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Ability to Interpret Graphs in Reaction Rate Material Based on Mathematical Understanding and Learning Style of Class XI High School Students

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Abstract. One aspect of process science skills that learners need to have is the ability to interpret. The ability to interpret graphs in students is currently considered difficult and still belongs to the very low category. This study aims to analyze the relationship between mathematical understanding and the learning styles of students in terms of their ability to interpret graphs. This type of research is descriptive-quantitative. The research sample consisted of class XI students at SMA Negeri 4 Takengon, which amounted to 67 students. The research data was collected using learning style-type questionnaires, multiple-choice questions on linear program material, and reaction rate material. The ability to interpret the graphs of students at SMA Negeri 4 Takengon is on the "medium" criterion, while the students' mathematical understanding is on the "very high" criterion. Students with visual learning style types are more dominant and have an average score of mathematical understanding and the ability to interpret graphs higher than students with auditorial and kinesthetic learning styles. The result of the correlation coefficient r = 0.912 shows a significant positive relationship between mathematical understanding and the ability to interpret graphs with a "high" and unidirectional interpretation.
Keywords: Ability to interpret graphs, mathematical understanding, learning style, reaction rate

Introduction

Reaction rate is a chemical concept taught in class XI in high school. The concept of reaction rate is a prerequisite for studying the concepts of equilibrium and thermodynamics. The subject matter of reaction rates includes the concepts of understanding reaction rates, reaction order, activation energy, factors that influence reaction rates, collision theory, catalysts, and reaction mechanisms, as well as the application of reaction rates in everyday life (Supasorn et al., 2022). These concepts are

abstract, so students are required to have skills that can facilitate their understanding (Ulva et al., 2021). Understanding concepts means that students are not only able to understand concepts but are also able to conclude, interpret, and apply the concepts they have acquired. Science process skills are skills needed by students to think logically and critically scientifically in solving problems in science learning (Darmaji et al., 2023). The ability to interpret data is one aspect of science process skills (Kamarudin et al., 2022). Therefore, the ability to interpret data needs to be trained so that learners' science process skills can improve. The ability to interpret, in the context of this study, is the ability to read and conclude data in the form of a graph.

Graphs are a form of representation that can display simpler and more detailed data, such as comparisons of several research data sets and field observations (Sinaga et al., 2022). When data is obtained from research results, graphs are used to show relationships, comparisons, and patterns in the data (Fatimah, 2023). In addition, data presented in the form of graphs will be easily understood by students compared to data presented in the form of description sentences (Amin et al., 2020). The explanation of reaction rate material on how to determine the reaction order and the factors that affect the reaction rate can be illustrated through graphs (Ulva et al., 2021). The reaction order describes the relationship between changes in reactant concentration and changes in reaction rate. However, the ability to interpret graphs in students is currently considered difficult and is still very low. The low ability to interpret graphs in high school is caused by aspects of students' understanding of graphs, criticism, and graphic construction that are still lacking (Dipalaya et al., 2022). Therefore, learners only infer information or experimental results based on theory, according to experts, but do not draw conclusions based on the data obtained. The difficulties experienced by students in understanding the reaction rate include difficulty explaining the relationship of reaction rate to time, then drawing graphs about the relationship between the two aspects, and difficulty understanding reaction order graphs (Susanti & Iskandar, 2019).

The ability of learners to interpret graphs requires a good understanding of mathematics to relate relationships between existing variables (Farida et al., 2020). Basically, mathematics deals with the process of solving problems through reasoning instead of rote memorization (Szabo et al., 2020). The process of understanding mathematics is in line with one of Piaget's theories of cognitive development, which explains how children can adapt and interpret objects and events around them. One of the goals of mathematical comprehension is to help students interpret and understand graphs critically (Ariza et al., 2024). Thus, understanding mathematics is needed to train thinking and reasoning to be able to solve problems and draw appropriate conclusions (Hayati & Kamid, 2019).

