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Analysis of Junior High School Students' Errors in Solving Mathematical Literacy Problems based on Newman Procedure Viewed from Students' Learning Styles

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Abstract:
This study aimed (1) to determine students' mathematical literacy skills viewed from learning styles; (2) to know and describe students' mistakes in solving mathematical literacy questions based on the Newman procedure viewed from students' learning styles; and (3) to know the causes of students' mistakes in solving mathematical literacy questions based on Newman procedure viewed from learning styles. This research was a qualitative research with a case study type and used a descriptive approach. The subjects of this study were 53 students of class VIII, 11 Public Junior High School, Tegal, Indonesia. The data were collected using questionnaires, tests, and interviews, which were then analyzed. The results showed that: (1) the students' learning styles were visual, auditory, kinesthetic, visual-kinesthetic, and auditory-kinesthetic; (2) visual learning style students have the best mathematical literacy skills because they reach the lowest level 3 and the highest level 4; whereas kinesthetic learning style students made the most mistakes; and (3) the causes of students' errors in solving mathematical literacy questions viewed from their learning styles tend to be the same, i.e.: students do not master patterns and sequence material, and students felt rushed when working on the questions.

Keywords: students' errors, mathematical literacy, Newman procedure, learning styles.

1. Introduction

Education is a tool that can improve the quality of human resources. Education can shape the character of an individual and make him/her a man/woman who has morality, faith and fear in God Almighty, and can educate the life of the Indonesian nation. This is what is needed in preparing and facing the competition of the global era. The important objectives of education need to be supported by cooperation between educational components so that they can be achieved properly in accordance to the Law No. 20 of 2003 (Republic of Indonesia, 2003).

Mathematics plays an important role in accelerating the mastery of information and communication technology (ICT). Hence, mathematics becomes one of the compulsory subjects at the school level. Mathematics taught in schools has a function to develop students' ability to calculate, measure, and use mathematical formulas used in everyday life (Masfufah and Afriansyah, 2021). In developing students' abilities, teachers are required to present mathematical information in the form of text or media. This relates to students' mathematical literacy.

Mathematical literacy is an individual's ability to formulate, use, and interpret mathematics into a variety of contexts. The mathematics learning objectives contained in the 2013 Curriculum Content Standards have give attention to aspects that contain students' mathematical literacy (Janah, Suyitno, and Rosyida, 2019). This shows that students' mathematical literacy is important to be achieved as mathematics-learning goals.

The mathematical literacy of students in Indonesia is still low. Based on the results of Program for International Students Assessment (PISA) released by the Organization for Economic Co-operation and

Development (OECD) for mathematical literacy in 2018, the average score obtained by Indonesia is still far below the OECD average score. Indonesian students' ability to read was 371 in average, while the OECD average was 487 (OECD, 2019). From these results, it can be seen that the mathematical literacy of students in Indonesia is still not satisfactory. The focus of PISA is literacy, which emphasizes more on students' competencies and skills obtained at school and can later be used in everyday life in various situations (Nurvicalesti, Walid, and Dewi, 2021).

To improve students' mathematical literacy, information is needed on the difficulties of students' experiences in solving mathematical literacy problems by analyzing students' errors. One procedure that can be used to analyze students' errors in solving mathematical literacy problems is the Newman procedure. Students' errors are categorized into five Newman procedures, namely: (1) reading; (2) comprehension; (3) transformation; (4) process skill; and (5) encoding errors (Tekaeni, Supandi, and Setyawati, 2020). Furthermore, it is concluded in Susanti (2019) that 37.1%; 47%; 73%; 80%; and 78.1% of students made reading; comprehension; transformation; process skills; and encoding errors, respectively. Based on this explanation, it can be seen that students still make mistakes in solving mathematical problems related to mathematical literacy skills.

Learning style is one of the characteristics of students that have an influence on student learning outcomes. Learning style is one of the factors that affect students' literacy (Edimuslim, Edriati, and Mardiyah, 2018). There are three main types of learning styles, namely visual, auditory, and kinesthetic. Individuals with visual, auditory, and kinesthetic learning styles receive information better by seeing; hearing; and by means of practice, respectively. An analysis of students' mathematical literacy skills in terms of students' learning styles concluded that (Hamidah, 2018):

1) Students who have visual learning style are able to complete up to level 5, which is the second highest level. Students are said to have met all indicators on mathematical literacy skill.
2) Students who have auditory learning style are able to complete up to level 5. However, the students are only able to meet 3 indicators.
3) Students who have kinesthetic learning style are able to complete up to level 4. The first student is able to reach the third indicator, while the second student is only able to reach the second indicator.

