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Misconception Analysis of Buffer Material using Three Tier Multiple Choice Test assisted by CBT for SMAN 9 Semarang

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Abstract

Student learning outcomes are still low. Students have an average score below KKM. KKM is determined by each school. KKM in SMAN 9 Semarang is 70. The low value of KKM is caused by students not yet mastering the prerequisite material acid-base. Based on these data student's misconception need to be analyzed. This study aims to analyze the misconception of buffer material on students. The type of this research is mixed method. The research design used was a sequential explanatory. The research procedure is following the mixed method syntax. The sample in this study were 128 students from SMAN 9 Semarang. Quantitative data were collected using 10 three-tier multiple choice test questions that used the student's reasons and level of confidence. The validation results of the test questions are valid and reliable. Qualitative data was collected by interviewing students. The results showed that students have scientific knowledge 16%, type 1 misconception 19%, type 2 misconception 22%, type 3 misconception 37%, lucky 1%, lack of knowledge type 1 1% concept, lack of knowledge type 2 1% concept, and lack of knowledge type 3 3%.

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INTRODUCTION

Chemistry is an important thing in daily life. Chemistry can be seen everywhere. Water, air, soil contain chemical compounds. Chemistry is also used in medicines to kill viruses and bacteria. Chemistry must be taught to high school students so that they know how to deal with the negative effects of hazardous chemicals. Chemistry is divided into three levels, macroscopic, submicroscopic, and symbolic (Davidowitz *et al.*, 2010; Kelly *et al.,* 2010; Jaber & Boujaoude, 2011; Johnstone, 2010; Talanquer, 2011; Rahayu & Nasrudin, 2014; Smith & Villarreal, 2015; Yahmin *et al.*, 2016; Maratusholihah *et al.*, 2017). Chemistry is a scourge for students (Özbayrak & Arzu, 2011; Muchtar & Harizal, 2012). Chemistry consists of abstract material (Rahayu & Nasrudin, 2014; Maratusholihah *et al.*, 2017; Sen & Yilmaz, 2017; Erman, 2016). Students hard to believe that chemistry really important in our world. Chemistry that is submicroscopic cannot be seen directly by our eyes. Chemistry that is macroscopic can be seen directly. The teacher must guide students to understand chemistry material. A teacher must choose the right method to teach in class.

Students do the learning process anywhere, both at home and at school. This causes students to develop their ideas before school learning takes place (Luoga *et al.*, 2013; Halim *et al.*, 2014; Rahayu & Nasrudin, 2014). The idea of students can come from the environment (Sen & Yilmaz, 2017; Brandriet & Bretz, 2014). Students who have ideas contrary to experts can be categorized as misconceptions (Damanhuri *et al.*, 2016). Students experience misconceptions in various chemical materials (Smith & Nakhleh, 2011; Pabuccu & Geban, 2012; Linenberger & Bretz, 2012; Arellano & Towns, 2014; Dhindsa & Treagust, 2014). Tumay (2016) stated the same thing, many students experienced misconceptions in basic of chemistry. This data also supported by finding misconceptions in buffer solution (Artdej *et al.*, 2010; Sesen & Tarhan, 2011; Orwat *et al.*, 2017). Misconceptions can be caused of several things including: student experience, books, teachers, (Barke *et al.*, 2009; Maratusholihah & Rahayu, 2017), learning journals, ineffective communication (Gudyanga & Madambi, 2014), lab activities (Brandriet & Bretz, 2014), and material complexity (Erman, 2016).

Buffer is material that is given after acids and bases. These materials are microscopic. These materials cannot be seen directly by our eye. Students only can imagine in their minds. Students need great effort to study buffers because buffer material is related to acid-base material. Students who do not understand acid and base material will make their own theories about buffers. The theory of students who are different from experts can be categorized the students experience misconceptions. Buffer solutions can be acidic or basic. Buffer solutions can be made by reacting strong acids that are out of reaction and weak bases. An example of an acid buffer solution is a mixture of CH_3COOH and CH_3COONa solutions, and a base buffer solution is NH_4OH and NH_4Cl. The acid buffer solution has a pH below 7, and a base buffer solution has a pH above 7. The most important thing about buffer solution is when added a little strong acid, strong base, and water, the pH of the solution is relatively unchanged. Buffer solutions can be found in the human body. Carbonic acid and hydrogen bicarbonate in the human body keep the pH close to 7.4. Another example of buffer solution in daily life is eye drops. Eye drops contain citric and phosphate acid to protect the chemical bonds between eye drops and keep eye drops from having a pH when we use them.

