

STUDENT'S MISTAKES IN SOLVING PROBLEM BASED ON WATSON'S CRITERIA AND LEARNING STYLE

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Submitted: September 30, 2022

Revised: October 31, 2022

Accepted: November 27, 2022

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Abstract

This study aims to determine the types of errors students face when solving math problems. First, review the error types based on Watson's criteria and student learning styles. This study uses an explanatory sequential design model. Data analysis techniques include Quantitative data analysis techniques, descriptive statistics, and inferential statistics. At the same time, the qualitative data analysis techniques include; data reduction, data presentation, and conclusion. The results showed that the errors based on Watson's criteria and learning styles obtained were based on student responses, including; Inappropriate Data 40%, Omitted Conclusion 20%, Response Level Conflict 40%, and Above Other 40%. Furthermore, the types of errors obtained in classroom learning include Inappropriate Data 25%, Omitted Conclusion 50%, and Skill Hierarchy Problems 25%. In the visual learning pattern, there are five error classes: Inappropriate Data 9%, Omitted Conclusion 55%, Response Level Conflict 18%, Skill Hierarchy Problem 27%, and Above Other 18%. Several factors influence the error, including; the decline in students' motivation, interest, and thinking skills. Efforts can be made to minimize student errors, including increasing practice on story questions and eliminating students' negative mindset towards learning mathematics.

Keywords: errors, math problems, watson criteria, learning style



1. Introduction

Science is the systematic arrangement of information in a topic to best explain phenomena in a particular area of expertise. Accordingly, (Kane et al., 2016; Shriki, 2010) described national education as "developing skills and shaping the character and civilization of a decent nation in connection with the formation of the nation's life, intending to develop the potential of students to become human beings who believe in God Almighty and are pious, have a noble character, healthy, capable, capable, creative, indolent, and inquisitive" in chapter II article 3 of the education system law no (M. D. Saputra et al., 2019).

The idea that "education is an eternal process of higher self-adjustment for beings who have matured physically and mentally who are free and aware of God and which is manifested in the natural environment, intellectually, emotionally, and human will" was also made clear (Hadinugrahaningsih et al., 2017; Jose M Ocampo, 2018). According to some of the views expressed above, education is a tool that everyone uses to attain their life goals and is a requirement. According to Aziz's assertion, a prosperous education can be free from ignorance, backwardness, and a poor economy (Engle & Conant, 2002; Shriki, 2010). As a result, education is crucial in life and serves as a foundation for everyone's originality and quality.

This study talks about math. We typically learn about mathematics in other sciences. Because so many fields rely on its discoveries and advancements, mathematics is the queen of the sciences (Bagni, 2004; Sullivan et al., 2009). Especially in learning mathematics of course, every student is expected to have mathematical abilities in the hope that when in the process of solving these problems, it is easier (Cahyati et al., 2018; Maskur et al., 2020). Problem-solving is usually contained in story problems to develop students' abilities.

Essential components of learning mathematics are technical abilities, problem-solving strategies, knowledge, skills, and understanding. So that students can achieve the objectives of learning mathematics, especially those related to solving story problems with a higher level of difficulty (Hidayah et al., 2020; P. Purba et al., 2017). In learning mathematics in schools, teachers usually make problem-solving activities an essential part of learning, intending to know the level of student mastery of the material and training students to apply their knowledge to

different situations and problems (Cenberci, 2018; Jose M Ocampo, 2018).

Evaluation-based problem-solving abilities are key to student achievement. After receiving the given learning material, each person is to be evaluated as a standard (Aini et al., 2019; Auria, 2019). Of course, there were two student responses when completing the evaluation: correctly answering the questions and the existence of errors (M. D. Saputra et al., 2019).

Following up on mistakes, the teacher plays a significant role as a facilitator. The lack of teacher competence in creating engaging mathematics learning and not involving students actively makes learning ineffective, resulting in a lack of motivation and interest in learning mathematics (Buhaerah, 2013).

