final results of the analysis will describe students' mathematical reasoning ability in terms of students' mathematical learning independence.

RESULT AND DISCUSSION

This research was carried out on April 12 2023 in Class XI students of MAN 2 Pekanbaru. Based on testing on 30 students by distributing the mathematical learning independence questionnaire, the percentage of mathematical learning independence was found as presented in Figure 2 below.

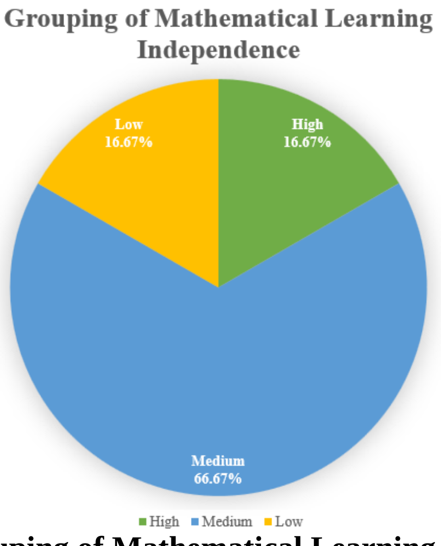


Figure 1. Grouping of Mathematical Learning Independence

Figure 1. explains that out of 30 students, 16.67% have a high level of mathematical learning independence (5 students), 16.67% have a low level of

mathematical learning independence (5 students), and the remaining 66.67% have a medium level of independence (66.67%, 20 students).

The average score of 30 students for each indicator of mathematical reasoning ability can be seen in Table 4 below.

Table 4. Average Score of Each Indicator

Indicator of Mathematical Reasoning Ability	Average Score
1	3.57
2	2.60
3	2.70
4	3.27
5	3.40

Table 4 explains that in the first, fourth, and fifth indicators of mathematical learning independence, the average student scores were 3.57, 3.27, and 3.40 respectively, meaning that almost all students answered with answers that were substantially correct and complete. Whereas in the second and third indicators, the average scores obtained by students were 2.60 and 2.70 respectively, which means that the average of 30 students answered with almost perfect answers but there were still some significant errors.

The results are shown in Table 5 below in relation to students' independence in their mathematical learning and their capacity for mathematical reasoning.

Table 5. Results of Mathematical Reasoning Ability in Terms of Mathematical Learning Independence

Students' Mathematical Learning Independence	The Final Value of Mathematical Reasoning Ability												Mean	Varians
	100	95	90	85	80	75	70	60	50	30	10	5		
High	1	1	1	2	0	0	0	0	0	0	0	0	89	38
Medium	1	4	3	4	2	1	1	1	1	1	0	1	77	553.5
Low	0	1	1	0	1	1	0	0	0	0	1	0	69	778.8

The data presented in Table 5 explains that students with high mathematical learning independence have an average score of the highest mathematical reasoning ability, namely 89 with the lowest score variance of 38. Students with medium mathematical reasoning ability have an average mean mathematical reasoning ability of 77 with a variance of 553.5. The students with low mathematical reasoning ability had the lowest average mathematical reasoning ability of 69 and the highest variance of 778.8. It can be concluded that students with high mathematical reasoning ability have better mathematical reasoning ability. This conclusion is in line with the statement that students who have to learn independence will be able to manage their study habits so that they can fulfill almost all indicators of mathematical reasoning ability which will later make their learning outcomes even better (Syahputri & Febriyanty, 2021).

As an effort to describe students' mathematical reasoning ability, they will be classified into 3 categories, namely in this case the researcher will take several students as representatives of each category from high mathematical learning independence, medium mathematical learning independence, and low mathematical learning independence to see the results tests of sequences and series questions that measure students' mathematical reasoning ability.

Analysis of Question No. 1

Question no 1 with indicators of doing mathematical manipulation. The following image displays student responses.