Based on the explanation above, it can be concluded that students have diverse mathematical literacy skills when viewed from students' learning styles. Students who have visual learning style have superior mathematical literacy skills than students who have auditory and kinesthetic learning styles. Therefore, this study is conducted to analyze and describe mistakes made by students in solving mathematical literacy problems based on Newman procedure in terms of students' learning styles. It also describes the causes of students making these mistakes.

2. Research Method

This was a qualitative research with a case study type, using a descriptive approach. The research was conducted at 11 Public Junior High School, Tegal, Indonesia. The subjects of this study were students in grade VIII-E and VIII-F of 11 Public Junior High School, Tegal. The research was conducted on the 2022/2023 academic year.

Data collection was carried out using questionnaires, tests, and interviews. The questionnaire used a Likert scale and contained 23 statements. The math test was in the form of essay questions with a total of 4 items. The mathematical material tested was pattern and series of numbers. The interviews conducted in this study were structured interviews. The questions given to the students were prepared in advance by the research team and contained in the interview guidelines.

Then, the data analysis of this study was carried out. The stages of data analysis techniques carried out by the researchers were data reduction, data presentation, drawing conclusion, and verification (Sugiyono, 2015). At the data reduction stage, the researchers summarize, choose the main aspects, and focus on the important aspects of students' math test answers. Here, the Newman procedures were used to analyze the errors made by students in (1) reading; (2) comprehension; (3) transformation; (4) process skill; and (5) encoding (Tekaeni, Supandi, Setyawati, 2020). After the data were reduced, the data were then presented in the form of a brief description, chart, and/or table. The last thing to do was to draw conclusion and verification.

3. Results and Discussion

Based on the questionnaires that have been given to the students in grades VIII-E and VIII-F 11 Public Junior High School, Tegal, Indonesia, the results on students' learning styles are obtained in Table 1. From Table 1, it can be observed that from the 53 students who were the subjects of the study, 19 students have visual learning style, 26 students have auditory learning style, 5 students have kinesthetic learning style, 2 students have visual-kinesthetic learning styles, and 1 student has auditory-kinesthetic learning style. Therefore, the auditory learning style dominates the learning style of students with around 49%. This is because students are more accustomed to hearing the teachers during learning. It may also be inferred from Table 1 that the least learning style is associated with the kinesthetic learning style. This indicates that learning based on practices is rarely done by students. Moreover, this also emphasizes the fact that teachers are more dominant in learning rather than the students. Students tend only to listen and/or see the teacher teaching in class.This is in accordance to the a study by Magbanua and Bearneza (2023) that the dominant learning style from 222 senior high schooll students taking general mathematics course using the blended-learning is auditory with an average performance level in the general mathematics.

Mathematical literacy according to PISA (2018) is divided into 6 levels (OECD, 2019). The 6th level is the highest level, while the first level is the lowest level. Each level of mathematical literacy has different indicators. Figure 1 shows the results of the achievement of students' mathematical literacy levels when viewed from the learning styles possessed by each student.

Table 1: Students' learning style outcomes.

No.	Learning Style	Number of Students
1	Visual	19
2	Auditory	26
3	Kinesthetic	5
4	Visual-Kinesthetic	2
5	Auditory-Kinesthetic	1