Researchers at Junior High School (JHS) X in Parepare found that some students had more difficulty understanding problems that were presented as narratives or descriptions. This is the rationale behind the researchers' desire to learn more about the mistakes made by pupils when solving mathematical problems. Of course, criteria are employed to make it simpler for researchers to detect responses provided by students through evaluation examinations in order to analyze student faults.

Watson's criteria are used in this study to make it easier to categorize students' errors from each step of students' answers. Watson is an expert in stimulus-response (S-R) psychologists who coined the eight criteria for identifying errors (Hassan & Madhum, 2007). These criteria will make it easier to categorize student errors from each step of student answers (Simonton, 2013).

The criteria for errors experienced in solving the problems referred to by Watson include: "inappropriate data, inappropriate procedures, missing data, missing conclusions, response level conflicts, indirect manipulation, skill hierarchy problem, and in addition to the seven categories (above other)" (Brown, 2010; Surya & Syahputra, 2017).

Previous research conducted by Fitria Nur Kusti Aisyah et al. showed that "the errors that occurred were inaccurate data, inappropriate procedures, skill hierarchy problems, missing data, no direct manipulation, conflict level responses, missing conclusions and in addition to the seven categories" (Panagiotis Kampylis, Pertti Saariluoma, 2011). In addition, the results of research from Runi Suriani show that "the types of error categories made are ID, IP, OC, RLC, SHP

and AO errors" (Cui et al., 2019). Miya Ayu Kumala Dewi et al., also in their article showed that "different levels of mathematical ability ranging from high, medium, and low resulted in different errors experienced by male and female students" (Brams et al., 2020).

Furthermore, research by RRS (RRS initial response) shows that "male students are more dominant in making mistakes than female students. Male students tend to make data omission errors with 13.33%, conflict response rate 13.33%, and 16.67% above others (Auria, 2019). Female students tend to make mistakes in eliminating conclusions by 24.14%" (Lamb, 2010).

The researcher's title for this description is "study of student errors in answering mathematical problems with the Watson Criteria and the learning styles of class VIII JHS X in Parepare pupils." The purpose of the study is to identify the different sorts of student errors based on Watson's criterion for student learning preferences.

The researcher is referring to a story difficulty when he mentions a mathematics issue. School mathematics is frequently used as an explanation question in daily life (Nelson et al., 2018; M. D. Saputra et al., 2019). Teachers use this math story problem to assess students' mathematical problem-solving abilities (Andriani et al., 2021; Skvortsova et al., 2021; Zahara et al., 2020). Mathematical problems in the form of stories are then converted into mathematical sentences, mathematical equations, or mathematical symbols (Gregori & Martínez, 2021; Zazkis & Zazkis, 2010). In line with this, problems with systems of linear equations of two variables are often found in word problems with real contexts (Mystakidis et al., 2018; Rohman et al., 2019).

2. Method

The type of research used is mixed methods. According to Schoonenboom & Johnson, "Mixed methods is a type of research in which a researcher combines qualitative and quantitative research approaches for broad and in-depth purposes, understanding and verification.

The approach used in this research uses the Explanatory sequential Design model. This design uses two research methods (quantitative and qualitative) with the aim that each technique is carried out one by one (not simultaneously) in two stages of research. This phase is also known as a two-phase design.

The research was conducted at HJS in Parepare. The research subject is class VIII. Three as many as 20 and the issues used at the interview stage were taken from each category of types of errors in the Watson Criteria, which were eight people.

Collecting and processing data is using the VAK learning style questionnaire, evaluation tests, and interviews. First, questionnaires are given directly to students to determine their learning styles. Then an evaluation test is conducted to determine the error category of the answers, and the final stage is to analyze each error category by conducting interviews to determine the factors causing errors.

The learning style questionnaire was compiled based on the VAK learning style indicator with a total of 15 items consisting of 5 items from the Visual aspect, five from the auditory part, and five from the kinesthetic element. The indicators determine student learning styles as follows.