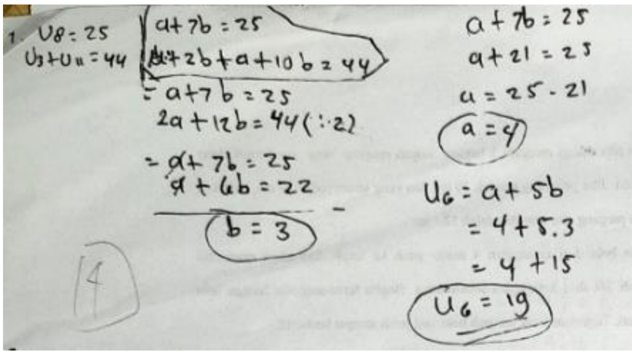


Figure 2. Students' Respons for The First Indicator of Mathematical Reasoning with High Mathematical Learning Independence

The answers given by the students for high mathematical learning independence show that these students have been able to manipulate the known equations from the problems so that they obtain additional information to be able to solve the problem.

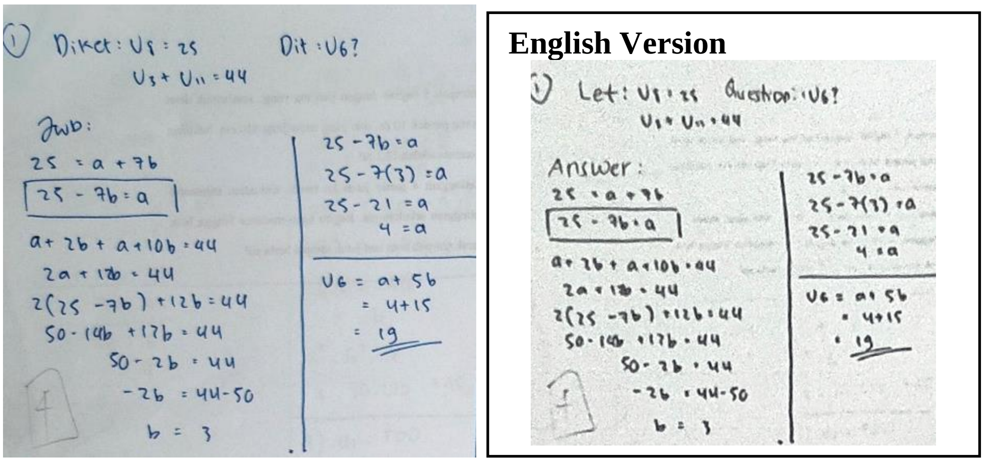


Figure 3. Students' Respons for The First Indicator of Mathematical Reasoning with Medium Mathematical Learning Independence

The answers presented by the students' medium mathematical learning independence also show the ability to perform mathematical manipulations where questions are solved using the substitution method.

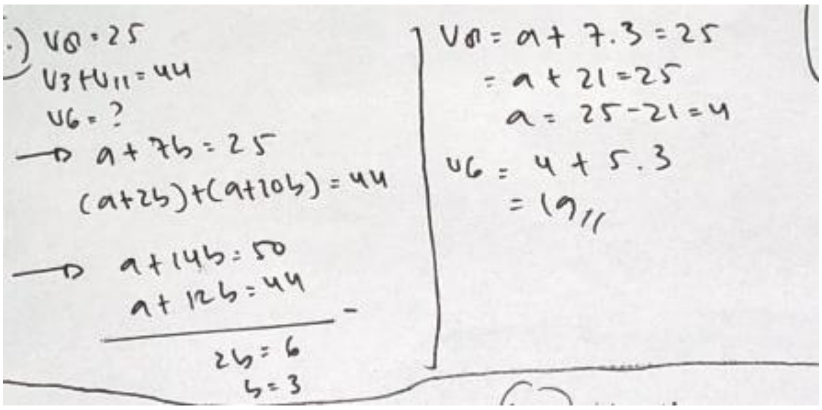


Figure 4. Students' Respons for The First Indicator of Mathematical Reasoning with Low Mathematical Learning Independence

By demonstrating the process of problem-solving utilizing substitution and elimination techniques, the students' responses to low mathematical learning independence questions are offered to demonstrate the students' capacity to manipulate mathematics.