METHODS

The study was conducted at SMAN 9 Semarang. XII IPA 2 is the class used for the trial class consisting of 28 students. The research subjects were 128 students of class XI IPA 4, XI IPA 5, XI IPA 6, and XI IPA 7.

This study was conducted using mixed method. The design used in the study is sequential explanatory. The first phase is collecting and analyzing of quantitative data, followed by the collecting and analyzing of qualitative data (Creswell, 2014). The steps in the sequential explanatory research design can be seen in Figure 1.

Figure 1. Sequential Explanatory Design

The data collection consists of test methods, and interviews. The test was conducted to obtain quantitative data through trial tests and three-tier multiple choice test diagnostic tests. The trial test was conducted in class XII IPA 2 which consisted of 28 students. Tests are carried out on students who have received buffer material. The trial test results were analyzed. The tests categorized as valid and reliable. The results of the subsequent analysis were used to carry out the three-tier multiple-choice diagnostic test on 128 students of class XI IPA 4, XI IPA 5, XI IPA 6, and XI IPA 7. Interviews were conducted and used as qualitative data. Interviews are also used as supporting data to strengthen test results. Based on the results of tests and interviews, it can be determined the level of understanding and misconceptions that occur in students.

Data analysis includes content validity, item validity, reliability, difficulty index, power difference, and misconception analysis. Expert validity is done by discussing the instruments used for research, with 2 UNNES lecturers and 1 chemistry teacher at SMAN 9 Semarang. A total of 18 questions were categorized as invalid, and 22 questions were categorized as valid. 20 questions were taken which included 10 hydrolysis questions and 10 buffer questions. The reliability of the question is obtained at 0.862, so the question can be classified as reliable. Based on the index of difficulty 1 question is categorized as easy, 15 questions are medium, and 24 questions are difficult. Different power questions obtained 2 questions including very good categories, 27 good questions, 4 questions are enough, 4 questions are bad, and 3 questions are very bad. The results of the problem test are improved based on suggestions from the validator and supervisor so that the instrument is suitable to be used. Student answers can be classified according to Arslan *et al.* (2012) shown in Table 1.

Table 1. An interpretation of the three-tier test misconception

First Tier	Second Tier	Third Tier	Category
Correct	Correct	Certain	Scientific Knowledge
Correct	Incorrect	Certain	Misconception Type 1
Incorrect	Correct	Certain	Misconception Type 2
Incorrect	Incorrect	Certain	Misconception Type 3
Correct	Correct	Uncertain	Lucky
Correct	Incorrect	Uncertain	Lack of Knowledge Type 1
Incorrect	Correct	Uncertain	Lack of Knowledge Type 2
Incorrect	Incorrect	Uncertain	Lack of Knowledge Type 3

RESULTS AND DISCUSSION

Content validity was carried out by two UNNES lecturers and one chemistry teacher. Validation is used to determine the reliability and validity of the instrument. Instruments must be valid and reliable, so it can be used in the study. Instruments were feasible to use based on the results of validation by 2 UNNES lecturers and 1 chemistry teacher at SMAN 9 Semarang.

The validity of the items was calculated by the point-biserial correlation. Test results from 40 questions found 22 questions were valid. 22 questions were taken 10 hydrolysis questions and 10 buffer questions. 10 buffer questions consist of 2 questions IPK 3.12.1, 1 question IPK 3.12.2, 1 question IPK 3.12.3, 3 questions IPK 3.12.4, and 3 questions IPK 3.12.4.

Difficulty index is calculated by comparing the number of students who answered correctly, and who answered incorrectly. Questions that have valid criteria have varying difficulty indices. The difficulty index calculation results can be seen in Table 2.

