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Identification of Misconceptions on Buffer Material Using Three-Tier Test in the Learning of Multiple Representation

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Abstract

This research was a mixed method with the design of sequential explanatory strategy. This research aims to identify student misconception on buffer solution material and obtain student response to multiple representation-chemoentrepreneurship (entrepreneurship in the chemistry field) teaching materials. Research subjects were 114 students from grade XI MIPA 3, XI MIPA 4, and XI MIPA 5 SMA Negeri 12 Semarang academic year 2017/2018. Three-tier multiple choice diagnostic test obtained from the research data amounted to 20 items, questionnaire to know the student's response to teaching materials, and interview to confirm student's answer. The result of the validation of teaching materials by three validators shows that the teaching materials of multiple representation-chemoentrepreneurship are very suitable to be used in chemistry learning with an average score of 190.33 from 212. The average score of the questionnaire is 28,026 with proper category and reliability of 0.906. The misconception profile obtained is the definition and the properties of the buffer solution 3.421%; the components of buffer solution 2.149%; working principle 2.632%; pH of buffer solution 3.596%; and the role of buffer solution 0.965% with a total misconception 12.763%.

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INTRODUCTION

Improving the quality of education can not be separated from the quality of learning activities. One of the critical factors in learning activities is the understanding of concepts. Understanding concepts are essential for students. Understanding the concept as a whole can improve the learning objective is to connect the subject matter problems with real-world problems. Another advantage gained is the ability to describe abstract and unfamiliar concepts in real conditions. Understanding concepts based on fundamental knowledge alone will result in an understanding that can be true or false. The new concept will be difficult to understand if students cannot connect previously owned concepts with new concepts (Irsyad et al., 2018).

Chemistry is highly conceptual and abstract concept (Kirik & Boz, 2012). Abstract chemical objects, filled with symbols or symbols of atoms and molecules, chemical formulas, molecular formulas, structural formulas, laws, rules, and chemical principles make chemistry difficult for students to learn. Students who have difficulty understanding the concept will make their interpretations of the concepts studied (Sendur et al., 2010). Therefore, it will influence the emergence of misconceptions.

Misconceptions are an understanding of student concepts that conflict with a scientific concept influenced by student experience (Kirbulut & Geban, 2014). The misconceptions experienced by students will disturb the acceptance of new concepts and are feared to inhibit the formation of knowledge on students' cognitive structures (Mubarak et al., 2016). Therefore, since an early stage, misconceptions must be identified so that teachers can design learning that is capable of overcoming misconceptions. One way to discover misconceptions is by diagnostic testing. The use of diagnostic tests can help teachers find student misconceptions about the teaching material being studied (Lin, 2004). A useful diagnostic test can provide an accurate picture of the misconceptions that students experience based on the error information it generates.

Efforts to prevent the emergence of huge misconception among students by applying and utilizing chemical learning media. Learning media is one means to stimulate student learning activities. One of the potential learning media developed is teaching materials. Components of teaching materials are designed to maximize abstract concepts into macroscopic, submicroscopic, and symbolic aspects. Exciting teaching materials are expected to stimulate students to learn the teaching material.

This research applies multiple representation-chemoentrepreneurship teaching materials on buffer material because the buffer material is abstract and causes misconception. This teaching material links direct learning to the phenomena around us that enable students to learn the process of processing material into a product of economic value, use, and fostering entrepreneurial spirit (Supartono, 2009). Learning with chemoentrepreneurship (entrepreneurship in the chemistry field) approach is not only oriented to the mastery of theory but also oriented to the formation of entrepreneurial interest and establishment of a strong character and never give up in overcoming the problem (Prayitno et al., 2017).

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METHODS

Research conducted using a mixed method research with sequential explanatory strategy design (Creswell, 2010). The following descriptive design was characterized by data collection and quantitative data analysis in the first stage and followed by the collection and analysis of qualitative data in the second stage to reinforce the results of quantitative research conducted in the first stage (Sugiyono, 2013). The subjects of this study were 114 students from class XI MIPA 3, XI MIPA 4, and XI MIPA 5 SMA Negeri 12 Semarang academic year 2017/2018. Sampling technique using purposive sampling.

Quantitative data collection through three-tier multiple choice diagnostic tests

consisting of 20 items. The test contains three levels: the first level in the form of questions about, the second level of choice of answers, and level three is the reason for the answer with an open reason. Students' answers are analyzed to identify misconceptions with the categories seen in Table 1. The percentage of misconceptions on each item was done by the formula:

P = f/N x 100%

Information:

P = percentage of misconception

F = number of students experiencing misconceptions

N = total number of students

The validity of the test instrument was done by expert judgment and reliability method with KR-21 formula. Qualitative data obtained by conducting interviews to support the data misconception and questionnaires. Questionnaires were distribute d to students of class XI MIPA 4 to know the student's response to multiple representation-chemoentrepreneurship teaching materials. The questionnaire validity was done by expert judgment method and reliability with Alpha Cronbach formula.