Summing up the three students' answers from high mathematical learning independence, medium mathematical learning independence, and low mathematical learning independence in the mathematical reasoning ability indicator for doing mathematical manipulation can be implemented well. Each level has a different strategy from the others.

Analysis of Question No 2

Question number 2 with indicators concludes statements. The following image displays the results of student answers.

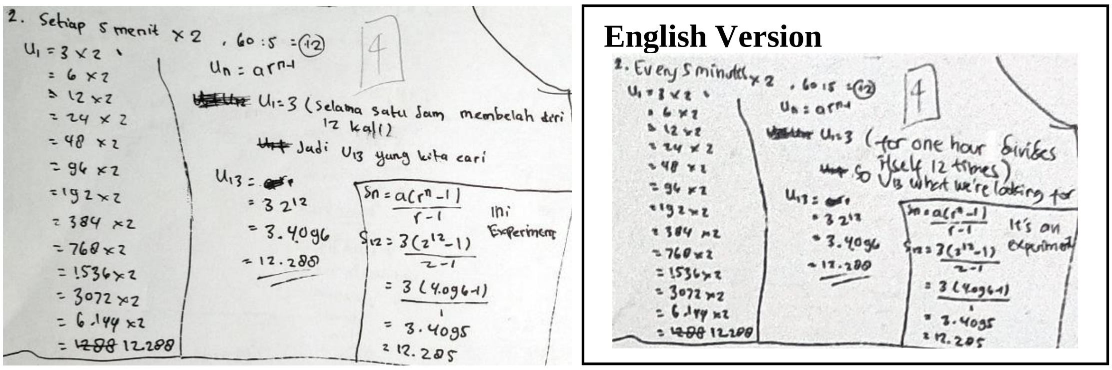


Figure 5. Students' Respons for The Second Indicator of Mathematical Reasoning with High Mathematical Learning Independence

The answers given by the students for high mathematical learning independence show that the students have been able to conclude from the statements. Initially, the answers were searched manually, then concluded with the formulas that had been learned. The existing streaks give an illustration of the initial doubts when using the formula.

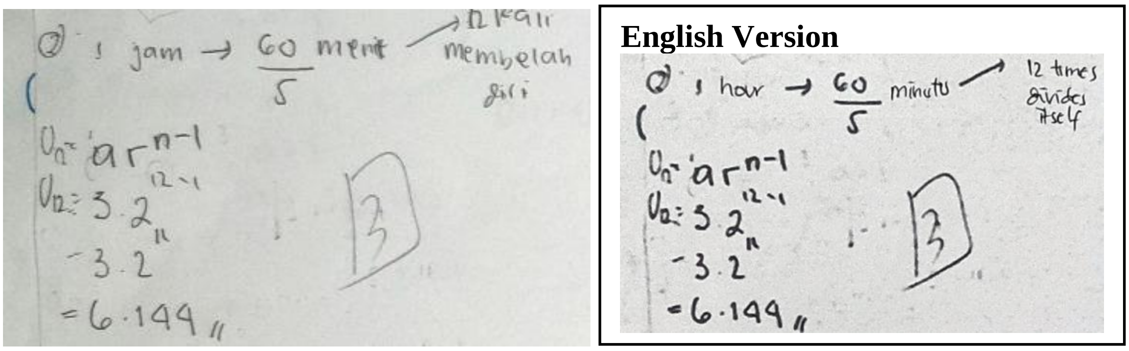


Figure 6. Students' Respons for The Second Indicator of Mathematical Reasoning with Medium Mathematical Learning Independence

Medium Mathematical learning independence students have not been able to solve the problems given perfectly. Analyzing the completion stage it was found that the settlement process was carried out well, but there was a mistake in ignoring the n + 1 value.