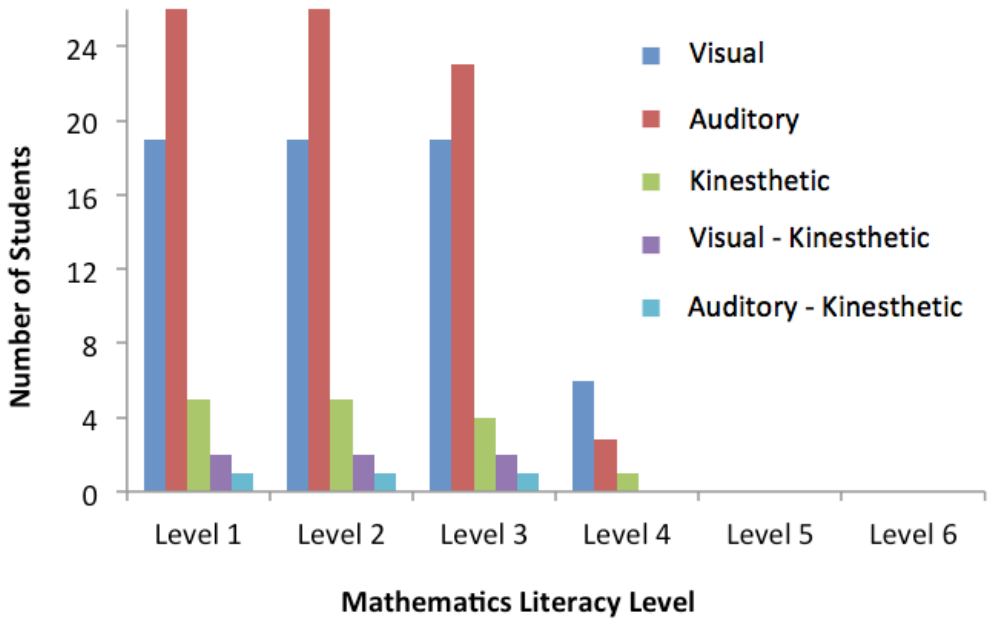

Figure 1: Achievement of students' mathematical literacy level in terms of learning style.

Based on Figure 1, it is obtained that all students have not been able to reach the 5th and 6th levels of mathematical literacy. Students with visual learning style have the best mathematical literacy skills, because students reach the lowest level 3 and the highest level 4. Students with auditory and kinesthetic learning styles have the same mathematical literacy skills, namely students reach the lowest level 2 and the highest level 4. Finally, students with visual-kinesthetic and auditory-kinesthetic learning styles have the same mathematical literacy skills, namely students are only able to reach the 3rd level. Obviously, the fact that the students fail to finish the 5th and 6th levels of the mathematical literacy are because mistakes and/or errors are made by them. Hence, we discuss various errors made by students based on the Newman procedures, i.e.: reading, comprehension, transformation, proces skill, and encoding, taken from the test results of the subjects and viewed from their learning styles.

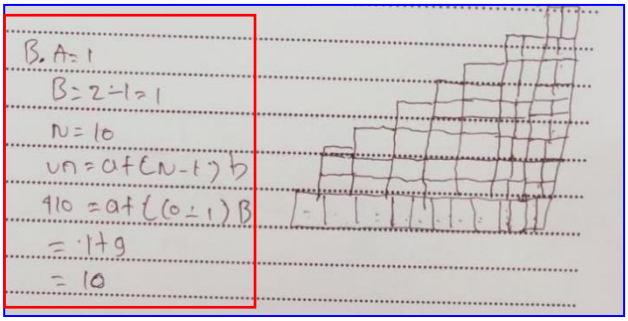

Figure 2: FAS subject's answer to Question Number 1b.

Firstly, we discuss errors made by students having visual learning style. Figure 2 shows a student, FAS, performs a transformation error. In this case, FAS uses the wrong strategy for solving Question Number 1b. This is in accordance with Edimuslim, Edriati, and Mardiyah (2019) that students with visual learning style have difficulty in choosing strategies to solve problems. The error is caused because subject FAS does not understand the material.

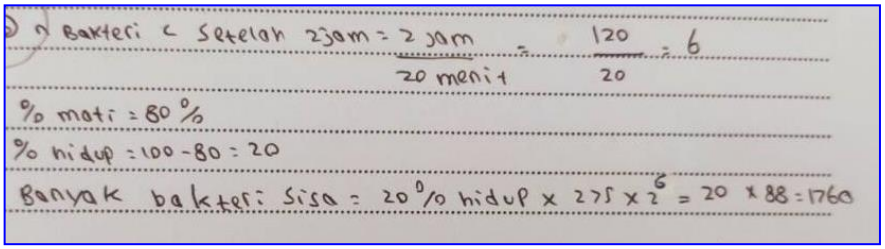

Figure 3: DNF subject's answer to Question Number 2b.

