

Analysis of Student Errors According to the Nolting Procedure on Mathematical Literacy Problems in View of Kolb's Divergent and Assimilation Styles

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Abstract. This study describes the types of student errors based on the Nolting procedure on mathematical literacy problems in the form of AKM questions in terms of Kolb's divergent and assimilation styles. This research uses descriptive qualitative type and has 28 subjects of class VIII students of SMP Negeri 10 Tanjungpinang. The data collection used were questionnaires, AKM questions and interviews. The use of data analysis techniques in this study includes reduction, data presentation and conclusion drawing. The findings of this study are that students with assimilation learning style type tend to make fewer mistakes than students with divergent learning style type. This finding shows that conceptual errors and application errors are the main obstacles for students in solving mathematical literacy problems, which are caused by limitations in understanding the problem and managing time effectively.

1 Introduction

In 21st century education, one of the required abilities is mathematical literacy. Mathematical literacy refers to the ability to apply mathematical concepts and skills to solve problems in various contexts of daily life [1–3]. In honing students' mathematical literacy skills, OECD (*Organization for Economic cooperation and development*) has organized PISA (*International Student Assessment Program*) which is used as an assessment of students' mathematical literacy in various participating countries [4,5].

The results of the PISA score data show that every year the mathematical literacy scores of Indonesian students always rank low ((Nadhila, Y.A 2022). In addition, the latest PISA data in 2022 also shows that Indonesia is ranked low at 366 for math scores [7]. The decline in scores indicates the difficulties experienced by many Indonesian students in solving PISA-type mathematical literacy questions [8,9].

To improve Indonesia's PISA rankings and scores, the Ministry of Education and Culture introduced the Minimum Competency Assessment (AKM) system. AKM is a standardized evaluation used to measure students' basic competencies in reading literacy

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and mathematics literacy [10,11]. The results of mathematical literacy obtained through AKM are contained and recorded in the education report card. In AKM reporting, mathematical literacy is tested in various domains, one of which is algebra which tests students' ability to understand, interpret and solve mathematical problems related to algebra. Based on the results of the SMP Negeri 10 Tanjungpinang Education report card report, it shows that the lowest mathematics literacy score is obtained in the Algebra domain competency score with a score of 57.03. Mursyidah (2023) explained that students' difficulties in solving mathematical literacy AKM questions often result in errors.

One of the error analysis procedures that can be used is the error analysis technique based on Nolting's theory. According to Nolting (2012) there is a grouping of 6 components of student *errors* when working on tests including *misread-directions* errors, *careless* errors, *concept errors*, *application* errors, *test taking* errors and *study* errors.

Analysis of student errors can be done with a more detailed approach through a review of learning styles, because learning styles have an important role in influencing students' mathematical literacy skills [14]. In research conducted by Madrayati et al. (2019), learning styles are known to influence student development in the learning process. One of the theories used to understand learning style differences is Kolb's theory, which classifies learning styles into four: divergent, assimilation, convergent, and accommodation [16].

2 Research Methodology

2.1 Participants

This type of research is descriptive with a qualitative approach, with the research subjects consisting of 28 students of class VIII SMP Negeri 10 Tanjungpinang. The determination of subjects was carried out using *purposive sampling*, namely by selecting subjects who had divergent learning style types and assimilation.

2.2 Design and Data Source

This research places the researcher as the main instrument, while the supporting instruments used include questionnaires, tests and interview guidelines. The questionnaire used was adopted from the instrument developed by Aliudin (2021). In addition, the AKM questions used were also adopted from the platform provided by Kemendikbud Ristek. Overall, questionnaires, tests and interviews were the data collection methods applied in this study.

Furthermore, data analysis was carried out through the stages of data reduction, data presentation and conclusion drawing, as proposed by Miles and Huberman (in Sugiyono, 2019). Meanwhile, the triangulation technique that researchers use is technical triangulation. Furthermore, in Table 1 below, the researcher presents the Nolting error indicators used in this study:

Table 1. Nolting Error Indicators.