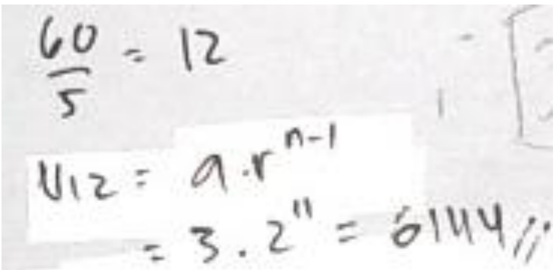
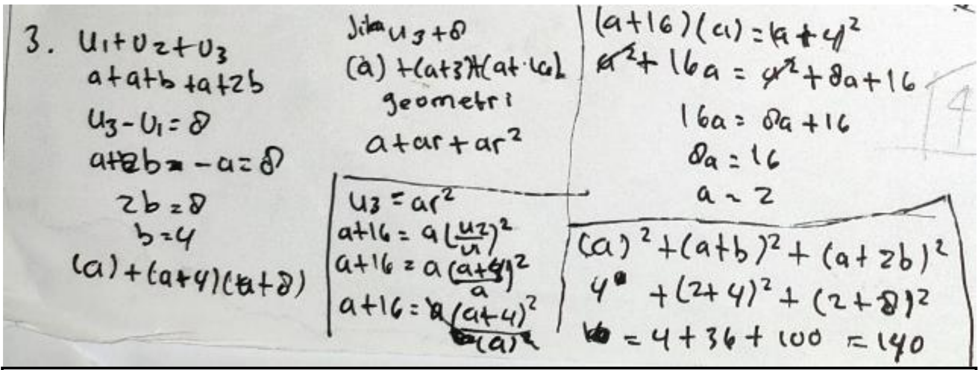


Figure 7. Students' Respons for The Second Indicator of Mathematical Reasoning with Low Mathematical Learning Independence

Students who struggle to learn mathematics independently also struggle to come up with flawless solutions to current difficulties. Low mathematical learning independence students are less accurate in taking the value of n, which requires ignoring the initial term and starting from zero minutes, just like medium mathematical learning independence students. Based on the student responses to a series of questions that contained indicators of mathematical reasoning ability for high mathematical learning independence, medium mathematical learning independence, and low mathematical learning independence students, a conclusion was drawn that only high mathematical learning independence students were able to perform well. All students in answering question number 2 had difficulties including initial doubts in determining the completion strategy by high mathematical learning independence students, errors in loading n values which meant less than perfect in finding all the information on the questions by medium mathematical learning independence students, and low mathematical learning independence students. This is due to not having studied the problem in the question so it is wrong to conclude.

Analysis of Question No. 3

Question no 3 with indicators can make conjectures. The following image displays student responses.



English Version

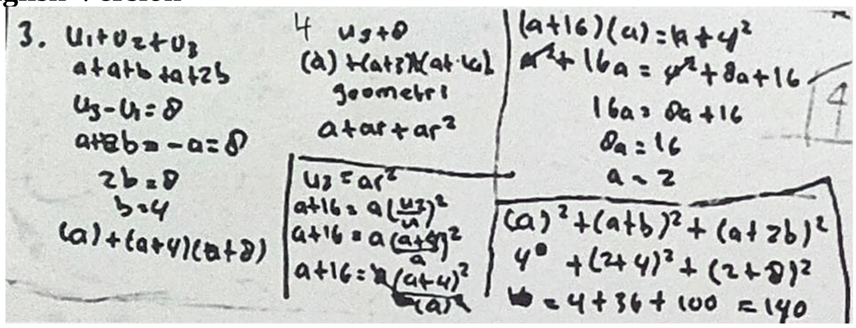
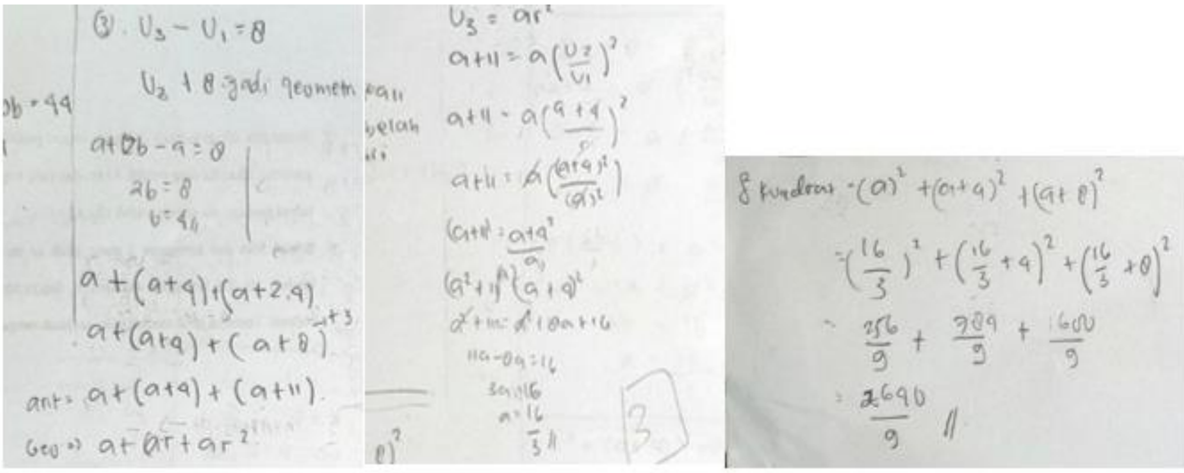