Table 1. VAK learning style indicators

| Learning Style Aspect | Indicator |
|-----------------------|---|
| Visual | I understood something according to the association of vision. |
| Auditory | Learn by listening |
| Kinesthetic | We are learning through physical activity, doing activities by moving, and conducting experiments or experiments. |

The questionnaire was used to know each student's learning style in class VIII MTsN Parepare (one of the junior high schools in Parepare, South Sulawesi). To categorize students' learning styles, scoring is done to see which learning styles are more dominant.

Table 2. Scoring of the VAK learning style instrument

| Answer | Score |
|-------------------|-------|
| Strongly agree | 4 |
| Agree | 3 |
| Not Agree | 2 |
| Strongly Disagree | 1 |

Evaluation tests are used to determine the types of student errors based on predetermined criteria, namely the Watson criteria. This criterion is used to facilitate researchers in classifying categories of student errors. The final stage interviews to know the causes of errors so that efforts are made to reduce student errors.

3. Result and Discussion

3.1 Result

The results of the calculation of the VAK learning style questionnaire were given to class VIII.3 JHS students obtained that the learning style of visual students is 55%, auditory learning style is 25%, and kinesthetic learning style is 20%.

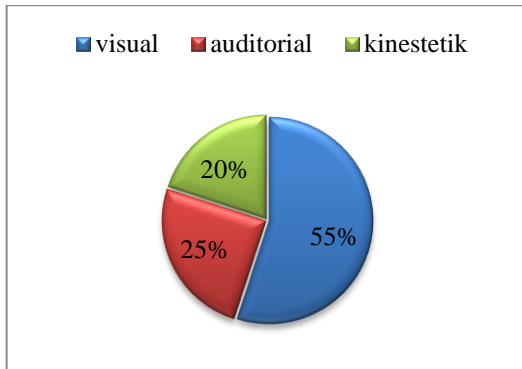


Figure 1. Percentage of Learning Styles

Furthermore, this section describes the categories of errors made by students in solving math story problems in the system of two-variable linear equations (STVLE) material based on the Watson criteria. The error analysis is carried out on each type of error as follows:

Inappropriate Data

Handwritten work for Figure 2:

$$\begin{aligned}
 x + 2y &= 4 \text{ tas perjam} \\
 x &= 4 \text{ tas perjam} - 2y \text{ (persamaan 1)} \\
 2x + y &= 3 \text{ tas perjam} \\
 2(4 \text{ tas perjam} - 2y) + y &= 3 \text{ tas perjam} \\
 8 \text{ tas perjam} - 4y + y &= 3 \text{ tas perjam} \\
 8 \text{ tas perjam} - 3y &= 3 \text{ tas perjam} \\
 -3y &= 3 \text{ tas perjam} - 8 \text{ tas perjam} \\
 -3y &= -5 \text{ tas} \\
 y &= \frac{-5}{-3} = 1,67
 \end{aligned}$$

Translate:
persamaan (equality), tas perjam (hourly bag)

Figure 2. F Test Results Question 1

The results of the “F” test show an error in the Incorrect Data type. He felt afraid to write the answer to the question, as seen by the answer “F,” so he crossed it out. Then immediately write down the data with equation 1 ($3x + 4y = 55$) and equation 2 ($x + y = 16$), but the data entered is ($x + 2y = 4$) bags per hour $x = 4$ bags per hour $2y$ equation 1.

Based on the statement from “F”, it is obtained that “F” cannot write the variable of an equation if the problem is presented in the form of a story.

Handwritten work for Figure 3:

Dik: Misalkan Mobil = x
Motor = y

Jadi:
 $Pers 1 = 3x + 4y = 17.000$
 $5y + 2y = 18.000$

Penye:
 Banyak uang parkir ?
 $\Rightarrow 3x + 4y = 17.000$
 $7y = 17.000$
 $x = \frac{17.000}{7}$
 $\rightarrow 5y + 2y = 18.000$
 $7y = 18.000$
 $y = \frac{18.000}{7}$

Translate:
dik (Is know), misalkan (for example), mobil (car), motor (motorcycle), Jadi, Pers, Banyak uang parkir (a lot of parking money)

Figure 3. ZZ Test Results Question 2

The results of the “ZZ” test indicate that an error has occurred in the incorrect data type (Inappropriate Data). From the questions, it was found that students wrote down the equation data 1 $3x + 4x = 17.000$ and $5y + 2y = 18.000$. Therefore, the problem has been able to assume an object, namely a car with a variable x and a motorcycle with a variable y . However, when writing the equation, students combine the x variable in equation 1 and so also in equation 2 combine the y variable so that the data in the equation is not correct. This results in an incorrect answer.

