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Examining Student Conception of Reaction Rate Through Three-Tier Multi-Representation Assessments

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Abstract

This study aims to analyze students' conceptions of reaction rate topics using the three-tier multi-representation test. Based on the characteristics of reaction rates concepts that involve the understanding of multiple representations, it is essential to analyze student conceptions that include multiple representations, namely macroscopic, microscopic, and symbolic. A three-tier diagnostic test can be done to assess students' conceptions, with the questions given in the first tier presented with macroscopic, microscopic, or symbolic representations according to the characteristics of the concept in question. This research uses a descriptive quantitative method conducted at Madrasah Aliyah Negeri 2 in Palu City, Central Sulawesi. The subjects of this study were 50 students consisting of 28 female students and 22 male students. It was determined by random sampling technique. Instrumentation used a three-tier representation test with 15 multiple-choice questions. Validation of instruments showed that the questions were feasible and fell into the high category. The findings reveal that only 29 % of students know the concept, categorized as low. Additionally, 40 % of students were identified as having misconceptions, placing them within the medium category, while 31 % of students exhibited not knowing the concept, also classified in the medium category. Symbolic representation emerged as the most challenging representation for students, with 35 % failing to comprehend it, categorized as medium. Furthermore, among students with misconceptions, symbolic and macroscopic representations were the most problematic, collectively accounting for 34 %, also classified as medium. These results underscore the need for targeted instructional strategies to address specific areas of difficulty and improve overall conceptual understanding.

Keywords: Conception category, diagnostic three-tier, macroscopic, microscopic, symbolic, reaction rates

Introduction

Education is a directed and organized effort to organize the teaching and learning process to guide students in realizing their potential (Pemerintah Indonesia, 2003). However, various problems in the field of education still occur and can hinder the achievement of the expected goals (Kurniawati, 2022; Tanjung et al., 2023; Widyaningrum et al., 2022). An example of chemistry learning is the existence of misconceptions and learning that does not pay attention to the initial conception of students (A'yun et al., 2018; Magfirah, 2019; Suyono, 2020).

Each student already has their visualization and understanding of natural events or phenomena they encounter in their daily environment, and they have developed them independently (Rahmawati et al., 2022). Visualization and understanding students develop are known as conceptions, which are interpretations made by a person of a particular concept in the framework that already exists in his mind (Cai et al., 2021). Each new concept is obtained and processed together with their already-established concepts (Faizah, 2016). At the same time, the misconception is an error in interpreting a concept because students understand concepts that do not follow scientific explanations (Astuti et al., 2016; Rahmawati et al., 2022). Misconceptions can be caused by students' wrong intuition towards concepts, wrong initial ideas, and incomplete explanations of a concept, thus causing students' reasoning to be wrong about the concept (Astuti et al., 2016).

Misconceptions can occur in all subjects, including chemistry (Stojanovska et al., 2014). High school chemistry materials contain many concepts that are pretty difficult and interrelated for students to understand (Andraini et al., 2021; Auliyani et al., 2017). For example, reaction rate material is complex for students to understand because some reaction rate subconcepts are challenging to visualise and involve many symbolic and mathematical equations (Pikoli et al., 2022). Based on the results of research (Safitri et al., 2019), it is known that students experience misconceptions and difficulties in understanding the concept of reaction rate and its relationship with concentration and pressure, this is because students have not been able to interpret abstract concepts in reaction rate material such as collision theory and factors that

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affect the reaction rate. Analysis of students' conceptions is very crucial to know. If a student with misconceptions and does not understand the concept rightly are ignored, it will affect their understanding of further chemistry topics.