No.	Error Type	Indicator
1	Misread-directions errors (Mi)	Students misinterpret and write down problem information
2	Careless Errors (Ca)	Students are less careful when working on problems and are wrong in formulating the right mathematical models and memorization
3	Concept Errors (Co)	Students do not know the formula/concept for solving
4	Application Errors (Ap)	Students are unable to apply formulas from the material learned
5	Test Taking Errors (Te)	1. Students do not complete the solution 2. Students are wrong in giving the conclusion of the answer

*Source: [19]

3 Result and Discussion

The results of Kolb's learning style questionnaire for class VIII students show that there are 7 students with divergent and assimilation learning style categories. The score intervals for each category of mathematical literacy are presented in Table 2 below.

Table 2. Student Scoring Results

Interval	Category
$x < 38.89$	Low
$38.89 \leq x \leq 72.22$	Medium
$x > 72.22$	High

The names of the students selected as research subjects can be seen in Table 3 below.

Table 3. Student Scoring Results

Subject	Category	Learning Style Type
TAA	Low	Divergent
SA	Medium	
BAN	High	
END	Low	Assimilation
RS	Medium	
MAF	High	

The following can be seen the percentage of errors made by students with divergent learning styles and assimilation presented in Table 4:

Table 4. Percentage of errors of divergent and assimilation learning style students

Interval	Category	
	Divergent	Assimilation
Misread-directions errors (Mi)	22%	21%
Careless Errors (Ca)	43%	32%
Concept Errors (Co)	72%	62%
Application Errors (Ap)	81%	67%
Test Taking Errors (Te)	61%	54%
Average	56%	47%

Based on Table 4 above, it can be seen that the largest percentage is found in students with divergent learning style types. Further explanation related to the results of the analysis of student errors with divergent and assimilation learning style type categories is presented as follows.

3.1 High Category Score on Divergent and Assimilative Learning Styles

3.1.1 Problem Number 1

The answer results of the BAN subject with a divergent learning style can be seen in Figure 1, while the answer results of the MAF subject with an assimilation learning style can be seen in Figure 2 below:

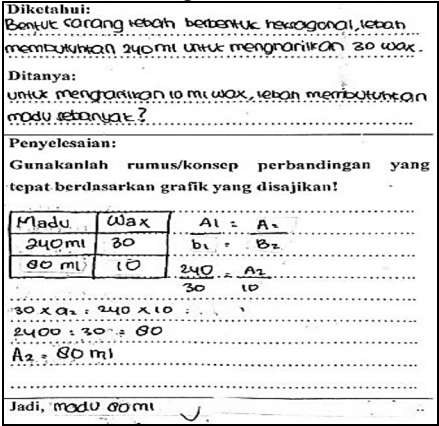


Fig. 1. The result of BAN subject's answer

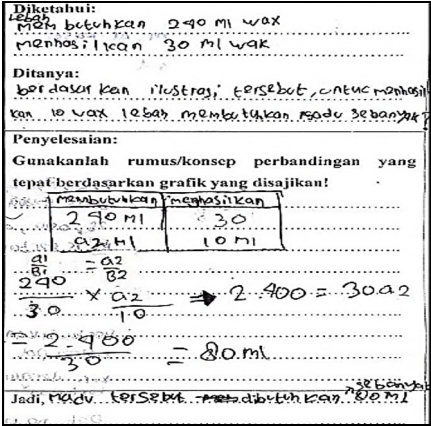


Fig. 2. The result of MAF subject's answer

Figure 1 and Figure 2 show that BAN and MAF subjects can write the problem information, do not make mistakes in calculations, write the formula for comparison worth and make the overall solution to the end of the conclusion correctly and precisely.

3.1.2 Problem Number 2

The answers of subject BAN with divergent learning style can be seen in Figure 3 below:

Diketahui: 23 bus terditi dari bus roda 4 dan 6 terditi 2 selama 3 jam. Jumlah roda dari bus roda 4 dan 6 tersebut adalah 108 roda.

Ditanya: kemunculan model jawaban yang benar ?

Penyelesaian:

Buatlah pemisalan yang tepat untuk menggantikan besaran yang ada pada soal!

$x = \text{bus roda 4}$
 $y = \text{bus roda 6}$

Buatlah model matematika yang sesuai dengan permasalahan tersebut!

