Students' Representation Ability in Chemistry

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Abstract

This study aimed to determine the representation ability of students in learning chemistry. The ability of representation consists of three levels, namely macroscopic level, submicroscopic level, and symbolic level. This study was a descriptive study. The subjects in this study were 53 XI grade students. The study instrument was in the form of a description test compiled based on indicators of representation ability. The results showed that the average score of students' representation ability at the macroscopic level is 66.94, and is in the good category. The average score of students' representation ability at the submicroscopic level is 47.17, and is in the medium category. The average score of students' representation ability at the symbolic level is 64.30, and is in the good category.

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1. Introduction

Chemistry is a branch of natural science that deals principally with the properties of substances which are very useful and relates to phenomena in our daily life [1]. All matter is made up of a large number of molecules called material, so it can be learned by understanding the concepts of chemistry. Incorrect understanding of concepts will affect other interrelated concepts. Therefore, understanding the correct concept of chemistry is considered important, because it will make it easier for us to study chemistry that has various characteristics [2].

Chemical material mostly has abstract characteristics [3]. Kean and MidleCamp in cite [2] described that the characteristics of chemistry include: (1) chemistry is largely considered as abstract material; (2) the chemistry material being studied is a simplification of the truth; (3) the chemistry materials are sequential and develop rapidly; (4) the chemistry material do not just solve problems, and (5) studying chemistry requires a lot of burden. The chemistry material also involve complex calculations, language that is rarely used in everyday life, and differences in the ability of representations to explain phenomena in chemistry [4].

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Chemistry is indeed a tough subject referring to those chemistry characteristics for most students. Students are not able to study chemistry because they have difficulty constructing the basis of chemical concepts. Most of them memorize symbols on a system without knowing the working principle of the system [5].

Chemistry can be understood by involving the ability of representation in learning which includes macroscopic representation, submicroscopic representation, and symbolic representation [6]. Macroscopic representation is related to abstract phenomena or can be observed through experience and is found in everyday life [1]. Macroscopic representation can be obtained through real experience observed by the senses, it can also be in the form of daily experiences such as color changes that occur in a chemical reaction [7]. Apart from experience, macroscopic level is logically acceptable and reasonable [8]. An explanation of how the symptoms of solid salts can dissolve in water is also a form of macroscopic representation [9]. The melting of ice cream and the rusting of iron are also forms of macroscopic ability [10].

Sub-microscopic level is related to phenomena in chemistry that can neither be seen nor directly visualised, and if the components can be accepted as true and real, it depends on the atomic theory of matter [11]. This microscopic representation is a depiction of original microscopic particles such as electrons, molecules, and atoms which cannot be observed directly [2]. To explain the phenomena observed by students at the macroscopic level, chemists can use the submicroscopic level by developing students' understanding through an explanation of concepts from atomic and molecular models. As an example in the case of iron rusting, chemical processes occur between iron and oxygen molecules in the air to form iron oxide [10]. Several studies have shown that this submicroscopic level is a level considered difficult by students who are just learning chemistry [12]. Students' understanding at this microscopic level tends to be left behind and can cause students to experience difficulties in developing concepts so as to cause students to misunderstand the concepts [13].

Symbolic levels describe phenomena in chemical matter that can be in the form of chemical equations, mathematical equations, graphs, reaction mechanisms, and analogies [14]. Symbolic representations in chemistry emphasize the depiction of chemical phenomena that can be presented with a variety of media such as models, images, algebra, and computational forms [15]. Symbolic representations can also be made to strengthen chemical understanding that starts with macroscopic and microscopic representations. In symbolic representation, students can translate phenomena and reactions that occur in the iron rusting process using chemical equations [10].

Farida [16] explicitly outlined indicators of the ability of representation in chemistry. Indicators of macroscopic level representation ability consist of: (1) composing a real observation of a phenomenon that can be seen and responded to by the five senses, (2) using the students' daily experience contextually, (3) representing the results of observations in the form of representation mode. Indicator of submicroscopic level representation ability is to present images about the structure and processes at the particle level to the observed macroscopic phenomena. Indicators of symbolic level representation capabilities include: (1) presenting words, static images, dynamic images (animation) or simulations, (2) writing data, chemical formulas, diagrams, pictures, reaction equations, stoichiometry, and mathematical calculations.

The three levels of representation in chemistry must be understood by students in a balanced way, so that students have a complete and correct understanding of chemistry [17]. Because of the importance of the level of representation in chemistry, researchers are interested in knowing the level of representation in students.

Chemical equilibrium material is one of the basic subjects in chemistry, because this material is related to other chemical materials such as solubility, electrochemistry, and acid-base [18]. Chemical equilibrium material is also an essential part of learning chemistry because this material is the basis in studying advanced chemistry such as solution equilibrium, phase equilibrium, and electrolysis equilibrium reactions [19].
Chemical equilibrium material is difficult material for students, because most of the concepts are abstract as in the concept of equilibrium and shift in equilibrium [20]. Difficulties experienced by students in understanding the concept of chemical equilibrium are also caused by the low ability of students to connect three levels of representation [20].