In addition, understanding chemistry also requires the ability to describe, interpret, and connect chemical concepts and phenomena in the form of macroscopic, submicroscopic, and symbolic representations simultaneously, known as multi-representation (Herunata et al., 2023; Li & Arshad, 2014; Suparwati, 2022; Safitri et al., 2019; Stojanovska et al., 2014). Macroscopic representation is a concrete level that is visible, where at this level, students observe phenomena and facts that occur, either through experiments or events in everyday life. The phenomena observed can be the appearance of odours, the occurrence of colour changes, the formation of gases, and the formation of deposits in chemical reactions. Submicroscopic representation is an invisible concrete level used to explain macroscopic phenomena. This representation provides an explanation at the particle level where matter is described as an arrangement of atoms, molecules, and ions, while symbolic representation is used to represent macroscopic and submicroscopic phenomena using chemical equations, mathematical equations, graphs, reaction mechanisms (Rahmawati et al., 2022; Safitri et al., 2019).

The interconnection of the three levels of representation will contribute to the construction of students' understanding and understanding of chemical phenomena. Therefore, this is quite basic and important to plan for in chemistry learning because students have relatively different levels of ability and visualization of understanding (Darmiyanti et al., 2017). However, the microscopic level is often ignored (Upahi & Ramnarain, 2019; Rahmawati et al., 2022). Even if studied, this level is studied separately in certain materials, such as only in the form of molecules (Nastiti et al., 2012). The results of the study also show that students have difficulty in solving chemical problems because they are unable to connect the three levels of chemical representation, which causes students to memorize continuously during the learning process, this memorization can be an obstacle to meaningful learning (A'yun et al., 2018; Li & Arshad, 2014).

Based on the characteristics of chemistry concepts that involve understanding multiple representations, it is important to analyze student conceptions that include multiple representations, namely macroscopic, microscopic, and symbolic. A three-tier diagnostic test can be done to assess students' conceptions. Three-tier diagnostic tests can identify students' conceptions more specifically than two-tier diagnostic tests because teachers can find out the concepts that have been understood, misconceptions, and concepts that students do not know (Laksono, 2020; Nahadi et al., 2015; Siswaningsih et al., 2019). In the three-tier test, the first tier is the question, the second is the reason, and the third is the confidence level (Siswaningsih et al., 2019). To discover students' conceptions of various types of representations, the questions given in the first tier are presented with macroscopic, microscopic, or symbolic representations according to the characteristics of the concept in question.

In previous studies, three-tier tests only involved symbolic or macroscopic representations. They showed that each level in multiple representations was not used equally in preparing tests to analyse conceptions in chemistry lessons (Yunitasari, 2019). Thus, it is necessary to analyse the extent of students' conceptions of reaction rate with the multi-representations. This study aims to analyse students' conceptions of reaction rate topics using the three-tier multi-representation test.

Methods

This research uses the descriptive quantitative method, a design that analyzes data in numbers and describes the conditions by explaining the findings obtained during the research. It was conducted at Madrasah Aliyah Negeri 2 in Palu City, Central Sulawesi. The subjects of this study were 50 students, consisting of 28 female students and 22 male students. The subjects were determined by random sampling.

This study used a three-tier representation test with 15 multiple-choice questions. The first level was the answer choices, followed by reasons for selecting answers at the second level, and the third level was the confidence level in choosing answers. The questions were designed to include macroscopic, submicroscopic, and symbolic representations in the questions and/or answer choices. Validation of the item instrument showed that the questions were feasible and fell into the high category. To analyze student conceptions, we use the guidelines (Hasyim et al., 2019). The percentage of each concept category then includes whether it is a high, medium, or low level based on the category of conception level.