Table 2. Results of Calculation of Problem Differences

No	Category	Number	Jumlah
1	Very Good	2, 10	2
2	Good	1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 19, 20, 21, 22, 24, 25, 29, 30, 33, 35, 37, 38, 40	27
3	Enough	18 ,23, 31, 36	4
4	Bad	15, 27, 28, 39	4
5	Very Bad	26, 32, 34	3

Reliability in this study calculated using KR-21 formula:

$$\left(\text{——}\right)\left(1 \quad \frac{M(n \quad M)}{}\right)$$

Information:

r_{11} = Reliability KR-21
n = Number of Item
M = Average Score
S_t = Total Variance

The reliability of the questions are 0.862. The questions categorized as reliable. The reliability of the question are very good. The profile of students' misconception about buffer material can be seen in Figure 2.

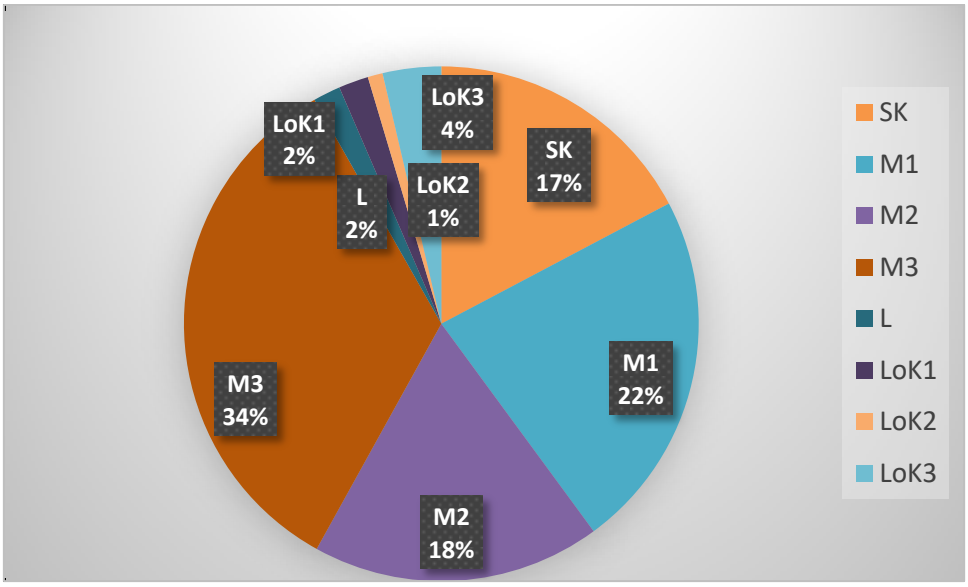

Figure 2. Profile of Students' Misconception on Buffer Material

Based on Figure 2 students profiles on buffer material are conceptual understanding of 16%, type 1 misconception 19%, type 2 misconception 22%, type 3 misconception 37%, lucky (lucky) 1%, not understanding type 1 1% concept, not understanding the concept type 2 1%, and do not understand the concept of type 3 3%. Students who understand the concept are very low under 50%. Overall student misconception is above 50%. The misconception profile of students in each IPK can be seen in Figure 3