$x + y = 23$
 $4x + 6y = 108$

Diperoleh:

$x + y = 23$
 $4x + 6y = 108$

Gunakanlah metode campuran (eliminasi dan substitusi) sebagai solusi dari penyelesaian soal!

$x + y = 23$ $\times 4$ $4x + 4y = 92$
 $4x + 6y = 108$ $\times 1$ $4x + 6y = 108$

$-2y = -16$
 $y = 8$

$x + y = 23$
 $x + 8 = 23$
 $x = 23 - 8$
 $x = 15$

Diperoleh: $x + y = 23 \rightarrow x = 15$
 $4x + 6y = 108 \rightarrow y = 8$

PERNYATAAN A

Tentukan apakah pernyataan A bernilai benar/salah

☐ Benar
☐ Salah

Penyelesaian

Tentukan rumus yang tepat untuk menghitung tarif parkir bus di terminal 2 selama 3 jam!

Tentukan rumus yang tepat untuk menghitung total pendapatan parkir bus roda 4!

Tentukan rumus yang tepat untuk menghitung total pendapatan parkir bus roda 6!

Fig. 3. The result of BAN subject's answer

In Figure 3, it can be seen that subject BAN can include the problem information and write the memorization and mathematical model correctly. However, despite successfully using the two-variable linear equation formula, he did not succeed in solving statements A, B and C according to the x and y values that had been found because BAN did not understand the meaning of the answer choice information presented by the problem. Meanwhile, the answers of MAF subject with assimilation learning style can be seen in Figure 4 below:

Diketahui: Sabanaak 23 bus dari roda 4 dan 6 terparkir di terminal 2 selama 3 jam. Jumlah roda 4 dan 6 tersebut adalah 108 roda Ditanya: kesimpulannya manakah yg benar?		PERNYATAAN A ☐ Benar ☒ Salah
Buatlah pemisalan yang tepat untuk mengganti setiap besaran yang ada pada soal! us. roda 4 = x us. roda 6 = y		Penyelesaian Tentukan rumus yang tepat untuk menghitung tarif parkir bus di terminal 2 selama 3 jam! $\begin{aligned} \text{tar. bus 12012.T. 2.700} \\ \text{tar. bus 12012.T. 2.700} \\ = 12.000 + 6.000 + 6.000 \\ = 24.000 \end{aligned}$
Buatlah model matematika yang sesuai dengan permasalahan tersebut! $\begin{aligned} x + y &= 23 \\ 4x + 6y &= 108 \end{aligned}$		Tentukan rumus yang tepat untuk menghitung total pendapatan parkir bus roda 4! $\begin{aligned} \text{Banyak bus roda 4 x harga} \\ = 15 \times 23.000 + 2.360.000 \\ \text{Banyak} \end{aligned}$
Diperoleh: Gunakanlah metode campuran (eliminasi dan substitusi) sebagai solusi dari penyelesaian soal! $\begin{aligned} x + y &= 23 \quad \times 3 \rightarrow 3x + 3y = 69 \\ 4x + 6y &= 108 \quad \times 1 \rightarrow 4x + 6y = 108 \\ \hline -3x - 3y &= -69 \\ 4x + 6y &= 108 \\ \hline x - 3y &= -69 \end{aligned}$		Tentukan rumus yang tepat untuk menghitung total pendapatan parkir bus roda 6! $\begin{aligned} \text{Banyak bus roda 6 x harga} \\ \text{Banyak} = 9 \times 23.000 \\ = 192.000 \end{aligned}$