Results and Discussion

This study aims to examine how students' conception of reaction rate material through the Three Tier Multi Representation Test after the learning process in the classroom occurred. Conception is a person's interpretation of a particular concept within the framework already in his mind, and every new concept is obtained and processed with the concepts he already has (Faizah, 2016). The research involved analyzing student answers and categorizing them based on their understanding of the concept: those who know it, those who have misconceptions, and those who do not know it. The results can be found in **Table 1.**

Table 1. Students' conception

Concept	Question No	Conception Category					
		Know the concept		Misconception		Not Knowing the concept.	
		∑	%	∑	%	∑	%
Reaction Rate	1	18	36	17	34	15	30
	3	17	34	18	36	15	30
Reaction rate equation	5	15	30	23	40	12	24
	9	13	26	24	48	13	26
	11	12	24	18	36	20	40
Factors affecting reaction rate	10	14	28	21	42	15	30
	12	14	28	23	46	13	26
	13	11	22	19	38	20	40
	14	22	44	18	36	10	20
	15	16	32	19	38	15	30
Collision theory	2	13	26	22	44	15	30
	4	18	36	17	34	15	30
	7	17	34	20	40	13	26
	8	13	26	21	42	16	32
	6	10	20	20	40	20	40
Average			29		40		31

Based on **Table 1.** Students who fall into the category know the concept as much as 29 % is considered low, students' misconceptions as much as 40 % is considered medium, and in the same manner, students do not know the concept as much as 31 % is considered medium. Students' conceptions were also analyzed for each representation: macroscopic, microscopic, and symbolic. Students' conceptions of each representation are shown in **Figure 1.**

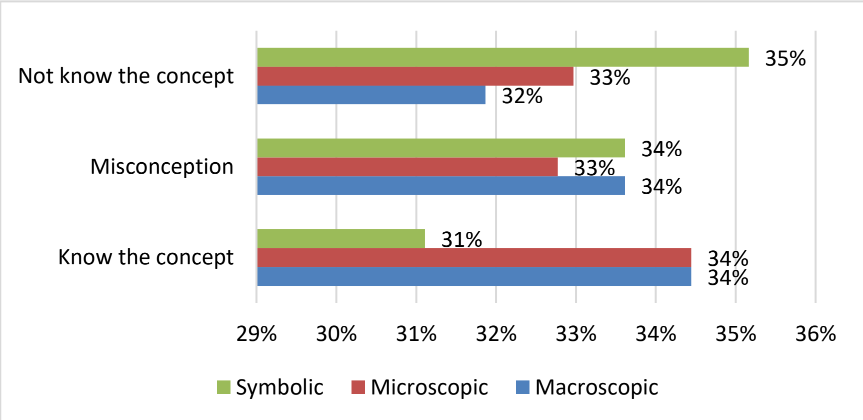

Figure 1. Students conception by representation type

Based on **Figure 1.** symbolic representation is the most significant type of representation that students, namely 35 %, do not understand. In students who have misconceptions, symbolic and macroscopic representations are the most misconceptions at 34 %.

Category 1: Know the concept

The percentage of students knowing the concept is 29 %, with the highest ability of students to understand the concept in macroscopic representation (**Figure 1**). When questions are presented with macroscopic representations, students find it easier to understand problems and chemical concepts. These representations exist concretely, and students can observe chemical phenomena or facts through experiments or everyday life. As an illustration, students may be prompted to describe the concept using food storage technology while learning about reaction rates. The technology used to explain the rate of reaction is uncomplicated and familiar to students, such as freezing and salting fish.

While the lowest representation in this category is symbolic representation, chemical representations at the symbolic level include pictures, algebra, physical models, chemical formulas, reaction equations, graphs, and reaction mechanisms (Desyana, 2014). For example, in the concept of reaction rate, experimental data are presented using chemical and mathematical symbols, and then students are asked to interpret the experiment results. The results showed that the student's abilities were not good in this section. This also occurred in other findings (Sari & Helsy, 2018), which showed that in symbolic representations, students tended to be less thorough in understanding the meaning of units and number presentations in the experimental data set.