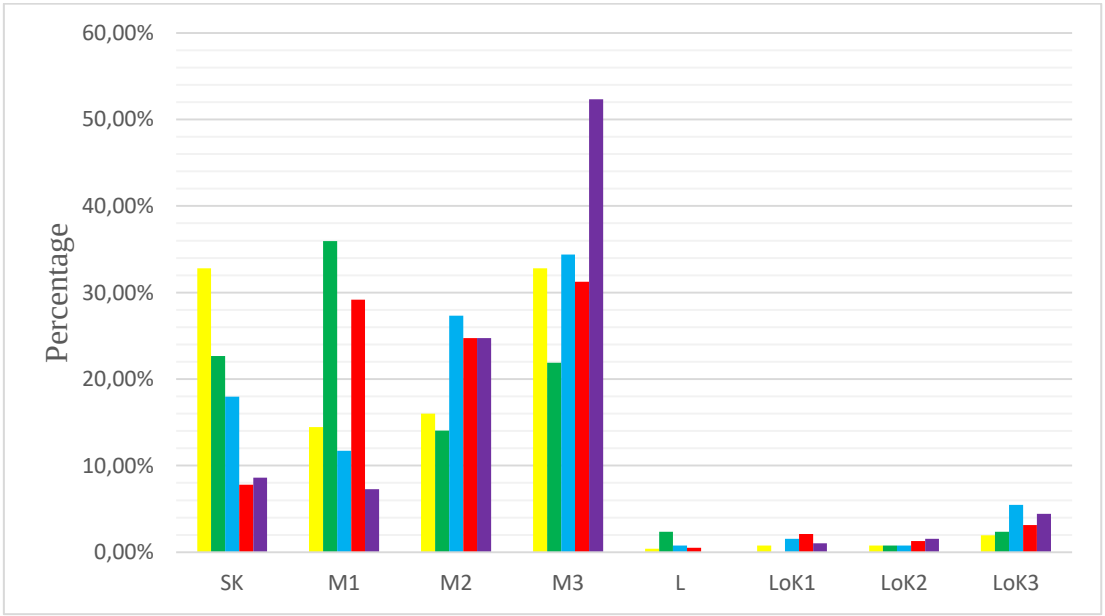

Figure 3. Profile of Students' Misconception on each IPK

IPK 3.12.1 is Identifying the pH of the buffer solution when diluted, plus a little acid or add a little base. The IPK is question number 11, and 12. The number of students who have scientific knowledge is 32.81% of 128 students, misconception type 1 14.45%, misconception type 2 16.01%, misconception type 3 32.81%, lucky 0 , 39%, lack of knowledge type 1 0.78%, lack of knowledge type 2 0.78%, and lack of knowledge type 3 1.95%.

The results of question number 11 are supported by the results of interviews with the Bulan, Ega Selfia, and Arsyad. Bulan choose confidence with her answer in the test. This is different with the interview. In the interview, Bulan can explain the answer. Ega Selfia was classified having misconception. This data supported with the results of the interview. The mixture of HF solution and NaF solution according to Ega will form a salt. There is misconception in here. A mixture of HF and NaF solutions is a mixture of buffer solutions. The buffer can be formed from weak acids/bases with the base/acid conjugate. Arsyad was categorized as lack of misconception. This is in supported by the results of the interview because Arsyad stated that he did not understand not sure about question number 11.

The interesting thing in number 12 is the answer from Ega Selfia dan bulan. Ega Selfia can answer and give reasons correctly so she categorized as having scientific knowledge. The interview results are different compare to the test. Based on the interview Ega was categorized as having misconceptions. Ega answered that the buffer solution can be formed from KOH and HNO_3. Buffer solutions cannot be made from strong acids/bases. Ega thinks HNO_3 is a weak acid. In the test, it was possible for Ega to copy her friends. Bulan was categorized as having misconception according to the test results. This result is different from the the interview. Bulan stated that he did not understand the material in the question. Bulan should choose not confidence with her answer.

IPK 3.12.2 is discussing the role of buffer solutions in living organisms and industry. The IPK 3.12.2 is question number 13. The number of students who have scientific knowledge 22.66% of 128 students, misconception type 1 35.94%, misconception type 2 14.06%, misconception type 3 21.88%, lucky 2.34 %, lack of knowledge type 1 0.00%, lack of knowledge type 2 0.78%, and lack of knowledge type 3 2.34%.

Test results can be supported by the results of interviews conducted on Bulan and Ega Renanda. Bulan said she has understood the material in the interview. Bulan categorized as student who has scientific knowledge. Different from the results of the interview on Ega Renanda. Ega in the interview said that she was not confidence with her answer, but in the test Ega choose confidence with her answer. Ega can be categorized as student who lack of knowledge,but this result is different with the test.

IPK 3.12.3 is analyzing the mechanism of the buffer solution in maintaining its pH against the addition of a little acid, a little base or a little water. The IPK is question number 14. The number of students who have scientific knowledge 17.97% of 128 students, misconception type 1 11.72%, misconception type 2 27.34%, misconception type 3 34.38%, lucky 0.78% , lack of knowledge type 1 1.56%, lack of knowledge type 2 0.78%, and lack of knowledge type 3 5.47%.

Based on the results of interviews on number 14 with Timothy, Feodora, and Ega Renanda there were differences in the test results they had done. They can be categorized as students who have misconceptions. The results is different from the interviews. They stated they were not confident about their answers. Students' confidence determines their misconception profile. Students categorized having misconceptions, if they are confident in their answers, but their answer are incorrect.