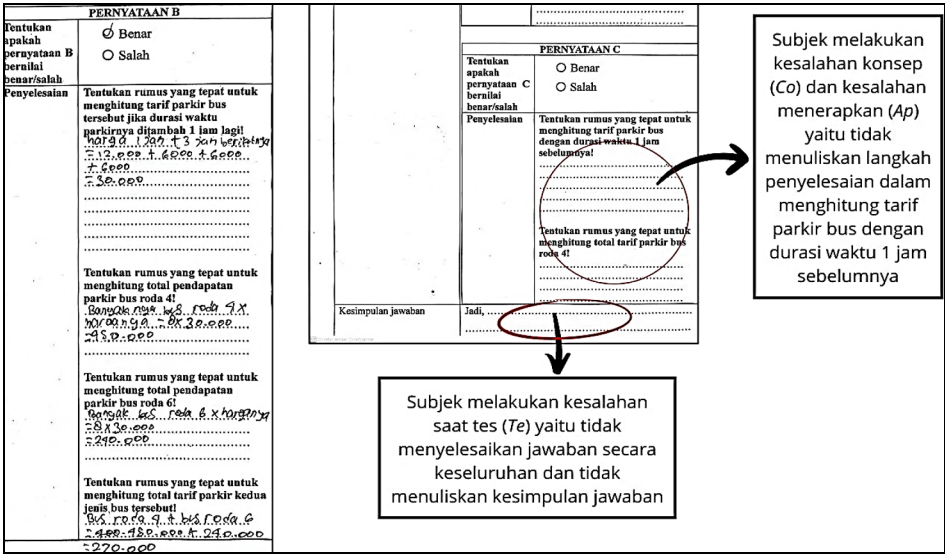
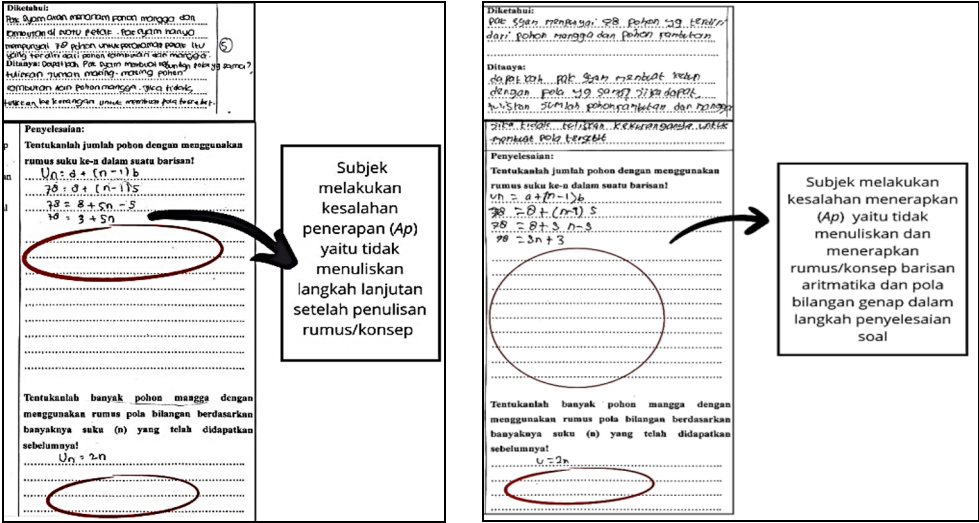


Fig. 4. The result of MAF subject's answer

In Figure 4, MAF subject can write down the problem information, write down the memorization and mathematical model correctly. In addition, MAF also applied the two-variable linear equation formula to the solution of statement A and B. However, in statement C, MAF did not apply the formula because he did not understand the meaning of statement C which caused him difficulty in determining whether statement C was true/false.

3.1.3 Problem Number 3

The answer result of BAN subject with divergent learning style can be seen in Figure 5, while the answer result of MAF subject with assimilation learning style can be seen in Figure 6 below:



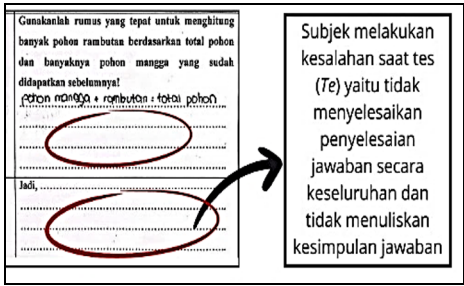


Fig. 5. The result of BAN subject's answer

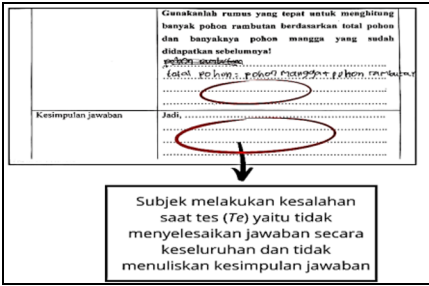


Fig. 6. The result of MAF subject's answer

Figure 5 and Figure 6 above show that BAN and MAF subjects have similar errors. Both subjects wrote down the problem information, there were no errors in writing the calculation results, and all the formulas used were written correctly and precisely. However, both of them had difficulties and were unable to apply the formula at the problem solving stage. Nevertheless, the interview results showed different reasons between the two subjects. BAN admitted that he forgot the working steps that should be done. While MAF explained that he could not solve it because of limited time.