Based on Figure 3, a subject, DNF, made an error in Question Number 2b. DNF made an error in the calculation process, i.e.: the calculation of $20\% \times 275 \times 2^6$ resulted in a wrong answer of 20×88. This shows that students with visual learning style can still make mistakes in the calculation process. This statement is in accordance with Rosanggreni (2018) that students with visual learning style still make mistakes at the process skills stage, although they are more likely to make mistakes at the transformation stage. The factor that causes students to make mistakes in solving questions is that students feel rushed when working on the questions, i.e.: they want to finish quickly.

Based on Figure 4, another student, IRDR, made a mistake on Question Number 2a. In this case, IRDR has not written down the answer requested by the question. The answer that should be written is "the least number of bacteria after dividing for 1 hour is bacteria B". The factor that causes IRDR to make a mistake is because he/she is in a hurry to do the problem.

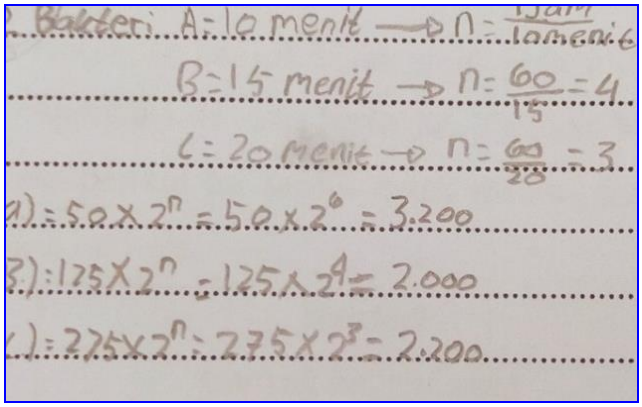

Figure 4: IRDR subject's answer to Question Number 2a.

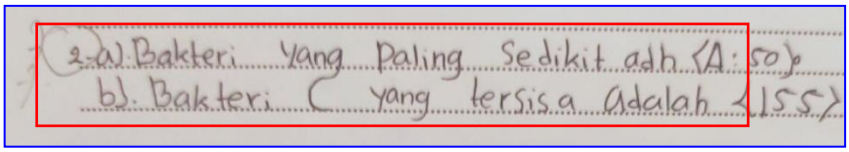

Figure 5: AO subject's answer to Question Number 2.

Next, we discuss various mistakes made by students with auditory learning style. Based on Figure 5, subject AO made a mistake on Questions Numbers 2a and 2b. For Question Number 2a, the reason for the answer by the subject AO is that in the table bacteria A is the bacteria with the least number. As for Number 2b, the answer by AO states that the remaining C bacteria after undergoing division for 2 hours is 155. The result is obtained from subtracting the number 275 from 80. This shows that AO has not been able to determine the right calculation operation to solve Questions 2a and 2b. In addition, AO has not been able to convert the sentence in Question Number 2 into its mathematical form. This is in line with the statement in Rosanggreni (2018) that students with auditory learning style cannot or incorrectly transform problems into mathematical forms because they are confused.

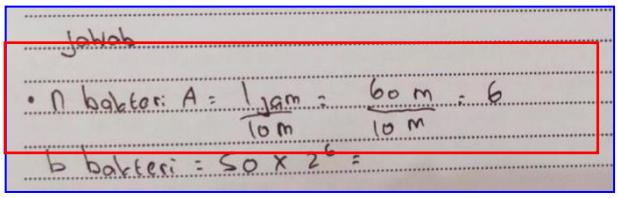

Figure 6: MH subject's answer to Question Number 2a.

Based on Figure 6, a student, MH, made a process skill error on Question Number 2a. The calculation process carried out by MH to determine the number of bacteria after the division process for one hour stopped halfway. Hence, MH has not been able to find multiplication result for 50×2^6. At the time of the interview, MH admitted to be confused with the 2^6 power operation. This shows that MH has not mastered the power operation material.

Based on Figure 7, SPF made a mistake writing the final answer to Question Number 2a. SPF has already executed the correct solving strategy. SPF has also been able to carry out the calculation process succesfully to produce the correct answer. This is in line with the statement by Edimuslim, Edriati, and Mardiyah (2019), namely that students with auditory learning style can use strategies to solve mathematical problems. However, SPF had not written the conclusion for the correct final answer. This happens because the subject is less thorough.