Based on the statement from “ZZ” it was obtained that “ZZ” was able to assume an object with a variable, either variable x or variable y , but did not understand the problem well. Therefore, when students determine equation 1 and equation 2 from the given situation, students experience an error by adding the same variables.

The Omitted Conclusion

Handwritten work for Figure 4:

$$\begin{aligned}
 \rightarrow 3x + 4y &= 55 \\
 x + y &= 16 \\
 x + y &= 16 \\
 x &= 16 - y \\
 \rightarrow \text{Substitusi } x = 16 - y \text{ ke persamaan } 3x + 4y &= 55 \\
 3x + 4y &= 55 \\
 3(16 - y) + 4y &= 55 \\
 48 - 3y + 4y &= 55 \\
 48 + y &= 55 \\
 y &= 55 - 48 \\
 y &= 7
 \end{aligned}$$

Translate:
subtitusi (substitution), ke persamaan (to the equation)

Figure 4. SWH Test Results Question 1

The results of the “SWH” test indicate that there is an Omitted Conclusion error. Errors occur because students only write down the results of the

variable from the variable $x = 9$ and the variable from the variable $y = 7$ without writing down what shows the request for the question requested, namely the number of working hours from Habib and Haqgul.

Based on the statement from "SWH," it was found that "SWH" was able to explain and follow the settlement procedure well. However, he did not write down the conclusion from the answers obtained because he did not know that the findings were also written in the solution. The reason is that they rarely do exercises after being given the material.

Mobil = x
Motor = y

Persamaan 1 = $3x + 5y = 17.000,00$
Persamaan 2 = $4x + 2y = 10.000,00$

$$\begin{array}{r} 3x + 5y = 17.000,00 \quad \times 4 \\ 4x + 2y = 10.000,00 \quad \times 3 \\ \hline 12x + 20y = 68.000,00 \\ 12x + 6y = 30.000,00 \\ \hline 0 + 14y = 38.000,00 \\ y = \frac{38.000,00}{14} \\ y = 2.714,29 \end{array}$$

$3x + 5y = 17.000,00$
 $3x + 5(2.714,29) = 17.000,00$
 $3x + 13.571,43 = 17.000,00$
 $3x = 17.000,00 - 13.571,43$
 $3x = 3.428,57$
 $x = \frac{3.428,57}{3}$
 $x = 1.142,86$

Translate:
mobil (car), motor (motorcycle)

Figure 5. NAP Test Results on Question Number 2

The results of the "NAP" test indicate that there is an Omitted Conclusion error because students have obtained and written down the effects of the variable from variable x , which is 4,000.00, and variable from variable y which is 1,000.00 without writing down indicating the request for the question requested, namely Determine the amount of parking money earned if there are ten cars and 15 motorbikes. Therefore, the remaining students should substitute the values of the x and y variables in the $10x + 15y$ equation to get $10(4.000 + 15(1.000) = 40.000 + 15.000$, so the total parking cost is 55.000

Based on the statement from "NAP," it was obtained that students could describe the completion process using the mixed elimination - substitution method. But forgot to write the conclusion with the excuse of being in a hurry because the time to work on the questions had run out.