Graph interpretation skills are correlated with students' learning styles in addition to their grasp of mathematics. Learning style means a method that students prefer for analyzing, obtaining, and interpreting a concept of knowledge (Chaudhry et al., 2020). Learning styles consist of three types, namely visual, auditory, and kinesthetic. Learning style has an important role because it can affect the ability of students to absorb information in the process (Saputra et al., 2021). Students will be able to solve problems in learning effectively based on their learning style (Dermawan et al., 2021). This research focuses on analyzing the ability to interpret graphs of high school students XI on reaction rate material, as well as identifying the correlation between understanding mathematics and visual, auditory, and kinesthetic learning styles on the ability to interpret graphs.

Methods

The type of research conducted is quantitative descriptive research. This research has been conducted at SMA Negeri 4 Takengon in the odd semester of the 2023–2024 school year. The study population was all students from grades X to XII at SMA 4 Takengon, which amounted to 450 people. The research sample selection technique uses purposive sampling techniques, namely selection techniques based on certain considerations (Arikunto, 2014). The research sample consisted of 67 class XI learners. Data collection was obtained using learning-style questionnaires and test questions. The test question instrument consists of linear program material questions used to measure mathematical understanding and reaction rate material questions used to identify the ability to interpret graphs. The test questions are in the form of multiple-choice questions with as many as 10 points developed based on the question indicators in Tables 2 and 3.

The assessment of the validity of the content of the question instrument has been said to be suitable for use by two experts in chemistry and mathematics. Instruments about linear programs and reaction rate questions have been tested on 30 students of class XII science at SMA 4 Negeri Takengon. The reliability coefficient of the linear program question test obtained from the results of the trial analysis is 0.743, with a high category. The test reliability value from the test results of the reaction rate is 0.866, which is in a very high category. The r_{value} of the table for a trial of 30 samples with a significant level of 5% is 0.70. Thus, the test results on linear program question instruments and reaction rates have a calculated $r_{value} > r_{table}$, so they are said to be reliable.

Table 1. Learning Style Questionnaire Grid

No.	Learning Style	Indicator	Item Number		Total
			Favorable	Unfavorable	
1.	Visual	a. Looks neat and orderly	1		10
		b. Active in responding	7		
		c. Highly detailed	2		
		d. Remember something based on what is seen	3	10	
		e. Not easily disturbed by the turmoil	8		
		f. Understand questions in writing		9	
		g. Require a note	5		
		h. Answer questions briefly	6		
		i. Prefer art over music	4		
2.	Auditory	a. Easy to be distracted by turmoils	11		10
		b. Repeat words heard	12		
		c. Like to listen to other people's explanations	13		
		d. Can repeat, imitate tones, lines, and colors of voices	15		
		e. Likes to argue orally	20		
		f. Speak smoothly	16		
		g. Likes to talk, discuss, and explain things widely	17		

No.	Learning Style	Indicator	Item Number		Total
			Favorable	Unfavorable	
		h. Lacks the ability to understand visualization data	18	19	
		i. Prefer listening to stories rather than reading		14	
3.	Kinesthetic	a. Learning with physical activity	25		10
		b. Touching people to get information	24		
		c. Being near someone who is talking	21		
		d. Physically oriented and highly active		28	
		e. Learning through direct practice	26		
		f. Learning by walking or looking directly	29	30	
		g. Using fingers to point at the words to be read	23		
		h. Not neat in writing		22	
		i. Prefers physical activities in doing everything		27	

(Source: Maryani et al., 2017)