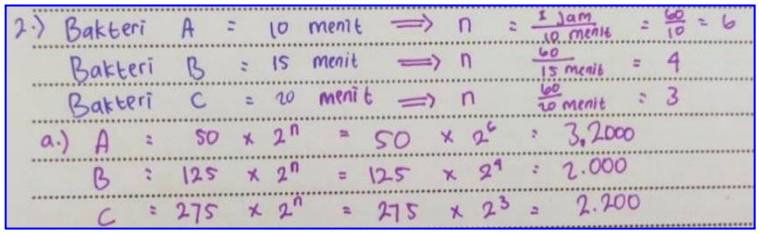

Figure 7: SPF subject's answer to Question Number 2a.

We now discuss the errors made by students with kinesthetic learning style. A student, SAP, made a mistake at the stage of reading. When reading the word 'many' (*banyak*), SAP said of another word, i.e.: 'imagine' (*bayangkan*). SAP looked nervous at the time of the interview, so that this may trigger an inappropriate word regading the question. This is in line with Widayanti (2013) that students with kinesthetic learning style tend to be easily disturbed by their own emotions. Because of the nervous feelings felt by students during the interview process, students with a kinesthetic learning style make mistakes when reading the questions.

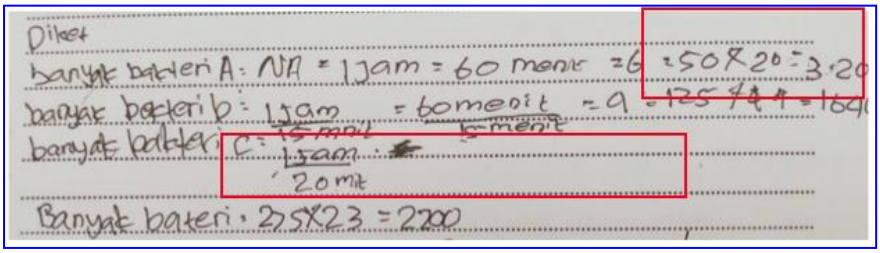

Figure 8: SAP subject's answer to Question Number 2a.

Based on Figure 8, SAP made a mistake at the understanding stage of the problem. SAP carelessly wrote numbers and symbols that are not clear on the answer sheet. This is in accordance with the results in Rosanggreni (2018), which states that students with kinesthetic learning style do not write down what is known from the questions because they do not understand the meaning of the questions and do not understand the questions with their own language. In addition to the error at the understanding stage, SAP also made mistakes at the transformation stage. SAP tries to use his/her own strategy to solve problems, although it has not been able to produce the correct answer.

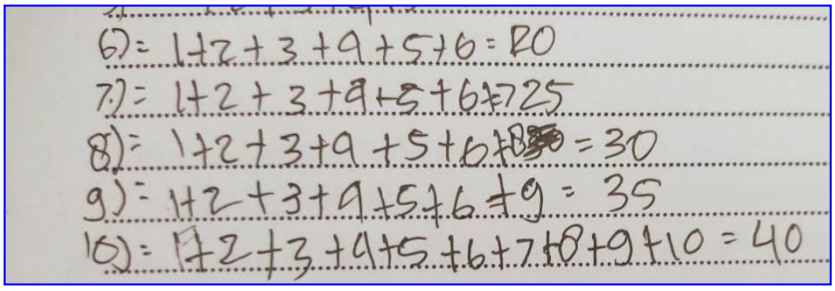

Figure 9: SAP subject's answers to Question Number 1b.

Based on Figure 9, SAP also made a mistake at the process skill stage. Here, SAP is not careful in the addition operation, so the results obtained are incorrect. The calculation error occurs when SAP specifies many squares for the 6th number pattern. Following this error, SAP made the wrong calculation up to the 10th number pattern. Because SAP was wrong in the process of specifying many boxes for the 10th number pattern, he/she could not write down the exact and correct final answer. This is in accordance with Rosanggreni (2018), which states that students with kinesthetic learning style do not write conclusions because they get incorrect calculation.

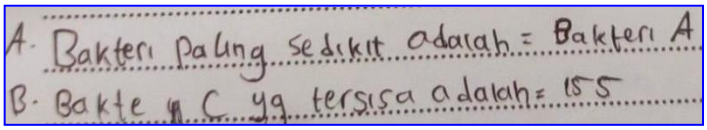

Figure 10: AJP subject's answers to Question Number 2.