3.2 Medium Category Score on Divergent Learning Style

3.2.1 Problem Number 1

The answer results of SA subject with divergent learning style can be seen in Figure 7, while the answer results of RS subject with assimilation learning style can be seen in Figure 8 below:

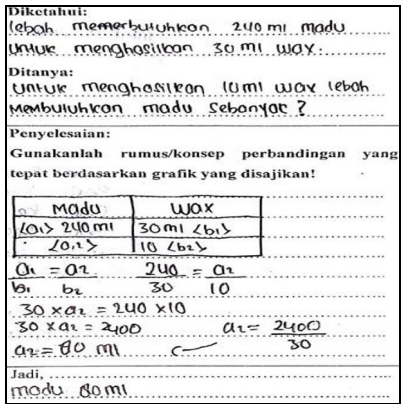


Fig. 7. The result of SA subject's answer

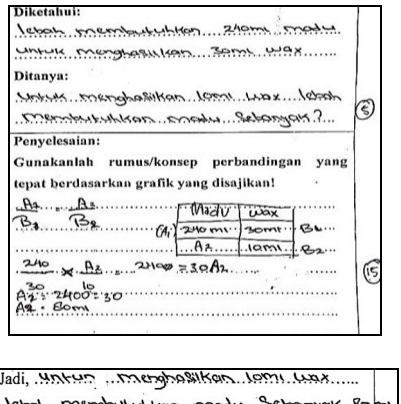


Fig. 8. The result of RS subject's answer

In Figures 7 and 8 above show that SA subjects and RS subjects can write the question information correctly and there are no errors made in the calculations. They are also able to use the formula of comparison worth correctly.

3.2.2 Problem Number 2

The results of the mathematical literacy test answers from subject SA with a divergent learning style can be seen in Figure 9 below:

3. Komponen soal (apa yang diketahui dan ditanyakan oleh soal)	Diketahui: terdiri dari bus 25, bus, roda 4 dan roda 6 Jmlh bus, roda 4 dan 6 adalah 100 roda. Ditanya: Kesimpulan mana yang benar?
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No.	LANGKAH-LANGKAH DALAM MENJAWAB SOAL	JAWABAN
1.	Proses penyelesaian soal (perhatikan rumus/konsep yang digunakan, penulisan dan pemodelan matematika yang digunakan, penulisan hasil perhitungan dan selisuh/hasil penyelesaian jawaban soal terakhir)	Penyelesaian: Buatlah pemisalan yang tepat untuk menganti setiap besaran yg ada pada soal! $x = \text{bus roda 4}$ $y = \text{bus roda 6}$ Buatlah model matematika yang sesuai dengan permasalahan tersebut! $x + y = 25$ $4x + 6y = 100$ Diperoleh,

No.	LANGKAH-LANGKAH DALAM MENJAWAB SOAL	JAWABAN
1.	Proses penyelesaian soal (perhatikan rumus/konsep yang digunakan, penulisan dan pemodelan matematika yang digunakan, penulisan hasil perhitungan dan selisuh/hasil penyelesaian jawaban soal terakhir)	Penyelesaian: Buatlah pemisalan yang tepat untuk menganti setiap besaran yg ada pada soal! $x = \text{bus roda 4}$ $y = \text{bus roda 6}$ Buatlah model matematika yang sesuai dengan permasalahan tersebut! $x + y = 25$ $4x + 6y = 100$ Diperoleh,

Fig. 9. The result of SA subject's answer

In Figure 9, subject SA wrote the problem information but did not include the memorization and mathematical model. In addition, SA also did not apply the formula, and did not write the answer conclusion at the end of the solution. SA also did not solve the problem at all because of difficulties in understanding how to solve the problem. While the answers of the RS subject with an assimilation learning style can be seen in Figure 10 below:

Diketahui: 25 bus terdiri dari bus roda 4 dan 6. Terdiri dari bus 25, bus, roda 4 dan 6. Jumlah bus, roda 4 dan 6 adalah 100 roda. Ditanya: Kesimpulan mana yang benar? Penyelesaian: Buatlah pemisalan yang tepat untuk menganti setiap besaran yang ada pada soal! $x = \text{bus roda 4}$ $y = \text{bus roda 6}$ Buatlah model matematika yang sesuai dengan permasalahan tersebut! $x + y = 25$ $4x + 6y = 100$ Diperoleh, Gunakanlah metode campuran (eliminasi dan substitusi) sebagai tolak dari penyelesaian soal!	Subjek melakukan kesalahan konsep (Co), kesalahan menerapkan (Ap), dan kesalahan saat tes (Te) yaitu tidak menuliskan langkah penyelesaian pada pernyataan B dan C dan tidak menuliskan kesimpulan jawaban
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Fig. 10. The result of RS subject's answer

In Figure 10, it can be seen that the RS subject can write the problem information completely and mathematical model correctly. However, he did not write the two-variable linear equation formula that should be used as the initial solution to the problem, and did not write the conclusion. This was caused by his ignorance about the steps of solving the problem.

3.2.3 Problem Number 3

The answers of SA subject with divergent learning style can be seen in Figure 11, while the answers of RS subject with assimilation learning style can be seen in Figure 12 below:

Diketahui:
Pak Slam akan menanam pohon untuk
menanam disekeliling Pelat.
Ruang Pelat itu yang terdiri dari pohon rambutan
dan pohon mangga.
Ditanya: Dapatkah Pak Slam membuat dgn pola yg sama?
Jumlah masing-masing Pohon
tambahan dan Pohon mangga!

Penyelesaian:
Tentukanlah jumlah pohon dengan menggunakan
rumus suku ke-n dalam suatu barisan!
 $U_n = 9 + (n-1) \cdot 3$
 $9 + 8 \cdot 3 = 12$

Tentukanlah banyak pohon mangga dengan
menggunakan rumus pola bilangan berdasarkan
banyaknya suku (n) yang telah didapatkan
sebelumnya!

Subjek melakukan kesalahan konsep (Co), kesalahan menerapkan (Ap) dan kesalahan saat tes (Te) yaitu tidak menuliskan dan menerapkan rumus/konsep, tidak terdapat penyelesaian jawaban secara keseluruhan dan tidak menuliskan kesimpulan jawaban

Fig. 11. The result of SA subject's answer

Diketahui:
Pak Syam mempunyai 78 pohon
yaitu Rambutan dan mangga.....

Ditanya:
dapatkan Pak Syam membuat dgn
pola yang sama? jika ya tuliskan jumlah
pohon rambutan dan mangga! jika
tidak tuliskan kekurangan untuk
membuat pola tersebut!

Subjek melakukan kesalahan kecerobohan (Co), kesalahan konsep (Co), kesalahan menerapkan (Ap), dan kesalahan saat tes (Te) yaitu tidak menuliskan proses penyelesaian soal sampai akhir kesimpulan

Fig. 12. The result of RS subject's answer

Figures 11 and 12 show that SA and RS subjects wrote the right formula in determining the formula for the n th term. However, there are differences where SA is only able to write the formula, while RS is able to write the formula but is unable to apply it as a whole. Both have similarities in not writing down the formula in calculating the number of mango and rambutan trees. Based on the interview, SA explained that he did not know the steps to be taken. While RS revealed that although he remembered the formula, he forgot how to solve it.

3.3 Low Category Score on Divergent Learning Style

3.3.1 Problem Number 1

The answer result of TAA subject with divergent learning style can be seen in Figure 13, while the answer result of END subject with assimilation learning style can be seen in Figure 14 below:

Diketahui:
Jumlah penduduk di kabupaten yang akan diukur
30 ml yang 1.....

Ditanya:
Berapa penduduk kabupaten yang akan diukur
30 ml yang 1.....