Table 2. Grid about Mathematical Understanding

No.	Aspects of Mathematical Understanding	Indicator	Item Number
1.	Restate a concept	Students are able to explain what is already known about the concept of inequality systems	1, 2
2.	Classifying objects according to their properties	Students are able to determine objects by type based on the properties of the equation system	3
3.	Demonstrating examples and non-examples of a concept	Students are able to give an example of a linear equation system with two variables	4
4.	Developing necessary conditions or sufficient conditions.	Students are able to create and define mathematical models based on linear programming problems	5, 6
5.	Presenting concepts in various forms of mathematical representation	Students are able to use concepts and present linear program problems in the form of graphs, diagrams, etc	7, 8
6.	Use and exploit and select specific procedures or operations	Students are able to complete linear program issues accurately	9

No.	Aspects of Mathematical Understanding	Indicator	Item Number
7.	Applying concepts or algorithms in troubleshooting	Students are able to solve mathematical models of linear programming problems related to everyday life.	10

(Source: Nurajijah et al., 2023)

Table 3. Grid of Graph-Interpreting Skills

No.	Aspects of Interpretive Ability	Indicator	Item Number
1.	Linking between variables	Students are able to determine the graph of reaction rate	1, 2
		Students are able to determine the order of reactions based on graphs	3
2.	Detecting patterns	Students are able to determine the factors that affect the reaction rate based on graphs	4, 5, 6
3.	Conclude	Students are able to deduce the concept of reaction rate based on graphs	7, 8, 9, 10

(Source: Karsimen et al., 2019)

Data analysis techniques are obtained from the results of scores obtained by students on learning style questionnaires, linear program questions, and reaction rate questions. The type of learning style of students is determined based on the average highest score from the questionnaire results. Students' understanding of mathematics and the ability to interpret graphs are obtained from the results of test scores analyzed using the formula in equation 1.

$$P = \left(\frac{f}{n}\right) \times 100\% \qquad (1)$$

P : percentage
f : frequency / score of students' answers
n : number of frequencies / total number of ideal scores

The results of comprehension test scores are grouped based on knowledge domain criteria based on Permendikbud No.104 of 2014 in Table 4. Therefore, learners' criteria can be obtained based on aspects of mathematical understanding and aspects of their ability to interpret graphs.

Table 4. Criteria for Student Understanding through Test Results

Score (%)	Criteria
90 - 100	Very High
75 - 89	High
55 - 74	Medium
40 - 54	Low
0 - 39	Very Low

(Source: Yanti et al., 2020)

Results and Discussion

Mathematical Understanding

The level of mathematical understanding can be obtained from the total number of learners who answered correctly. The total value obtained by each student will be analyzed and grouped based on the knowledge domain criteria in Table 4. The percentage of the number of students based on the grouping of mathematical comprehension criteria can be seen in Figure 1.

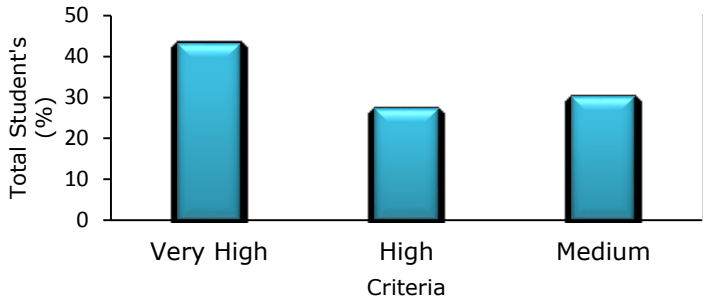

Figure 1. Learners' level of mathematical comprehension

Students who have an understanding of mathematics with very high criteria as much as 43% mean that 29 out of 67 get scores between 90 and 100. The students' high criteria of 27% mean that as many as 18 out of 67 get a score of 80. The mathematical understanding of students with moderate criteria has a percentage of 30%, meaning that as many as 20 out of 67 students get scores of 60 and 70. Figure 1. shows that the level of mathematics understanding of grade XI students at SMA Negeri 4 Takengon is more dominant, with very high criteria and a percentage of 43%. The students' understanding of mathematics is very high because some students are able to master the concepts well from the teacher's explanation at the previous meeting regarding linear program material. The results of the study are in accordance with the results of Nurajijah et al. (2023), which show that mathematical understanding is in the high category because students have been able to master all indicators of understanding the concepts tested.