Response Level Conflict

Pers A : $x + y = 16$
Pers B : $3x + 4y = 55$

$$\begin{array}{r} x + y = 16 \quad \times 3 \\ 3x + 4y = 55 \quad \times 1 \\ \hline y = 7 \end{array}$$

Substitusikan ke Pers. A :
 $x + y = 16$
 $x + 7 = 16$
 $x = 16 - 7$
 $x = 9$

Jadi, jam kerja Habib 7 jam
jam kerja Haqgul 9 jam

Translate:
Pers or persamaan (equality), substitusikan (substitute)

Figure 6. DAA Test Results Question 1

The "DAA" test results show that in solving the problem, the STVLE problem-solving technique is not used to determine the value of the x variable, such as elimination, substitution, or mixed methods. Instead, DAA directly writes the results of the variable y without showing the completion steps. And the conclusion given is incorrect because it obtained the value of the variables $y = 7$ and $x = 9$ but wrote it in reverse, namely $y = 9$ and $x = 7$

Based on the statement from "DAA," the leading cause of errors was rushing when you saw that many of his friends had gathered, so they were less focused on determining the conclusion.

Modul matematika
 $3x + 5y = 17.000 \dots (1)$
 $4x + 2y = 10.000 \dots (2)$

eliminasi persamaan (1) dan (2)
 $5x + 5y = 17.000 \times 4 \quad 20x + 20y = 68.000$
 $4x + 2y = 10.000 \times 3 \quad 12x + 6y = 30.000$
 $14y = 38.000$
 $y = 2.714,29$
 $y = 1.000$

Substitusi nilai $y = 1.000$ ke salah satu persamaan :
 $3x + 5y = 17.000$
 $3x + 5(1.000) = 17.000$
 $3x + 5.000 = 17.000$
 $3x = 17.000 - 5.000$
 $3x = 12.000$
 $x = 4.000$

Jadi biaya parkir 1 mobil Rp. 4.000,00 dan 1 motor Rp. 1.000,00

Translate:
modul matematika (math module), eliminasi persamaan (equation elimination), substitusi nilai $y = 1.000$ ke salah satu persamaan (substitute the value $y = 1.000$ into one of the equations), jadi biaya parkir 1 mobil Rp. 4.000 dan 1 motor Rp. 1.000 (so, the cost of parking 1 car Rp. 4.000 and 1 motorcycle Rp. 1.000)

Figure 7. HF Test Results Question 2

The test results show that students initially follow the steps by writing down the two equations according to the questions given to get the values of the x and y variables. However, when writing

the conclusions, the students experienced errors because when looking for parking fees, they obtained ten cars and 15 motorbikes, written in a mathematical model. As a result, they acquired $10x + 15y$. Still, students immediately concluded the values of the x and y variables.

Based on the statement from "HF," it was obtained that students could explain the procedure correctly. However, when writing the conclusion, he ended up wrong because he ignored the request from the question.

Skill Hierarchy Problem

Habib = x
Haqqul = y

Persamaan 1 = $x + y = 16$
Persamaan 2 = $3x + 4y = 55$

$$\begin{array}{r} x + y = 16 \quad | \times 3 \quad | \quad 3x + 3y = 48 \\ 3x + 4y = 55 \quad | \times 1 \quad | \quad 3x + 4y = 55 \\ \hline 0 - y = -7 \\ y = -7 \end{array}$$

$x + y = 16$
 $x + (-7) = 16$
 $x = 16 + 7$
 $x = 19$

Translate:
persamaan (equality)

Figure 8. NAP Test Results Question 1

The results of the "NAP" test indicate that students have understood this matter because, from the answers, they can write answers in a structured manner. Still, when doing calculations to get the value of the variable y , the student makes an error where from the results of the translation, it is obtained $y = -7$ so that when substituting the value of y into equation 1, namely from the variable $x + y = 16$, the value of the variable x obtained is from the variable $x = 19$.

Based on interviews, it was found that the cause of errors during the calculation process was because they were in a hurry to solve the problem, so they ignored the sign operation on the variable coefficient when moving to the right-hand side to get the value of the y variable.

$$\begin{array}{l} 3x + 5y = 17.000 \rightarrow \times 4 \rightarrow 12x + 20y = 68.000 \\ 4x + 2y = 18.000 \rightarrow \times 3 \rightarrow 12x + 6y = 54.000 \\ \hline 14y = 14.000 \\ y = 1.000 \\ 12x + 20y = 68.000 \\ 12x + 20(1.000) = 68.000 \\ 12x + 20.000 = 68.000 \\ 12x = 48.000 \\ x = 4 \end{array}$$

Figure 9. F Test Results Question 2

The "F" test results indicate that students can determine the equation of the story questions are given. Still, when solving, the students do not describe the operations and immediately write down $14y = 14.000$, then get $y = 1.000$. Furthermore, when doing calculations to get the value of the variable x , students make mistakes from the translation results when substituting the value of y into the equation.