Category 2: Misconception

In these findings, misconceptions occur when students answer the first-tier test incorrectly, but by chance, the reasons expressed are correct, and the student is confident in their choice. In this case, misconception often occurs about factors that influence reaction rates in macroscopic representation. In **Figure 2.** students are presented with the activity of a firewood logger cutting wood into small pieces. They are then asked to explain the reasons for cutting firewood into small pieces from the perspective of factors that affect the reaction rate, in this case, combustion. However, most students mistakenly believe that concentration plays a role in this phenomenon when the surface area of the wood is getting more prominent, causing the combustion process to occur faster.

10. Seorang Bapak penebang kayu sedang memotong kayu bakar yang akan digunakan sebagai bahan bakar memasak. Kayu dipotong menjadi lebih kecil oleh penebang kayu. Aktivitas yang dilakukan penebang kayu memanfaatkan konsep tentang salah satu faktor laju reaksi yaitu…

Figure 2. Examples of macroscopic representation problems

This misconception arises because students confuse concentration with the amount of firewood. They mistakenly assume that the chance of a fire burning firewood is more significant if the wood is small and there is a lot of it. However, they fail to see that, in this case, the wood's surface area is responsible for the faster combustion process. On the other hand, concentration expresses the amount of solute dissolved in a solvent unit and is unrelated to the amount of wood. This misconception occurs because students do not clearly understand concepts related to concentration and surface area. These chemical concepts are interrelated, and if students do not fully understand the concept of concentration, misconceptions can arise, making it difficult to distinguish between concentration and surface area. To avoid misconceptions, students must correctly understand the meaning intended in chemical chemistry concepts, including concentration (Reina et al., 2022).

Other than that, misconceptions occur when students answer questions and reasoning incorrectly but are confident that their answers and reasoning are correct. This misconception is most observed in collision theory with symbolic representations. In this case, students are presented with experimental data that uses symbols and numbers to illustrate how the reaction time changes with variations in concentration and temperature. They are then asked to predict where more effective collisions occur under different concentration and temperature conditions. In the experimental data, substance A, with the same weight but in a different form, namely powdered and pieces, is added to solution B with the same concentration. Then, students were asked to predict which reaction was faster between substance A powder and substance A pieces regarding the possibility of a practical collision. Because the weight of substance A is the same and the concentration of substance B is the same, students predict that the effective collisions that occur are the same and the speed is also the same. Even though, in this case, the surface area also affects the probability of a practical collision. This also shows that students cannot distinguish between concentration and surface area.

Category 3: Not knowing the concept

The percentage of students who fall into the category of not understanding the concept is 31 %. Students who do not understand the concepts are seen in reaction rate equations with symbolic representation, the concept of factors that influence reaction rates with macroscopic representation, and the concept of collision theory with symbolic representation. In the concept of reaction rate equations with symbolic representation, students are asked to predict the increase in reaction rate if the temperature is increased based on existing data. To predict an increase in reaction rate, students must be able to state the rate equation based on the data provided and perform mathematical operations based on the rate equation derived from the data.

From the overall results of the Three-tier tests, students who did not know the concept were more significant than those who knew the concepts, and there is a misconception about the concept rate of reaction. Of the four concepts tested, the highest misconception is the concept of factors that affect the reaction rate, with a conception percentage value of 44 %. The research results are the same (Qodriyah et al., 2020). The material on the factors that affect the reaction rate has a higher percentage of misconceptions than other sub-materials. This can happen because students have difficulty understanding the concept because of its relationship with previous concepts, such as concentration. Overall, these findings showed that teachers should pay attention to students' prior knowledge by doing a pre-assessment that can diagnose students' state of knowledge related to the topic they will learn. With this result, the teacher can give a short explanation to remind them of concepts related to reaction rates.

Conclusions

The conceptions of students analysed using a valid instrument on the reaction rate material showed that students with the category know the concept as much as 29 % fall into low category, students' misconceptions as much as 40 % fall into medium category, and students do not know the concept as much as 31 % which is also medium category. Symbolic representation is the most significant representation that students, namely 35 %, do not understand. In students who have misconceptions, symbolic and macroscopic representations are the most misconceptions at 34 %.

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