One material in chemistry that contains three levels of representation is the chemical equilibrium material. Macroscopic level in equilibrium can be in the form of the concept of color changes in combustion reactions and condensation events when heating water which is the application of the principle of Le Chatelier. Submicroscopic level in chemical equilibrium can be in the form of molecular images of substances at the beginning of a reaction and at equilibrium. Symbolic level can be in the form of writing equilibrium reaction equations. To study chemistry that is abstract and related to the level of representation, some teacher roles are needed in learning [2]. The role of the teacher can be done by making teaching aids [15], also by implementing learning strategies that are appropriate to the characteristics of students [21]. As a first step in planning and determining the strategies and teaching aids used in learning, an initial description of students' abilities in chemistry learning is needed, especially in chemical equilibrium material that illustrates the levels of their presentation.

2. Methods

This study was a descriptive study that describes the levels of students' presentations on chemical equilibrium material. The subjects in this study were XI grade students at SMK Negeri 4 Takalar consisting of 53 students. The instruments in this study consisted of macroscopic, submicroscopic, and symbolic level understanding tests. The tests were made in the form of description, consisting of 6 test items arranged based on indicators of representation ability. Data analysis technique used in this study was descriptive analysis techniques to obtain conclusions about the ability of students to solve problems at the macroscopic, submicroscopic, and symbolic levels on chemical equilibrium material.

3. Results and Discussion

3.1. Level of Macroscopic Representation

In this study, the measurement of macroscopic level representation consisted of 3 questions. Based on the results of the descriptive analysis, it was found that the average score of macroscopic abilities of students as a whole was 66.94. Criteria and percentage of students' ability to answer the macroscopic representation problem can be seen in table 1.

Table 1 Analysis of Students' Macroscopic Representation Ability

No.	Category	No. of Students	Percentage (%)
1.	Very less than satisfactory	0	0
2.	Less than satisfactory	7	13.21
3.	Satisfactory	8	15. 09
4.	Good	18	33. 96
5.	Very Good	20	3774

Based on the data in Table 1, there were 7 students having the representation ability in the less than satisfactory category with a percentage of 13.21%, 8 people in the satisfactory category with a percentage of 15.09%, 18 people in the good category with a percentage of 33.96%, and 20 people in the very good category with a percentage of 37.74%.

Analysis of students' macroscopic representation ability was also carried out for each indicator measured. There were 3 indicators to measure the ability of macroscopic representation. The completeness analysis of each indicator of macroscopic level representation ability can be seen in table 2.

The first indicator is the ability of students to observe the real state of phenomena that can be seen and sensed. In this problem a picture was presented about the process of burning wood and then students were asked to give statements or conclusions about the reactions that occur based on the phenomenon of burning wood. In this indicator, students who answered completely was amounted to 50 people from 53 students, with a percentage of 94.33%. According to Arikunto [22], this percentage is in the very good category. The large number of students who complete in answering questions on the first macroscopic representation indicator shows that students are able to observe through their

senses the phenomena in everyday life that can be seen and linked to chemical equilibrium material that has been studied in school.

The second indicator measured in macroscopic representation is the ability of students to use contextual day-to-day experiences. To measure this indicator, questions were given containing questions about students' experiences in heating water, when the water is heated, it will reach the point of condensation into water vapor. Through this phenomenon, students were asked to relate it to the Le Chatelier principle. Based on these questions, there were only 7 students who answered the questions completely with a percentage of 13.21%. This percentage is in the very less than satisfactory category.

Based on these results, it was found that students as a whole have not been able to relate the phenomena that are found based on daily experience, if they are contextually related to the Le Chatelier principle described in the equilibrium material.

The third indicator measured in macroscopic representation is the ability of students to represent observations in the form of representation mode. To measure this indicator, problems were presented in the form of observations containing data on the amount of ammonia produced based on changes in temperature and pressure, then students were asked to describe the data contained in these observations into the concept of equilibrium. Based on the students answers, it was obtained that there were 25 people out of 53 students who were able to answer questions completely with a percentage of 47.17%. This percentage is in the moderate category. Based on these results, it was found that students are quite capable in analyzing and describing observational data.

Table 2 Completeness Analysis of Students' Macroscopic Representation Ability Indicators.