We next discuss the errors made by students with visual-kinesthetic learning style. Based on Figure 10, a student, AJP, made a mistake at the transformation stage for Question Number 2a. Based on the result of the interview, AJP answered 'Bacteria A' because in the table the number of bacteria A is the least among other bacteria, namely 50. From these answers, AJP seemed not to be able to convert the sentence in the problem into its mathematical form correctly, so that AJP cannot choose the correct calculation operation. This is because AJP has not yet understand patterns and seqeunce materials.

In addition, AJP also made a mistake in the process skill stage on Question Number 2b. During the interview process, AJP looked confused when asked to explain the calculation process for Question Number 2b. This is in accordance with Wiedarti (2018) that students with visual-kinesthetic learning styles tend to prefer detailed notes rather than having to engage in a discussion. Because AJP has a predominantly visual and kinesthetic learning styles, he/she needs to read a lot and work on patterns and number sequence problems so that similar mistakes are not made in the future. Not only that, AJP also made a mistake at the stage of writing the final answer. Because AJP made a mistake at the previous stages, he/she could not write the correct final answer. This is in line with the results in Wiedarti (2018), which states that students with visual-kinesthetic learning styles have low ability to evaluate results so that it affects the final decision or answer.

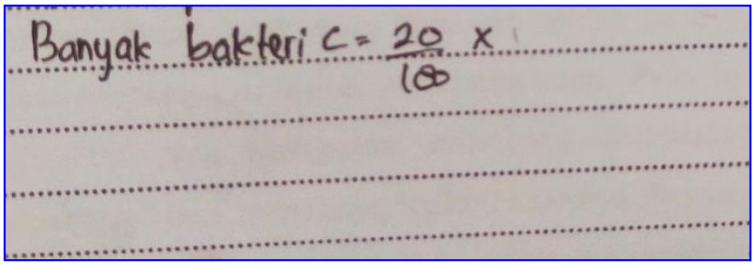

Figure 11: KAW subject's answer to Question Number 2b.

Based on Figure 11, the transformation error made by KAW is in Question Number 2b. KAW seemed unable to determine the appropriate strategy to solve Question Number 2b. During the interview session, KAW admitted that he/she felt rushed because he/she was running out of time. This is in accordance with Widayanti (2013) that students with auditory-kinesthetic learning styles are more easily distracted by their own emotions.

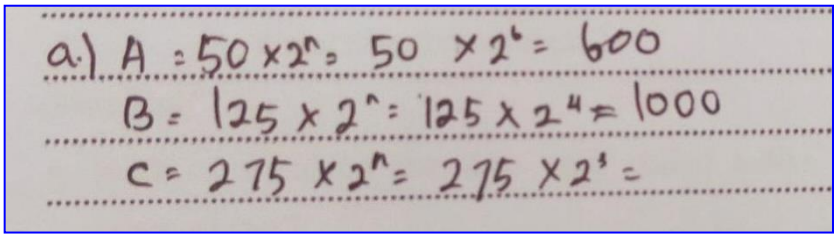

Figure 12: KAW subject's answer to Question Number 2a.

Based on Figure 12, KAW also made a mistake in the process skill stage on Question Number 2a. The calculation process conducted by KAW stopped halfway. Moreover, KAW made a mistake in the multiplication operation. Based on the result of the interview, KAW seemed confused with the meaning of 2^6. Initially, KAW replied that 2^6 is 2 x 6. Then the answer is corrected by KAW that 2^6 is a multiplication of the number 2 as many as 6 times. This is in line with Rosanggreni (2018), which concluded that students with auditory-kinesthetic learning styles are incorrect in doing calculations because they use mathematical rules incorrectly.

4. Conclusion

The learning styles possessed by the students as the research subjects are visual, auditory, kinesthetic, visual-kinesthetic, and auditory-kinesthetic. Students with visual learning style have the best mathematical literacy skills of all learning styles because the students achieve the lowest 3rd level and the highest 4th level of mathematical literacy. Students with kinesthetic learning style made the most mistakes. Kinesthetic learning style students made mistakes in all five Newman procedures, namely reading, understanding, transformation, process skill, and writing the final answers. Students with visual, auditory, visual-kinesthetic, and auditory-kinesthetic learning styles made mistakes in the three Newman procedures, namely transformation, process skill, and writing the final answers. The factors that cause students' errors in solving mathematical literacy problems when viewed from learning styles tend to be the same, i.e.: i) students do not master the materials, especially in this case is patterns and sequences and ii) students feel rushed when working on the problems.

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