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ANALYSIS OF STUDENT MISCONCEPTIONS IN LEARNING BUFFER SOLUTION MATERIAL USING FOUR-TIER TEST WITH CERTAINTY OF RESPONSE INDEX METHOD

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ABSTRACT

This research aims to identify students' misconceptions about buffer solution material. This type of research uses a descriptive quantitative approach. The subjects in this research were 33 students from one class XI Science at SMA Negeri 1 Girsang Sipangan Bolon using a purposive sampling technique. The data analysis technique uses interpretation of the results of the four-tier diagnostic test with Certainty Response Index. Based on the results of data analysis, it is known that the percentage of misconceptions is 41%, not understanding concepts 32%, and understanding concepts 27%. The misconceptions that occur are in the medium category. The misconception profile for each buffer solution sub-material as follows: definition and properties of buffer solutions 37,6%, components of the buffer solution 42,5%, calculation of the pH value of the buffer solution 44%, and the role of buffer solutions for living things 40,6%. The biggest misconception sub-material is calculation of the pH value of the buffer solution 44%. The smallest misconception sub-material is definition and properties of buffer solutions 37,6%. The results of the research found that there are still many students who experience misconceptions, so further research needs to be carried out to identify student misconceptions in other materials.

Keywords: misconceptions; four-tier diagnostic test; certainty of response index; and buffer solution

INTRODUCTION

Learning is carried out between students and educators in an effort to convey and receive knowledge using various learning methods and resources so that the learning process can be carried out efficiently and effectively in achieving learning goals. The success of a lesson is seen in the achievement of the learning objectives that have been set. Learning itself creates interaction between the teacher and students in order to achieve the learning objectives that have been set, where the teacher conveys information in the form of knowledge to students, and students are expected to understand and master the material that has been presented by the teacher (Mediartika & Aznam, 2018). In learning, there are often problems between teachers and students. Students in the learning process have a basis for building understanding based on their own concepts; this also often happens in chemistry learning in high school. As the constructivist philosophy points out, knowledge is built by students themselves with the help of teachers (Bayuni et al., 2018). The teacher teaches learning material, and students understand the material presented according to their own abilities.

Chemistry is a science that contains successive and tiered concepts. If students

do not understand the initial concept, then they will have difficulty understanding more complex concepts. Chemistry lessons also contain many abstract concepts (Ekawisudawati et al., 2021). This abstract concept is what makes students have different perceptions of understanding chemical material and consider chemistry to be a difficult lesson to understand (Kustiarini et al., 2019). Difficulties like this result in students having an understanding that is not in accordance with the actual concept or is often referred to as a misconception. (Putri & Laksono, 2022).

Misconceptions can also be interpreted as different understandings, which sometimes may not be in accordance with scientific concepts (Putri & Subekti, 2021). Misconceptions often occur during the learning process. Misconceptions are resistant to change, long-lasting, deeply established in an individual's cognitive ecology, and difficult to eradicate even with training tailored to address them. Misconceptions might arise if the process of assimilation of prior knowledge to learning is not integrated with knowledge gained by pupils in the classroom. Misconceptions are frequently maintained by a rather strong student mindset, which is difficult to change and cure (Bayuni et al., 2018). Therefore, efforts are needed to evaluate whether students have mastered the concepts correctly or not so that misconceptions do not occur continuously. The occurrence of misconceptions has an impact on students' understanding of subsequent material. One of the misconceptions in chemistry learning that occurs among students is the buffer solution material. Buffer solution material is important material, and it is hoped that students will have good mastery of concepts and mathematical skills because buffer solution material contains some prerequisite material for an initial understanding of the concepts of stoichiometry, equilibrium, and the concept of acids and bases. These materials really influence students' understanding of buffer solution learning (Stephanie et al., 2019). Based on the results of an interview conducted with one of the chemistry teachers at SMA Negeri 1 Girsang Sipangan Bolon, at this school there has never been any research on misconceptions in learning. And when the researcher interviewed one of the chemistry teachers, she found that one of the most common materials with misconceptions in learning chemistry in class XI were buffer solution. In buffer solution material, the difficulty experienced by students, which gives rise to misconceptions in this material, is in calculating the pH value of a solution. This may happen because students do not understand the concept of a given compound being categorized as an acid buffer or base buffer, thus causing problems for students in deciding which formula to use to answer the questions asked.