Ability to Interpret Graphs

The level of ability to interpret graphs is obtained from the total number of students who answered correctly about the reaction rate. The total score obtained by each student is grouped based on the criteria in Table 4. The percentage of students who have been grouped based on mathematical comprehension criteria can be seen in Figure 2.

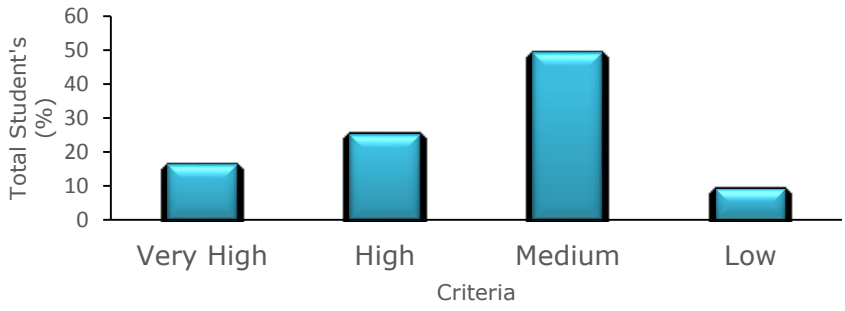

Figure 2. Level of ability to interpret learners' graphs

The ability to interpret the graph of students who have very high criteria of 16% means that as many as 11 out of 67 get scores of 90 and 100. Students who have the ability to interpret graphs with high criteria of 25% mean that as many as 17 out of 67 get a score of 80. The ability to interpret student charts with medium criteria is 49%, meaning that 33 out of 67 students obtained scores of 60 and 70. While students who have the ability to interpret low-criteria graphs by 9%, meaning that 6 out of 67 students get scores of 40 and 50, Based on Figure 2, the ability to interpret graphs of grade XI students at SMA Negeri 4 Takengon is more dominant with medium criteria, with a percentage of 49%. Students are still unable to solve graph-related test questions because, during the learning process, the teacher explains the concept of reaction rate but does not provide practice questions related to graphs. The results of the study are in accordance with those found by Deratama et al. (2022), who found that the factors causing the low ability to interpret data are students who are not trained to solve problems, there are no teaching materials that support higher-order thinking, and there is low interest in reading among students.

Types of Student Learning Styles

Identification of learning style type groups is obtained from the results of questionnaire responses given by students. The grouping of learning styles for each student is obtained based on the highest average score of the three types of learning styles. If there is the highest score in one type of learning style, then the type of learning style that is dominant is owned by an individual (Aulia et al., 2022). A recapitulation of the percentage of learning style types of grade XI students at SMA Negeri 4 Takengon can be seen in Figure 3.

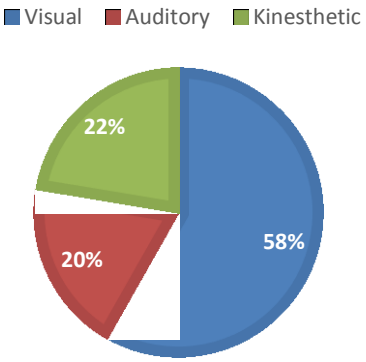

Figure 3. Percentage of learning style type groups

Figure 3 shows the most dominant type of visual learning style possessed by grade XI students at SMA Negeri 4 Takengon, which is 58%. Based on the results of the learning style questionnaire responses, it shows that students are more interested in reading graphs compared to practicum and learning videos on reaction rate material. The results of the study are supported by Zagoto et al. (2019), who found that diagrams, maps, graphs, and images are examples of data visualization that support the type of visual learning style in understanding the material, while the auditorial learning style can maximize the use of audio and group discussions, as well as field practices for kinesthetic learning styles. Identification of learning styles aims to determine ways of learning that make it easier for students to understand the material and achieve optimal learning outcomes. Based on the type of learning style, there is no better or worse learning style than other learning styles (Saputra et al., 2021). The results of the average score analysis obtained by students from mathematics comprehension tests and tests of the ability to interpret graphs in each type of learning style can be seen in Figure 4.