Macroscopic Level Representation Problem Indicator	No. Questions	Number of students who answered completely	Percentage (%)	Category
Compile a real observation of a phenomenon that can be seen and perceived by the five senses, for example: changes in color, temperature, pH, gas formation and sediment that can be directly observed or can be interpreted by the senses.	1	50	94,33	Very good
Use the students' everyday experience contextually.	2	7	13,21	Very less than satisfactory
Represent the results of observations in the form of representation modes such as written reports, discussions, oral presentations, venn diagrams, graphs and so on.	3	25	47,17	Moderate

3.2. Level of Submicroscopic Representation

Measurement of submicroscopic level representation was conducted by using 1 problem, based on the results of descriptive analysis, it was obtained an overall student average score of 47.17. Criteria and percentage of students' ability to answer submicroscopic representation questions can be seen in table 3.

Based on the data in Table 3, there were 20 students who had the representation ability in the very less than satisfactory category with a percentage of 37.74%, 16 people in the satisfactory category with a percentage of 30.19%, and 17 people in the very good category with a percentage of 32.07%.

Table 3 Analysis of Students' Submicroscopic Representation Ability

No.	Category	No. of Students	Percentage (%)

1.	Very less than satisfactory	20	37.74
2.	Less than satisfactory	0	0
3.	Satisfactory	16	30. 19
4.	Good	0	0
5.	Very Good	17	32.07

The ability of submicroscopic representation is measured by giving questions to students by presenting a picture about the state of N_2O_4 and NO_2 substances, then students were asked to draw particles of substances at the beginning of the reaction and after the equilibrium reaction occurs. In this indicator, only 17 students answered completely out of 53 students, with a percentage of 32.07%. According to Arikunto [22], this percentage is in the less than satisfactory category. The results of the analysis of these data indicated that the ability of students to describe particles of substances at the beginning of the reaction and after the equilibrium reaction is still lacking. Students were still not capable in observing the picture features of the presented substances. Furthermore, the results of completeness analysis of submicroscopic level representation ability indicator can be seen in table 4.

Table 4 Analysis of students' Submicroscopic Representation Ability Completeness Indicators.

Submicroscopic Representation Problem Indicator	No. Questions	Number of students who answered completely	Percentage (%)	Category
Presents images of the structure and processes at the particle level to the observed macroscopic phenomenon.	4	17	32,07	Less than satisfactory

3.3. Level of Symbolic Representation

The symbolic representation level measurement test in this study consisted of two questions. Based on the results of the descriptive analysis, it was found that the average score of the symbolic abilities of students as a whole was 64.30. Criteria and percentage of students' ability to answer questions about symbolic representation can be seen in table 5.

Table 5 Analysis of Students' Symbolic Representation Ability

No.	Category	No. of Students	Percentage (%)
1.	Very less than satisfactory	12	22.64
2.	Less than satisfactory	1	1.89
3.	Satisfactory	9	16.98
4.	Good	11	20.75
5.	Very Good	20	37.74

Based on the data in Table 5, there were 12 students who had the representation ability in the very less than satisfactory category with a percentage of 22.64%, 1 person in the less than satisfactory category with a percentage of 1.89%, 9 people in the satisfactory category with a percentage of 16.98%, and 11 people in the good category with a percentage of 20.75%. 20 students in the very category with a percentage of 37.74%.

Analysis of students' symbolic representation abilities was also carried out for each indicator measured. There were two indicators to measure the ability of symbolic representation. The first indicator was presents words, static images, dynamic images (animation) or simulations. In this problem, the questions were presented in the form of sentences and the reaction processes that occur, namely homogeneous or heterogeneous, then students were asked to write the reaction equation of the sentence. On this indicator, students who answered completely were amounted to 40 people from 53 students, with a percentage of 75.47%. According to Arikunto [22] this percentage is in the good category. The percentage amount showed that students are capable of presenting words into reaction symbols.

Table 6 Indicator Analysis of the Students' Symbolic Representation Ability

Symbolic Level Representation Problem Indicator	No. Questions	Number of students who answered completely	Percentage (%)	Category

Presenting words, static images, dynamic images (animation) or simulations.	5	40	75,47	Baik
Writing data, chemical formulas, diagrams, pictures, reaction equations, stoichiometry and mathematical calculations.	6	20	37,74	Kurang

The second indicator measured in symbolic representation was the ability of students in writing data, chemical formulas, diagrams, pictures, reaction equations, stoichiometry and mathematical calculations. To measure this indicator, a problem that was presented contained a mathematical calculation of the relationship of Kc and Kp. Through these problems, students were asked to analyze by calculating the value of Kc and Kp. Based on these questions, there were only 20 students who answered the questions completely with a percentage of 37.74%. These percentages indicated that the ability of students to write data to do mathematical calculations respectively is still lacking. The results of the completeness analysis of each indicator of the symbolic level representation ability can be seen in Table 6.

4. Conclusion

The results showed that the average score of students' representation ability at the macroscopic level is 66.94, and is in the good category. The average score of students' representation ability at the submicroscopic level is 47.17, and is in the medium category. The average score of students' representation ability at the symbolic level is 64.30, and is in the good category.

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