Figure 8. Students' Respons for The Third Indicator of Mathematical Reasoning with High Mathematical Learning Independence

With high mathematical learning independence, students have been able to make conjectures. The statements contained in the problem are made into mathematical statements.



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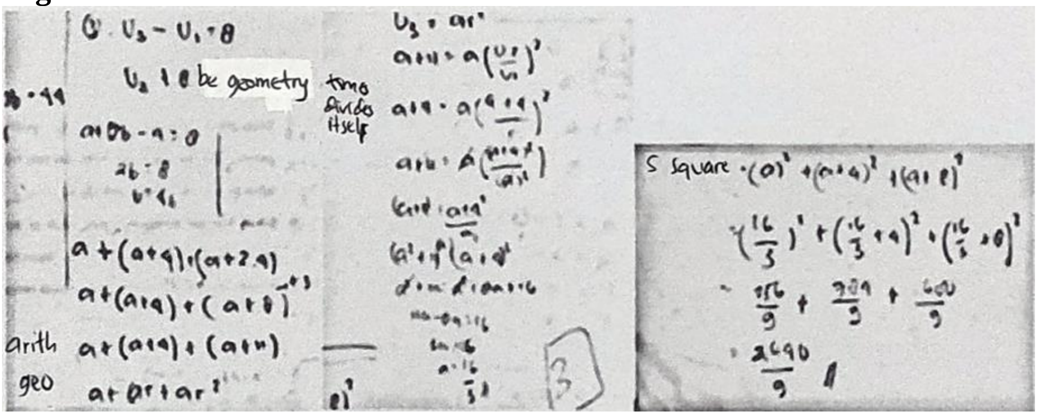

Figure 9. Students' Respons for The Third Indicator of Mathematical Reasoning with Medium Mathematical Learning Independence

Medium mathematical learning independence students almost solve the problems given correctly. It's just that students of medium mathematical learning independence made a mistake in the form of wrongly loading the addition of numbers in the third term so that geometric sequences were not formed and the solution was wrong. For medium mathematical learning independence, students should add 8 instead of 3.

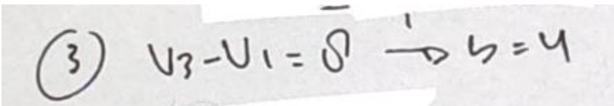

Figure 10. Students' Respons for The Third Indicator of Mathematical Reasoning with Low Mathematical Learning Independence

Students of low mathematical learning independence are only able to find the difference from a given sequence. As for proposing number guesses as a solution to problem-solving, it has not yet been seen in the students' answers to low mathematical learning independence.

According to the three students' responses, who had varying degrees of mathematical learning independence, conjectures might be made and put forth by students with high and medium levels of mathematical learning independence. The high mathematical learning independence students succeeded in giving conjectures based on mathematical examples and were correct, while the medium mathematical learning independence students tried to provide conjectures, but were wrong in loading the number value that should have been eight. This makes the students not get perfect scores and make mistakes in forming geometric sequences. As for students of low mathematical learning independence, they have not been able to meet the indicators of proposing conjectures as a mathematical solution to the questions given.