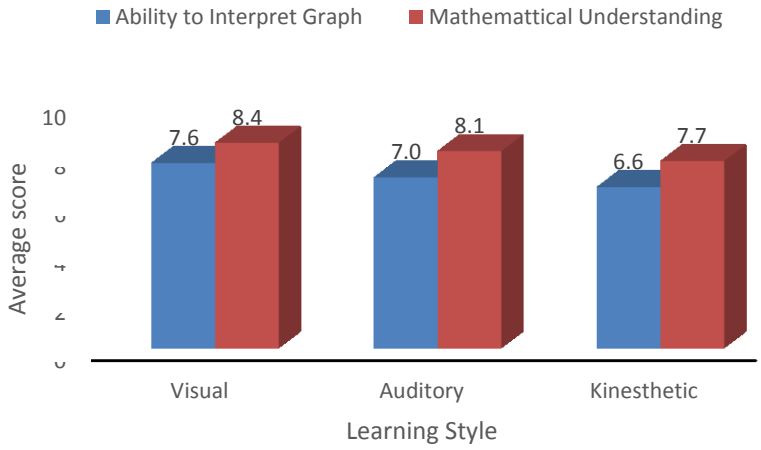

Figure 4. Average score of learning style type group

Based on Figure 4, The average score of mathematical comprehension and the ability to interpret graphs in visual learning style learners is higher than auditorial and kinesthetic learning styles. This can happen because the teacher's teaching techniques and learning media support the type of visual learning style. The results of the study were supported by research by Rini et al. (2020), which showed that students with visual learning styles get better grades because they are able to obtain information from reading.

Correlation of Mathematical Understanding to the Ability to Interpret Graphs

The normality test using Kolmogorov-Smirnov with a significant level of 0.05 shows the conclusion that the data on mathematical understanding and the ability to interpret graphs are not normally distributed. If the data is declared not normally distributed, then the data can be analyzed with the Wilcoxon signed rank test nonparametric test (Rahmawati et al., 2021). The Wilcoxon test results have a significance value of 0.000. Asymp value. The sig. (2-tailed) < 0.05 then accepts H_a and rejects H_0. Drawing conclusions based on these results, there is a relationship between the value of mathematical understanding and the value of the ability to interpret graphs. The correlation test can be done using the Pearson Product Moment formula with the 2021 version of SPSS 21. The result of the correlation coefficient of 0.912 with high interpretation shows a positive or unidirectional relationship between mathematical understanding and the ability to interpret graphs. If the level of understanding of mathematics students is high, then their ability to interpret graphs will also be high. Conversely, if the level of mathematical understanding of learners is low, then their ability to interpret graphs is also low. This happens because mathematical understanding is related to the relationships between variables that make it easier to interpret data. The results of the research are supported by research by Maysaroh et al. (2021) showing a positive relationship between the mathematical understanding of the concept of exponent numbers and the results of learning the chemistry of reaction rate materials. Based on the determination test, an r-square value of 0.831 was obtained, which means that there is a significant influence of the mathematical understanding of linear program material on the ability to interpret material graphs, with a reaction rate of 83%. Another factor that can affect this is 17%.

Conclusion

Based on the research results, it can be concluded that the ability to interpret is in the medium criteria with a percentage of 49% obtained by class XI students at SMA Negeri 4 Takengon. The correlation coefficient of 0.912 indicates that there is a positive relationship between mathematical understanding of linear programming material and the ability to interpret graphs of reaction rate material. Students with a visual learning style obtained a higher average score of mathematical understanding and ability to interpret graphs than students with auditory and kinesthetic learning styles.

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