Penyelesaian:
Gunakanlah rumus/konsep perbandingan yang
tepat berdasarkan grafik yang disajikan!

Waktu	Waktu
240	30
30	10

$\frac{240}{30} = \frac{30}{10}$
 $30 \times 10 = 300$
 $300 \div 10 = 30$
Jadi,
Subjek melakukan kesalahan kecerobohan (Co) dan kesalahan menerapkan (Ap) yaitu salah dalam menuliskan hasil perhitungan, tidak menuliskan rumus/konsep perbandingan yang tepat dan kurangnya langkah penyelesaian soal

Subjek melakukan kesalahan saat tes (Te) yaitu tidak menuliskan penyelesaian secara keseluruhan dan tidak menuliskan kesimpulan jawaban

Fig.13. The result of TAA subject's answer

Diketahui:
Jumlah penduduk di kabupaten yang akan diukur
30 ml yang 1.....

Ditanya:
Berapa penduduk kabupaten yang akan diukur
30 ml yang 1.....

Penyelesaian:
Gunakanlah rumus/konsep perbandingan yang
tepat berdasarkan grafik yang disajikan!

Subjek melakukan kesalahan kecerobohan (Co), kesalahan konsep (Co), kesalahan menerapkan (Ap) dan kesalahan saat tes (Te) yaitu tidak menuliskan proses penyelesaian soal sampai akhir kesimpulan jawaban

Fig. 14. The result of END subject's answer

In Figure 13, subjects TAA and END wrote the problem information correctly. However, at the completion stage, TAA made mistakes in the calculation operation and did not write the correct comparison formula because he was not careful and forgot to write the formula. In addition, TAA did not apply and solve the problem according to the formula/concept he used, did not write the answer as a whole and did not write the

conclusion. Meanwhile, END did not do the calculation process at all, because he had forgotten the comparison material he learned in grade VII.

3.3.2 Problem Number 2

The answer of subject TAA with divergent learning style can be seen in Figure 15, while the answer of subject RS with assimilation learning style can be seen in Figure 16 below:

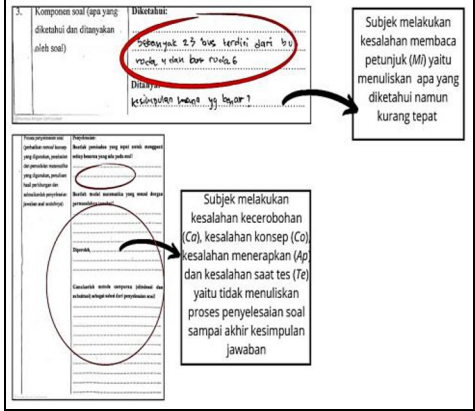


Fig. 15. The result of TAA subject's answer

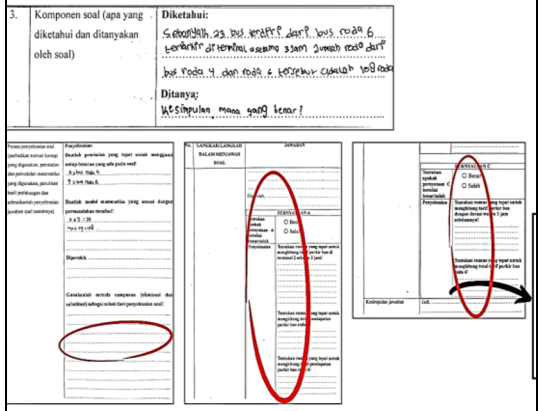


Fig. 16. The result of END subject's answer

In Figure 15, subject TAA wrote down the problem information but there was a deficiency in the known information because he did not pay careful attention to the information given. Meanwhile, Figure 16 shows that END subject wrote completely. Furthermore, TAA did not write the mathematical model and did not solve the problem at all. He also did not use the formula in the solution and did not write the conclusion of the answer. TAA revealed that he did not know how to solve the problem. On the other hand, END wrote down the equation and mathematical model but he did not succeed in applying the formula in statement A, B and C, because he did not understand the material well.