Analysis of Question no 4

Question no 4 with indicators to find patterns or characteristics of mathematical phenomena to make generalizations. The following image displays student answers.

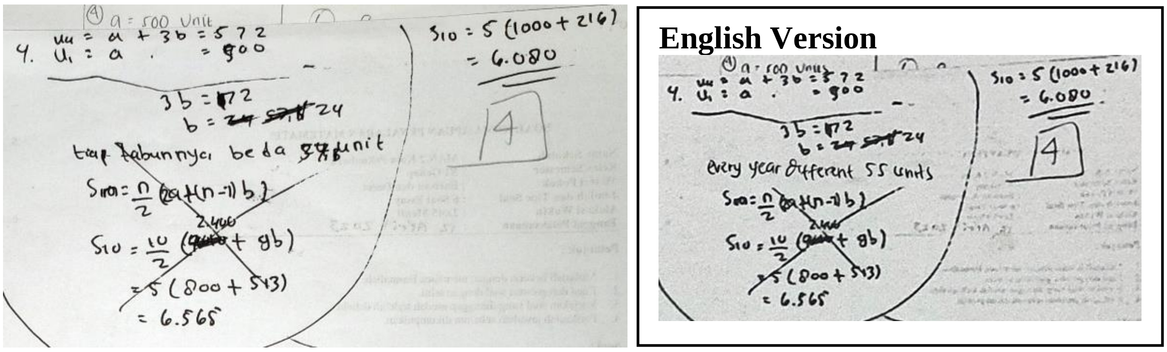

Figure 11. Students' Respons for The Fourth Indicator of Mathematical Reasoning with High Mathematical Learning Independence

With high mathematical learning independence, students have been able to solve problems correctly and apply them to a formula.

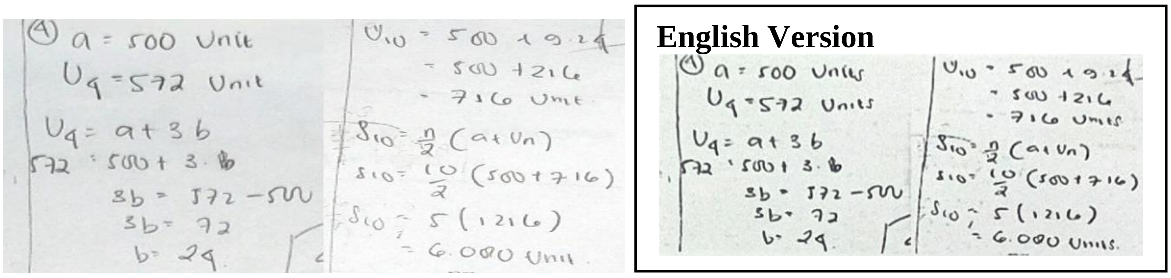

Figure 12. Students' Respons for The Fourth Indicator of Mathematical Reasoning with Medium Mathematical Learning Independence

Medium mathematical learning independence students also did not find it difficult to solve problems. Answers are presented correctly and meet the 4th mathematical reasoning ability indicator.

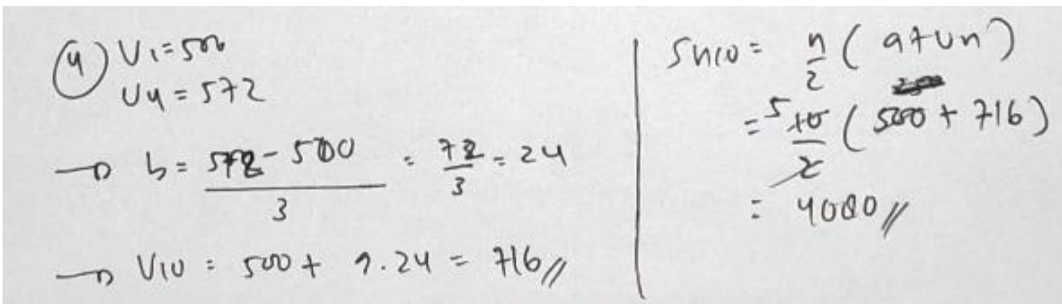

Figure 13. Students' Respons for The Fourth Indicator of Mathematical Reasoning with Low Mathematical Learning Independence

Students with low mathematical learning independence almost solved the problem correctly but made a mistake in the calculation in the last step. This error resulted in imperfect answers given.