Diagnostic tests can help detect misconceptions. Diagnostic tests are used to assess students' strengths and weaknesses in learning. (Mubarak et al., 2016). There are several types of diagnostic tests, including two-tier, three-tier, and four-tier. The four-tier diagnostic test is a development from three-tier test, where the development is based on the level of confidence in choosing reasons. So, the interpretation of this three-tier diagnostic test can be too low for those who don't understand the concept, and it

can also be too high for those who understand the concept. Until now, it has been impossible to distinguish between students who have misconceptions and those who do not understand the principles presented in the session. If you do not distinguish between the two, it will be difficult to discern the next step because correcting misconceptions is not the same as correcting children who do not understand the concept. Therefore, a three-tier diagnostic test was developed, namely a four-tier diagnostic test assisted by CRI, which consists of: the first tier contains multiple choices consisting of four distractors and one answer key; the second tier contains the level of confidence of students in choosing the answer in The first tier, the third tier, contains students' reasons for answering questions, and the fourth tier is the level of confidence in choosing the reason answer (Diani et al., 2019). The first tier of the four-tier tests is the content tier, and it describes the respondents' knowledge. The second tier assesses the respondent's confidence in his or her response to the content tier. The third tier is the reason, which includes the reasoning behind the answer to the primary inquiry. The fourth layer of confidence asks whether the respondent is confident in his or her response to the third tier (Kiray & Simsek, 2021). Certainty Response Index (CRI) is one way to differentiate between understanding a concept, misunderstanding a concept, and not understanding a concept. CRI is the level of certainty in students' answers to the questions given. The CRI value (0–5) shows the level of confidence in answering the questions given. A CRI value < 2.5 indicates a lack of student confidence in answering questions. The number 0 indicates the lowest level of self-confidence that students have; this shows that students do not understand the concept being stated. The number 5 shows that students' confidence in answering questions is the highest; this shows that students understand the concept being stated (Sadhu et al., 2017).

METHOD

The research method used in this study is descriptive method with a quantitative approach. Quantitative descriptive research is the process of describing, researching, and explaining what is being examined as it is and making conclusions from numerically observable events. The subjects in this research were 33 students from one class XI Science (XI IPA 2) at SMA Negeri 1 Girsang Sipangan Bolon using a purposive sampling technique. The research procedures carried out in this study are divided into 3 stages, namely the preparation stage, implementation stage and final stage which are described in the following figure 1.

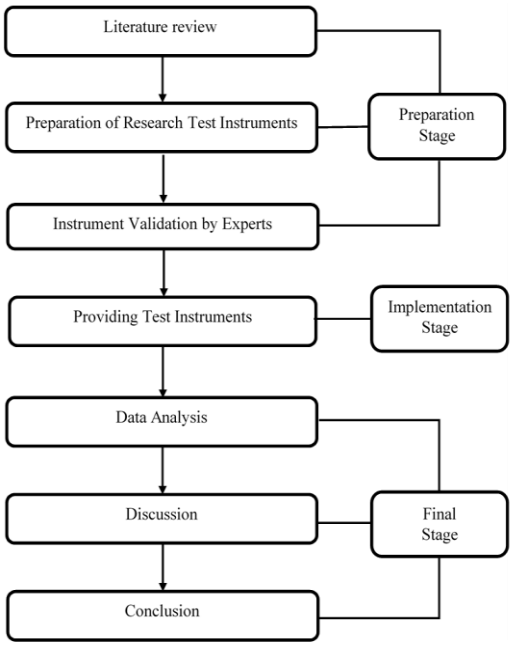

Figure 1. Research Procedure Schema

The research instrument used in this study is a multiple-choice test with four tiers, often known as a four-tier multiple-choice test with the Certainty Response Index used to determine the level of confidence in answering the question. The data collection techniques in this research are four-tier test with certainty of response index question and interview.

The four-tier diagnostic test interpretation guidelines used were adopted from the research of Fariyani et al., (2016) which are described in the following table 1. and the CRI criteria can be seen in table 2.