Table 1. Categories of Understanding of Students

Answer	Reason	Certainty	Description
True	True	Sure	Understanding concept
True	True	Not sure	Less understanding
True	False	Sure	Misconception
True	False	Not sure	Less understanding
False	True	Sure	Misconception
False	True	Not sure	Less understanding
False	False	Sure	Misconception
False	False	Not sure	Do not understand

RESULTS AND DISCUSSION

The study of buffer material materials in this study used multiple representation-chemoentrepreneurship teaching materials arranged by researchers. The teaching materials have been validated by three validators and revised based on validator suggestions. The average score of validation of the validity of the teaching materials is 190,333 of the total score of 212 with a very decent category. Student's response to the instructional material was made by filling out the questionnaire by the students of class XI MIPA 4 and obtained the average score of questionnaire result was 28,026 from total 40 with proper category and reliability 0,906 which means reliable questionnaire for use. Student responses to multiple representation-chemoentrepreneurship teaching materials shown in Figure 1.

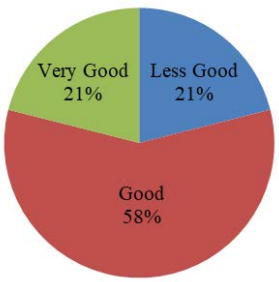

Figure 1. The result of Student Response Questionnaire on Teaching Materials

Based on the results of the interpretation of the combination of student answers, obtained the profile data according to the categories in Table 1. The data in the form of percentage category understanding of student concepts presented in Figure 2.

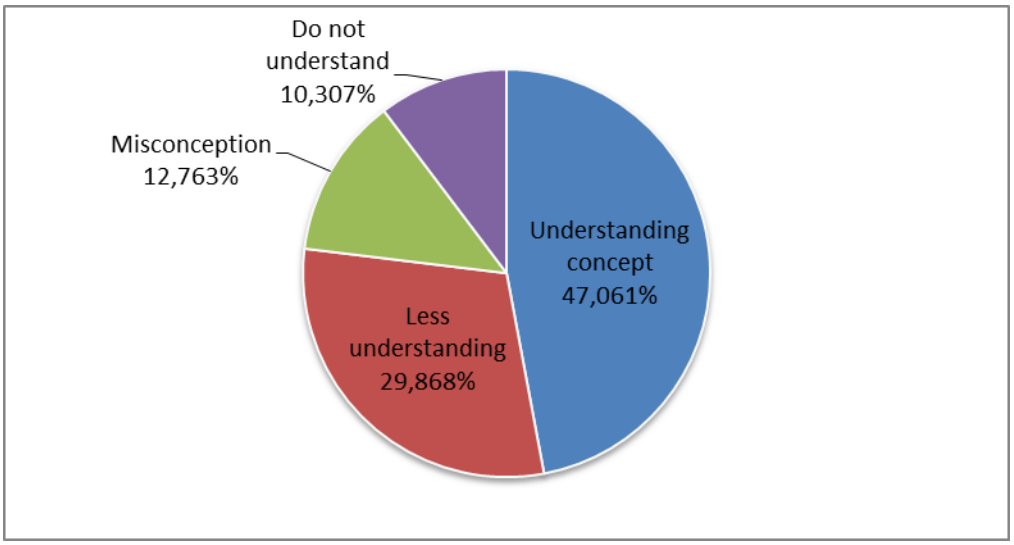

Figure 2. Percentage of Understanding Category of Student Concept

Further misconception analysis was performed to determine the percentage of misconceptions on each concept of buffer solution material and presented in Table 2.

Table 2. Profile Data Misconception On Each Concept of Buffer Solution

No.	Concept	Item	Percentage (%)
1	Definition and the properties of the buffer solution	1,2,3	3,421
2	Components	6,10,12,15	2,149
3	Working principle	7,14,19	2,632
4	pH of buffer	4,5,9,11,16,17,18,20	3,596
5	Role of buffer	8,13	0,965
Total			12,763

The misconceptions experienced by students occur in all concepts of buffer solutions, is the definition and properties of the buffer solution, the buffer solution components, the working principle of the buffer solution, the pH of the buffer solution, and the role of the buffer solution. The percentage of student misconceptions on each item of the buffer solution test shown in Figure 3.