Based on interviews, it was found that the cause of errors during the calculation process was the grounds that they could not carry out the calculation process with large nominal numbers, so they needed a calculation aid, namely a calculator, to solve the problem

Above Other

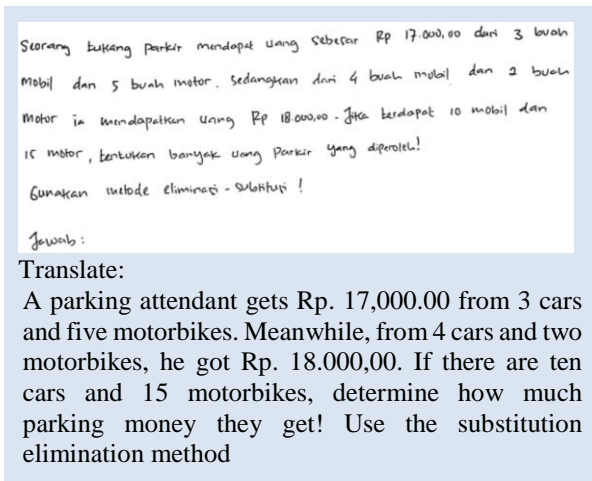
Diketahui
Jam kerja Habib dengan Variabel x
haqqul dengan Variabel y
sehingga diperoleh persamaan
Persamaan 1 = $3x + 4y = 55$
Persamaan 2 = $x + y = 16$
Dit: Jam kerja masing"
Peny .

Translate:
Diketahui (is known), jam kerja Habib dengan variable x (Habib's working hours with variable x), Haqqul dengan variable y (Haqqul with variable y), sehingga diperoleh persamaan... (so, we get the equation...), dit or ditanyakan (asked), jam kerja masing-masing (hours of work each), peny or penyelesaian (solution)

Figure 10. PH Test Results in Problem 1

The test results show that students can write down and distinguish the variables from the questions but only write what is known and asked without settling.

Based on interviews that researchers have conducted, PH has understood the questions given, starting from explaining what is known in the problem and assuming the variables x and y . The factors that cause errors are when they are about to finish. The students do not understand how to solve them because they forget the method used in solving the problem.



Translate:

A parking attendant gets Rp. 17,000.00 from 3 cars and five motorbikes. Meanwhile, from 4 cars and two motorbikes, he got Rp. 18,000.00. If there are ten cars and 15 motorbikes, determine how much parking money they get! Use the substitution elimination method

Figure 11. AR Test Results Question 2

The test results show that students experience errors in categories other than the seven error criteria on the Watson criteria because they only rewrite the questions given without solving the problems.

Based on the interviews that have been conducted, AR does not understand the questions, is unable to determine variables, and does not know the methods used to solve problems. The causal factors are based on the results of interviews that "AR" has difficulty understanding the formulas in mathematics, which results in not being interested in learning mathematics.

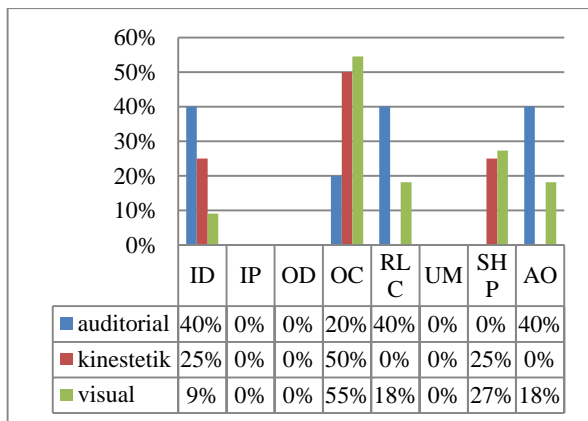


Figure 12. Percentage of Student Errors

In general, from the two questions given, it can be concluded that the percentage of each error in each category from the Watson criteria and student learning styles, namely with an auditory learning style, as many as four types of error categories, namely ID as much as 40%, OC as much as 20%, RLC as much as 40% and AO as much as 40%, kinesthetic learning styles as many as three types of error categories based on Watson criteria, namely ID as much as 25%, OC as much as 50% and SHP as much as 25% as well as in visual learning styles as many as five types of error categories based on Watson criteria, namely ID as