Analyzing the three answers related to the indicators found a pattern or nature of mathematical symptoms to make generalizations for high mathematical learning independence students, medium mathematical learning independence students, and low mathematical learning independence students were successfully fulfilled. For students of low mathematical learning independence this indicator has been fulfilled, but analysis of the answers shown shows student errors in doing calculations. This means that students of low mathematical learning independence students made a mistake in writing the last answer correctly so they did not get a perfect score for the answer to question number 4.

Analysis of Question no 5

Question no 5 with indicators checks the validity of an argument. The following image displays student responses.

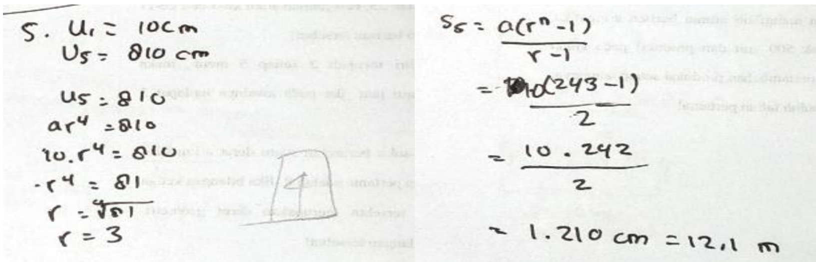

Figure 14. Students' Respons for The Fifth Indicator of Mathematical Reasoning with High Mathematical Learning Independence

With high mathematical learning independence, students can solve problems correctly using existing formulas. It's just that high mathematical learning independence students do not give reaffirmation of answers stating the validity of the answers submitted.

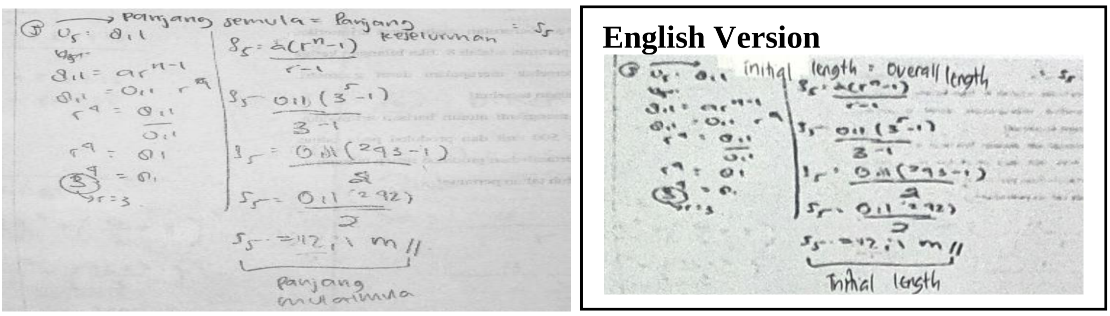

Figure 15. Students' Respons for The Fifth Indicator of Mathematical Reasoning with Medium Mathematical Learning Independence

Students with medium levels of mathematical independence have also been successful in delivering the proper solution completion procedure; however, there is no confirmation of the correct answer at the conclusion of the answer. It can be said that students have not met the indicators of checking the validity of a statement.

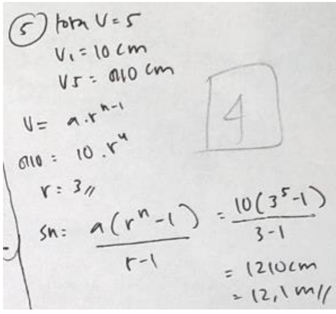

Figure 16. Students' Respons for The Fifth Indicator of Mathematical Reasoning with Low Mathematical Learning Independence

Low mathematical learning independence students can also solve problems well. The only drawback is that there is no reaffirmation that the statement given is true.