IPK 3.12.4 is determining the pH of the buffer solution. The IPK is question number 15, 16, and 17. The number of students who have scientific knowledge 7.81% of 128 students, misconception type 1 29.17%, misconception type 2 24.74%, misconception type 3 31.25%, lucky 0.52%, lack of knowledge type 1 2.08%, lack of knowledge type 2 1.30% and lack of knowledge type 3 3.12%.

The results of test number 15 are supported by the results of interviews with Fransiska and Zidna. Fransiska was categorized as student who has scientific knowledge. This is not different with the results of the interview. Fransiska can explain the formula for calculating buffer solutions in the interview.

Zidna was categorized as students who lack of knowledge from the test. This is different from the interview, which stated that Zidna had understood about number 15. Further interviews were needed to strengthen the data that had been obtained. Based on the results of the interview, Zidna stated that she only understood the concept of solution, but did not understand the formula for calculating the pH of the buffer solution.

Number 16 was supported by the results of interviews with Zidna and Feodora. Zidna was categorized into students who experience misconceptions. This is consistent with the results of the interview that Zidna expressed her understanding and confidence in her answer. The test results of Zidna's answers did not match the answer key.

Feodora is categorized as misconception. The result was different compare to the interview. Feo said in an interview that she was not confidence. Feo answer confidently in the test. Thisproblem need more attention in three tier test study.

The results of test number 17 are supported by the results of interviews with Fuad and Zidna. Fuad stated that he did not understand the material in number 17. This was different compare to the results of the tests. Fuad should choose not confident when doing the test.

Zidna test was categorized into students who lack of knowledge. This is not differnt with the results of the interview. Zidna stated that she forgot about the material. Zidna was not confident about her answer.

IPK 3.12.5 is understanding the explanation of how to make a buffer solution with a certain pH. The IPK is question number 18, 19, and 20. The number of students who have scientific knowledge 8.59% of 128 students, misconception type 1 7.29%, misconception type 2 24.74%, misconception type 3 52.34%, lucky 0.00%, lack of knowledge type 1 1.04%, lack of knowledge type 2 1.56% and lack of knowledge type 3 4.42%. This is consistent with the misconceptions found in the study of Maratusholihah et al. (2017), students experience a misconception in making a buffer solution.

Fuad and Jesica interviwed to support the test result. Fuad said he did not understand the question number 18 during the interview, but answered confidently when he doing the test. Cika cannot explain the reason in the interview but answers confidently when doing the test. Cika and Fuad should choose not confident when doing the test so they can be categorized into students who lack of knowledge. Students remember buffer solutions can be formed from excess weak acids/bases with strong bases/acids. Students only see the concentration of a solution, ignoring the volume of solution. This misconception is the same as the misconception found by Maratusholihah et al. (2017).

The results of the analysis of question number 19 were supported by the interviews with Kendra and Iqbal. Iqbal stated that he did not understand the question number 19 during the interview, but answered confidently when doing the test. Kendra could not give the reason in the interview but answered confidently when doing the test. Iqbal and Kendra should choose not confident when doing the test so they can be categorized into students who lack of knowledge.

Number 20 is the last number in the test. The results of interviews with Kharisma and Jesica were used to support the test results. The results of the Kharisma test and the results of the interviews support each other. Kharisma stated that he understood how to calculate the pH of a buffer solution, but she was not confident answering the question. Kharisma can be categorized into student who lack of knowledge.

Cika test results can be categorized into students who experience misconceptions. The test is different from the results of the interviews. Cika cannot explain the reason for choosing the answer during the test. Cika was not confident then Cika can be categorized into students who lack of knowledge. It was quite surprising in the interview. Cika stated that there were no correct answer in A, B, C, D, and

E. Cika did not read the questions because the choice of reason E could be filled by the students. There is at least 1 correct answer in each question. Each students can choose or make their own answers.

CONCLUSION

Based on the results of the study, it can be stated that the three-tiers multiple-choice test instrument is valid and reliable. Profile of participants in buffer material students have scientific knowledge 16%, misconception type 1 19%, misconception type 2 22%, misconception type 3 37%, lucky 1%, lack of knowledge type 1 1%, lack of knowledge type 2 1 %, and lack of knowledge type 3 3%. Students' misconceptions are very high above 50%. Evaluation is needed to reduce student misconception. Misconception analysis instruments also need to be developed to produce better data.

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