much as 9%, OC as much as 55%, RLC as much as 18%, SHP as much as 27% and AO as much as 18%.

3.2 Discussion

Error-Producing Factors. Motivation, interests, and talents are only a few of the many variables that affect students' mistakes. These elements can be observed in the cases of students who are less motivated to learn as a result of a shortage of study time at school, a lack of enthusiasm in learning mathematics, and restricted student abilities in the arithmetic process (Hobri et al., 2021). Students are also less inclined to review the subject and complete practice exams. Another aspect is the presence of sicknesses, which results in a shortage of educational activities in classrooms and forces learning to occur online (Sternod & French, 2016).

Efforts to Minimize Errors in Solving Mathematical Problems. The subsequent efforts can be made to minimize errors made by students

They were developing an Interest in Learning Mathematics for Students. Lack of interest in teaching mathematics will negatively impact students (She et al., 2021; Zhou et al., 2020). Affected students will quickly think that mathematics is complicated mathematics is boring and even skip classes to avoid math lessons (Even & Kvatinsky, 2010; Warner & Kaur, 2017). The results of the study by Zakaria and Norazah M. Nordin showed that "the level of achievement and motivation of students who indicated mathematics anxiety was lower than students who did not show mathematics anxiety" (Cahyati et al., 2018; Cenberci, 2018).

Increase Exercise

To develop well, students need to be familiarized with problem solving activities. The way to do this is to train yourself to answer questions to get used to them so that it is easier to work on story questions (Auria, 2019; M. D. Saputra et al., 2019). According to the associative theory formulated by Thorndike, "the law of learning according to Throdike is the law of practice, which means that the more you practice, the stronger one's memory" (Warner & Kaur, 2017).

Teachers can provide questions and challenges so that curiosity arises. Students will respond critically if the question is also enjoyable. The existence of an interest in facing challenges and a greater willingness to overcome these challenges is the principal capital in solving

problems (Daulay & Ruhaimah, 2019; Faturrohman & Amelia, 2020; Hobri et al., 2021).

Eliminating students' negative mindset against mathematics learning

Besides being a facilitator, the teacher is also a motivator teacher. If the teacher wants to build a positive mindset for students, the teacher must also be able to motivate students so that students have a growth mindset. Teachers have an essential role in influencing the attitude and work patterns of students; teachers must also be willing to build cooperation with parents so that what is applied at school can also be used at home so that students feel mathematics is a fun subject anytime and anywhere.

4. Conclusion

From the results of the error analysis of all the questions given, it can be concluded that the percentage of each error in each category from the Watson criteria and student learning styles, namely the auditory learning style, as many as four types of error categories, namely ID 40%, OC 20%, RLC 40% and AO 40%, kinesthetic learning styles as many as three types of error categories based on Watson criteria, namely ID 25%, OC 50%, and SHP 25% and in visual learning styles there are five types of error categories based on Watson criteria, namely ID 9%, OC 55%, RLC 18%, SHP 27%, and AO 18%.

Motivation, interests, and talents are variables that affect students' blunders. Based on influencing factors, such as boosting students' practice answering story questions, removing students' negative outlook about learning mathematics, and developing students' interest in learning mathematics, efforts can be taken to reduce student errors.

Acknowledgements

It should be stated that the study of this article involves several disciplines. Please, editors, take the time to review so that this article becomes better and of higher quality and if it can be given a place for publication. I am very grateful to many colleagues for their responses and suggestions for improving this paper. I hope a brief note will convince them, and thanks to the journal staff at Jupitek Journal

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