Table 1. Interpretation of Four Tier Diagnostic Test Results

Response	Confidence Response	Reason	Confidence Reason	Criteria
Correct	High	Correct	High	Understand
Correct	Low	Correct	Low	Not understand
Correct	High	Correct	Low	Not understand
Correct	Low	Correct	High	Not understand
Correct	Low	Incorrect	Low	Not understand
Incorrect	Low	Correct	Low	Not understand
Incorrect	Low	Incorrect	Low	Not understand
Correct	High	Incorrect	Low	Not understand
Incorrect	Low	Correct	High	Not understand
Correct	Low	Incorrect	High	Misconception
Correct	High	Incorrect	High	Misconception
Incorrect	High	Correct	Low	Misconception
Incorrect	High	Correct	High	Misconception
Incorrect	High	Incorrect	Low	Misconception
Incorrect	Low	Incorrect	High	Misconception
Incorrect	High	Incorrect	High	Misconception

((Fariyani et al., 2016) and (Aini & Silfianah, 2022))

Table 2. CRI Response Scale

Category	Scale	Certainty Level
Totally Guess Answer	0	Low/Not Sure
Almost Guess	1	
Not Sure	2	
Sure	3	High/Certain
Almost Certain	4	
Certain	5	

((Hasan et al., 1999) and (Mukhlisa, 2021)

Student answers based on the criteria of understanding concept, not understanding concept or misconceptions are percentages using the following equation (Djarwo, 2018):

$$\%MK = MK/N \times 100\ \%$$

Information:

MK = Group of students who have misconception

N = The number of students

Percentages based on each criterion of understanding, not understanding or misconceptions can be grouped into several categories in Table 3. below:

Table 3. Categories of Student Understanding Level

Value	Category
0% ≤ MK≤ 20%	Very Low
21% ≤ MK ≤ 40%	Low
41% ≤ MK ≤ 60%	Medium
61% ≤ MK ≤ 80%	High
81% ≤ MK ≤ 100%	Very High

(Djarwo, 2018) and (Rachmadhaniar et al., 2024)

RESULT AND DISCUSSION

Students' Conceptions on Buffer Solution Material

Identification of misconceptions is carried out after obtaining data from misconception trials. The questions used in this research have passed the validity test, reliability test, differential power test, question difficulty level test, and distraction test. Based on the results of the test items, there are 20 questions that will be used by researchers that have met the requirements and represent each sub-chapter indicator for buffer solution material. Based on the results of the Four-Tier with CRI diagnostic test on buffer solution material, it was determined that students' conception levels were grouped into 3 categories, namely Understanding the Concept (PK), Not Understanding the Concept (TPK), and Misconceptions (MK) on each question item. The provisions for categories of students' level of understanding depend on each student's answers at the question level and level of confidence when answering the test instrument given. The results of these conception categories can be seen in Figure 2.

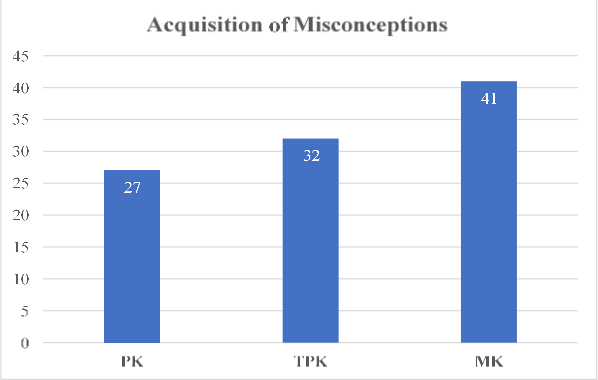

Figure 2. Average percentage from questions item per category

Based on the results of the four-tier diagnostic test on the buffer solution material that had been given to students, the results showed that the percentage of misconceptions among students was greater than those in the categories of understanding the concept and not understanding the concept, which had an average of 41% and was included in the medium category. Meanwhile, the categories of understanding the concept and not understanding the concept, respectively, have an average of 27% and 32%, which are included in the low category. Based on the results obtained, it can be concluded that the majority of students have experienced misconceptions about buffer solution material.

Student Misconceptions on Each Buffer Solution Concept

The data obtained from the Four-Tier with CRI diagnostic test was then interpreted to determine the level of students' misconceptions about each concept in the buffer solution material. The data obtained is interpreted in Figure 3. as follows:

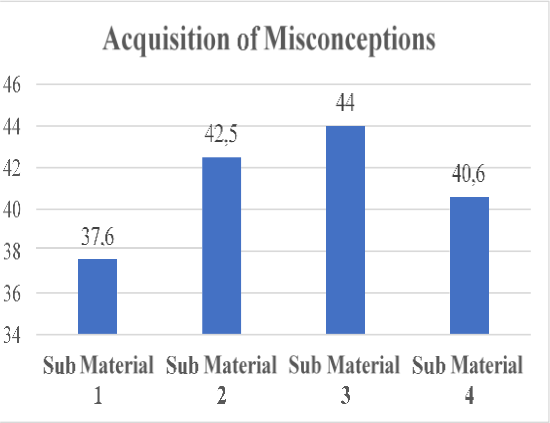

Figure 3. Average misconceptions per sub-material in buffer solution

From the test results obtained, it can be seen that the lowest level of misconception is in the first concept, namely the definition and properties of buffer solution, at 37.6% in the low category. Meanwhile, the highest level of misconception among students is in the third concept, namely the calculation of the pH value of the buffer solution, which is 44% in the medium category. And two concepts in between, namely components of the buffer solution and the role of the buffer solution for living things, amounted to 42.5% and 40.6%, with the second category of these concepts being medium.

Discussion

Definition and properties of buffer solutions

The main topic of discussion in the first indicator regarding the definition and properties of buffer solutions is found in questions 1, 2, 3, 4, and 5. The results of the analysis of student misconceptions found in each question show that the highest percentage of misconceptions is in questions 2 and 4 of 45.5%, at number 5 it is 42.4%, at number 3 it is 39.4%, and the lowest is at number 1 at 15%. The average percentage of student misconceptions found in this concept was 37.6% in the low category. The misconception that occurs in this sub-material are that students know that a buffer solution contains a weak acid and its conjugate base, but to determine which compounds are weak acids, weak bases, conjugate acids, and conjugate bases, students still have difficulty distinguishing one from another and students who forget the principle of buffer solutions: a buffer solution is a solution that can maintain its pH if a small amount of acid, base, or dilution is added.

Components of the buffer solution

The main topic of discussion in the second indicator regarding components of the buffer solution is in questions 6, 7, 8, 9, and 10. The results of the analysis of student misconceptions found in each question show that the highest percentage of misconceptions is in question number 8 at 48.5%. , at number 6 it was 45.5%, at number 10 it was 42.4%, at number 9 it was 39.4%, and the lowest was at number 7 at 36.4%. The average percentage of student misconceptions found in this concept was 42.5% in the medium category. The misconception that occurs in this sub-material are that students still do not understand that the compounds used when mixed will produce acid or base

compounds and are still confused about which compounds act as bases or conjugate acids and students do not understand the mixture of compounds that can form a buffer solution.

Calculation of the pH value of the buffer solution

The main topic of discussion in the third indicator regarding the definition and properties of buffer solutions is found in questions 11, 12, 13, 14, and 15. The results of the analysis of student misconceptions found in each question show that the highest percentage of misconceptions is in questions 12 and 15 of 45.5%; on numbers 11, 13, and 14, it is 42.4%. The average percentage of student misconceptions found in this concept was 44% in the medium category. The misconception that occurs in this sub-material are determining whether the compound being tested is an acidic or basic buffer solution, which influences students' lack of understanding of using the pH calculation formula for buffer solutions, especially when Ka and Kb are calculated.

The role of buffer solutions for living things

The main topic of discussion in the fourth indicator regarding the definition and properties of buffer solutions is found in questions 16, 17, 18, 19, and 20. The results of the analysis of student misconceptions found in each question show that the highest percentage of misconceptions is in question number 20, which is 54.6. %; in numbers 17 and 19, it was 39.4%; in number 18, it was 36.4%; and the lowest was in number 16, at 33.3%. The results of the analysis of student misconceptions found in each question show that the highest percentage of misconceptions is in question number 20, in numbers 17 and 19, in number 18 and the lowest was in number 16. The average percentage of student misconceptions found in this concept was 40.6% in the medium category. The misconception that occurs in this sub-material is students are confused about determining compounds that play a role in maintaining the pH of extracellular fluids in the human body. Which should be the carbonate buffer but becomes a phosphate buffer and vice versa and students still have difficulty distinguishing acidosis and alkolysis

CONCLUSION

Based on the results of the research that has been carried out, it can be concluded, among others: The results of the research found that student in class have 41% of misconceptions in the medium category, 32% not understanding in the low category, and 27% understanding in the low category. The misconception profile for each buffer solution sub-material is as follows: the biggest misconception sub-material is calculation of the pH value of the buffer solution 44%. In the middle misconception sub-material is the components of the buffer solution 42,5% and the role of buffer solutions for living things 40,6%. The smallest misconception sub-material is definition and properties of buffer solutions 37,6%.

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