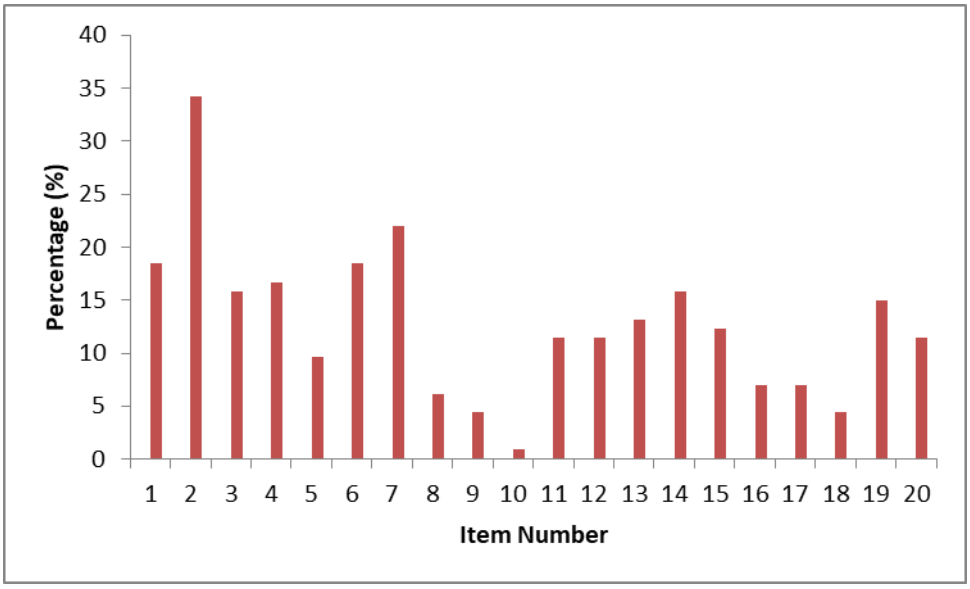

Figure 3. Percentage of Misconception Student Class XI MIPA 3, XI MIPA 4, and XI MIPA 5 SMA Negeri 12 Semarang on the Material of Buffer Solution

Based on the analysis of written test answers and interviews, the main factors causing misconceptions originate from students themselves. Findings on student response patterns indicate that students only memorize not understand concepts. Based on Figure 3, the biggest misconception is on item 2 with the indicator being presented drawing several solutions containing one or more compounds. The student can determine the buffer solution had the largest buffer capacity. The results of students' answers and interviews show that students have not been able to distinguish between conjugate acids and bases because students are accustomed to memorizing the names of weak acids, strong acids, weak bases, and strong acids so that students are less able to distinguish the buffer solution components. Students do not understand the concept that the more mole the buffer component, the greater the ability to maintain the pH (the higher the buffer capacity). Misconceptions also occur because students find it difficult to represent the submicroscopic phenomenon of a chemical reaction displayed in the diagram listed in the problem. Item 11 also shows the result that students assume that NH3 is acidic, so the pH calculation is incorrect. Students assume that NH3 if ionize, produces H+ ions, so it is acidic, according to the student's recitation that the acid always has hydrogen.

Item 7 also has a huge misconception of 21.930%. The indicator of item 7 is to interpret the acid-base titration curve to determine the area which is the buffer zone. Based on the interview results, the ability to read graphic symbols correctly is still low.

Students do practicum twice in learning using multiple representation materials - chemoentrepreneurship. The first practice is to identify the presence of a buffer solution in an isotonic beverage. The macroscopic aspect can be seen from the student observation of the color change of the universal indicator when the solution is added slightly stronger acid, slightly strong base, and diluted and determines the pH of the solution to conclude further whether the solution is a buffer solution or not. The second practice is the manufacture of chemoentrepreneurship products containing buffer solution. Item 8 is adapted from a practice question and got a misconception of 6.140%. Understanding students' concepts can evolve through a series of observational processes or actions performed during practicum (Anggareni et al., 2013). Practicum can reduce the misconceptions that occur because the lab can strengthen the long-term memory of students

regarding macroscopic aspects (Susilaningsih et al., 2018).

The smallest misconception occurs in point 10. The indicator of item 10 determines the equation of the buffer formation reaction of the buffer solution component and the symbolic aspect indicator. Students can write the equation of reaction between a weak acid (citric acid) with strong base NaOH which will produce sodium citrate to form acid buffer solution. This item has the name of the weak acid and strong base so that students have no difficulty in determining the acid and base.

CONCLUSION

Based on the results of research and discussion, it can be concluded that student misconception occurs in all concepts of buffer material. The identified misconceptions are the definition and properties of the buffer solution of 3.421%; buffer component of 2.149%; working principle of 2.632%; pH of buffer solution of 3.596%; and the role of buffer solution of 0.965% with a total misconception of 12.763%.

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