According to the students' responses to the questions about high mathematical learning independence, medium mathematical learning independence, and low mathematical learning independence, it was evident that the three students had not demonstrated their ability to check the veracity of a statement, which is the fifth indicator of mathematical reasoning ability. The three students succeeded in providing the correct answer-finding completion process but neglected to check the validity of a statement which could have made students mistaken in the completion process. Therefore, indicators checking the validity of a statement should not be ignored.

Overall the results of the analysis of students' mathematical reasoning ability in terms of students' answers to high mathematical learning independence, medium mathematical learning independence students, and students' low mathematical learning independence are presented in Table 6 below.

Table 6. Analysis of Mathematical Reasoning Ability

Indicator of Mathematical Reasoning Ability	Mathematical Learning Independence		
	High	Medium	Low
doing mathematical manipulation	√	√	√
concludes statements	√	X	X
can make conjectures	√	√	X
to find patterns or characteristics of mathematical phenomena to make generalizations	√	√	√
checks the validity of an argument	X	X	X

In Table 6, it is known that students with high mathematical learning independence have good mathematical reasoning ability and can realize 4 of the 5 indicators of mathematical reasoning ability that are measured. These results are relevant to Syahputri & Febriyanti's research. Students with mathematical learning independence can realize 3 of the 5 indicators of mathematical reasoning ability and students with low mathematical learning independence are only able to apply 2 of the 5 indicators of mathematical reasoning ability that are measured. No one can answer question number 5 perfectly. Because of the lack of reaffirmation about proving a problem. Should be at the end of the proof, students mention that the statement is true or false. But students do not write it down. Students are only accustomed to writing answers to problems without reaffirming questions. Overall the results of this study indicate that students with high mathematical learning independence are more skilled in applying students mathematical reasoning ability, this ability is trained because students already have a good self-concept to maximize their abilities and increase their mathematical knowledge. It can be said that mathematical learning independence has a positive impact on increasing students' mathematical reasoning ability as it is said that mathematical learning independence has a significant influence on students' mathematical reasoning ability (Cahya et al., 2021; Fajriyah et al., 2019). This means that students' mathematical learning independence is something that teachers and students need to pay attention to so that students' mathematical reasoning abilities can be improved and applied.

Students with high independence in learning mathematics have good mathematical reasoning abilities. Students with medium mathematics learning independence have medium mathematical reasoning abilities. While students with low mathematics learning independence have low mathematical reasoning abilities. But in this research, there are limitations, it is not equipped with interviews and observations of research subjects.

CONCLUSION

The results of this study found that the mathematical reasoning ability of MAN 2 Pekanbaru students in terms of mathematical learning independence only had difficulties in the 2nd, 3rd, and 4th indicators. In the 2nd indicator of mathematical reasoning ability, students with medium mathematical learning independence and low mathematical learning independence are not correct in finding many terms. The student ignores the existence of the first term. In the 3rd indicator, high mathematical learning independence students were able to answer the questions well, medium mathematical learning independence students made mistakes in entering information in their answers, but the completion steps were correct, and low mathematical learning independence students had not been able to solve the problem correctly. In the 4th low mathematical reasoning ability indicator, only students with mathematical learning independence did not have the correct answer, due to an error in doing the calculations.

The results of this study concluded that it is necessary to pay attention to mathematical learning independence because it will more or less have an impact on students' mathematical reasoning ability. Students with high mathematical learning independence showed better results in students' mathematical reasoning ability, compared to students with medium mathematical learning independence and low mathematical learning independence. Thus, students with high mathematical learning independence own students with an average mathematical reasoning ability of 89, students with medium mathematical learning independence own students with an average mathematical reasoning ability of 77, and students with low mathematical learning independence own students with an average mathematical reasoning ability of 69.

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