3.3.3 Problem Number 3

The answer of subject TAA with divergent learning style can be seen in Figure 17, while the answer of subject RS with assimilation learning style can be seen in Figure 18 below:

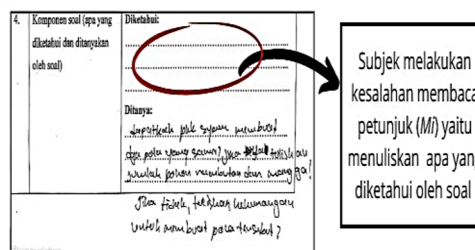


Fig. 17. The result of TAA subject's answer

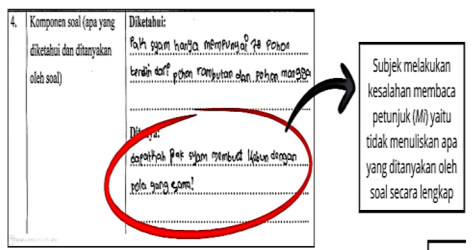


Fig. 18. The result of TAA subject's answer

In Figure 17, it can be seen that subject TAA only wrote the question without including the known information. Meanwhile, subject END wrote the known information correctly and precisely only. However, he wrote what was asked by the problem incompletely. Both TAA and END subjects did not work on the problem solving process, did not perform calculations, did not write down the three formulas for solving the problem, and did not write the conclusion. Based on the interview, subject TAA realized the

information of the problem but doubted his answer. Furthermore, he also stated that he did not know the formula that should be used in solving the problem.

3.4 Result

Most of the divergent subjects could elaborate the answers well according to the procedure. High divergent subjects made application errors and errors during the test while medium divergent subjects made concept errors, application errors and errors during the test. There were no errors in reading the instructions in the high and medium divergent groups, in line with the research of Chasanah *et al.* (2020) which explains that divergent students excel in understanding various information presentations. Low divergent subjects tended to make many errors including clue reading errors, carelessness, concept, applying and test errors. This supports previous findings which show that divergent students are prone to errors and easily bored when working on problems for a long time so that they are less careful in performing calculations [21,22]. However, based on the interview, it appears that the divergent subject listened and responded to each question very well before answering the questions given by the researcher. This is in accordance with the characteristics of divergent students who tend to approach by looking and listening [23].

In the assimilation group, high assimilation subjects made application errors and errors during the test while medium and low assimilation subjects made three types of errors, namely concept, application and test errors. Judging from the systematics of the work, it was found that high and medium assimilation subjects worked on the solution in a more structured manner so that they tended not to make carelessness, as explained by Furqon *et al.* (2021). Furthermore, both high, medium and low assimilation subjects were the subjects who obtained the smallest percentage of errors in the indicator of errors in reading instructions (*Mi*). Therefore, high, medium and low assimilation subjects did not make mistakes in the indicators of reading errors (*Mi*) and carelessness errors (*Ca*). Meanwhile, the interview results show that the assimilation subject can answer the researcher's questions in more detail and coherently. This description shows that before acting in doing something, assimilation subjects tend to use a logical approach [17]. Assimilation students also tend to have an interest in abstract concepts. This is certainly related to mathematics which is a collection of abstract concepts so that assimilation subjects tend to like math lessons [25].

4 Conclusion

This study indicates that students with divergent and assimilation learning styles generally face the greatest difficulties and challenges in conceptual errors and application errors. The findings in the field showed that students made the most mistakes in answering question number 4 with the subdomains of Relationships, and Functions (including Number Patterns). Divergent subjects predominantly made types of applying errors and errors during the test.

For divergent students, implementation errors occur due to students' lack of understanding of the answer choice information presented in the problem and divergent students' ignorance in determining the next step of completion. Meanwhile, errors during the test occurred due to students' inability to complete the problem solving and not utilizing time effectively. In addition, assimilation subjects also predominantly make application errors, mainly because they are unable to fully understand the problem statement and solution steps, even though they are able to recognize the formula that must be used. Meanwhile, errors during the test in the assimilation group were caused by incomplete

completion of the solution so as not to find a solution. These findings show that conceptual and application errors are the main obstacles for students in solving mathematical literacy problems, which are caused by limitations in understanding the problem and managing time effectively. In addition, reading the clues was the least error made by subjects with divergent and assimilation learning styles.

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