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Analysis of Student Misconceptions Using A Web-Based Diagnostic Test On Redox Material

Lamtiur Paronauli Silaban*, Ida Duma Riris, Zainnudin Muchtar, Elfrinda Ginting, Haqqi Annazili Nasution
Medan State University
***Corresponding Author: ronaulisilaban356@gmail.com**

Abstract: This study aims to determine the presence of student misconceptions in redox material, misconceptions in each concept of redox material, and factors causing student misconceptions in redox material in class XII MIA SMA N 2 Percut Sei Tuan. This research is a quantitative descriptive research. The sampling technique in this study used purposive sampling technique. The samples in this study were 32 students of class XII MIA 1 who were selected based on the recommendation of the chemistry teacher. Data collection techniques were carried out using a web-based three-tier diagnostic test, misconception questionnaire, and in-depth interviews (teachers and students). The results showed that the misconceptions identified using the web-based three tier diagnostic test on the redox concept as a whole was 31.718%, while students who experience incomprehension of the concept is 54.687%, students who understand the concept is 13.906% and understand the concept is not sure 1.25%. Students' misconceptions on each concept of redox material are highest on the concept of compound names at 43.8% and the lowest on the concept of equalizing redox reactions with the oxidation number method and the ½ reaction/ion electron method at 26.6%.Based on the results of questionnaires and interviews, each factor has an influence on misconceptions, the biggest misconceptions are teacher factors and teaching methods, namely 21.32% and 21.28%.

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Introduction

The Merdeka curriculum is considered more effective and focuses on the subject matter, character and skill development of students and creates a more active and fun learning atmosphere. In this curriculum, teachers are given the freedom to manage learning in the classroom and students are motivated to be active in discussions and dare to argue. Learning can also be done outside the classroom so that discussion activities are much more comfortable, not bored and schools adjust learning methods and subjects to the content of the curriculum, and this program aims to involve students in a student-centered approach (Napitupulu et al., 2023; Rahayu et al., 2022; Setiawan et al., 2023).

Chemistry learning taught at SMA Negeri 2 Percut Sei Tuan already uses the Merdeka curriculum. The subject matter of redox reactions is taught in class XII Odd Semester. To teach chemistry material, it is necessary to understand the characteristics of each chemistry teaching material (Fajri and Muna, 2023).Redox material is classified as material that is difficult for students in SMA class XII to understand. This is because students

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are not fully able to understand the concepts of redox such as defining redox reactions, how to determine the oxidation number of a molecule/ion based on the oxidation number rule, substances that act as reductants or oxidizers in redox reactions so that misconceptions occur in the answers to redox reaction questions (Khaerudin et al.,2023; Adjei et al., 2022).

Based on the results of interviews conducted at SMA N 2 Percut Sei Tuan, chemistry learning still uses lecture methods and question and answer discussions with the Problem Based Learning learning model. Then, the learning tools used are learning modules, Flow of Learning Objectives (ATP), Learning Outcomes (CP), package books and power point media for material exposure to students. In understanding the material, the level of student understanding is still low because students still have difficulty in understanding the concept of redox, how to determine the oxidation number of an element in compounds or ions and the redox reaction equation. Through the learning results, 50% of students still do not understand the name of the compound so that they have the wrong concept in determining the oxidation number and also wrong in understanding the redox reaction equation. This is because in the previous curriculum, namely the K13 curriculum, redox material was contained in grades X and XII so that the distance between the grade levels made them forget the concept of redox in grade X so that it needed to be repeated in grade XII. Therefore, grade XII students still tend to be wrong in answering or working on redox reaction equation questions. Meanwhile, in the Merdeka curriculum, redox learning is only carried out in class XII. In addition, the teacher has also never conducted an exam using a diagnostic test to find out students' misconceptions but only uses a regular test.

One form of conceptual error that occurs is in determining the oxidation number of the H atom in the H_2O compound is +2, while it is the value of 2 H atoms not 1 H atom. Students use this method when doing the pre-test based on the explanation of the material from the teacher. The same thing also happens when students determine the oxidation number value of O, namely giving answers +2 and -2, while the compound in the problem is not a peroxide. Relatively weak concept understanding is found in the subconcepts of redox reactions based on electron transfer; increase or decrease in oxidation number; redox reactions; oxidizing and reducing substances; and application of redox reactions. Among these subconcepts, the application of redox reactions has the lowest percentage of student understanding at 14.29% and 26.98% for the redox subconcept material based on electron transfer. While based on theory, redox reactions involve the transfer of electrons from one reactant to another. When oxidation occurs, reduction also occurs, and substances that lose electrons will be oxidized and substances that gain electrons will be reduced (Yuniarti et al., 2020; Rahmiati et al., 2022; Mayeem et al., 2023).

Knowledge of the representation of oxidation-reduction reactions, the dependence between oxidation and reduction reactions, the electron transfer process, the meaning of oxidation numbers, identifying reagents as oxidants or reductants, and redox reaction balancing are the most commonly found errors (Goes et al., 2020).

A misconception refers to a concept that is not in accordance with scientific concepts or the accepted understanding of experts in that field (Medina, 2022). Learning can be successful when students are able to understand concepts correctly. In fact, students still experience misconceptions (Annisa, 2019). Therefore, it is important to determine misconceptions in subjects where students have learning difficulties and identify the factors that cause these misconceptions to appear (Ayyıldız et al., 2022). There are several ways that can analyze student misconceptions such as: concept maps, diagnostic tests, interviews, class discussions and questions and answers (Annisa, 2019).

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There are several diagnostic tests, including: diagnostic essay tests, multiple choice tests, interviews and graded multiple choice tests. Each diagnostic test has its own advantages and disadvantages (Yuberti et al., 2020). One type of diagnostic test is the three-level multiple choice test. This test consists of three parts, each containing questions about the concept of the material, the reason for answering the first question, and the student's level of confidence in the previous two parts of the question. This method is very effective for measuring students' level of understanding (Mellyzar, 2021).

In this research, diagnostic tests were carried out using the web which is certainly much more effective than a manual system for conducting tests (Lestariningtias et al., 2020). Quizizz is a web application that supports learning, document creation, exercises, quizzes with attractive images. Creating assignments or quizzes with images means that teachers can add images to the questions (Annisa & Erwin, 2021). Quizizz offers a number of benefits. To start, it's quite simple to use; created quizzes may be posted straight to the Quizizz media application and customized with choice options, backgrounds, and images. Students can then be given access to quiz codes, statistical information on student quiz scores is available through the Quizizz media application and can be downloaded as an Excel spreadsheet. Fourth, because the quiz has a time limit, using the Quizizz media application is quite versatile (Rizki et al., 2022).

The web-based diagnostic test will examine students' misunderstandings about redox information in order to identify learning challenges and misperception sources. Moreover, it is anticipated that the web-based diagnostic test will boost students' interest in learning throughout the course of the lesson, giving them a better understanding of their capacity to engage in learning or work on redox material questions, identify material that has been mastered or not, and serve as a resource for teachers to reinforce and deepen material that has not been mastered.

Research Methods

This research is a descriptive research with quantitative method. This descriptive research aims to identify and analyze misconceptions experienced by students on redox material. The population in this research were all XII grade students of SMA N 2 Percut Sei Tuan in the odd semester of the 2023/2024 school year with a Merdeka curriculum on Redox teaching material. The sample used in this research was 32 students. Sampling was done by purposive sampling technique. Purposive sampling is a sampling method that requires special consideration, namely based on recommendations from schools (Firmansyah, 2022).

The research instruments used were instruments in the form of three-tier multiple-choice diagnostic tests, non-test instruments in the form of questionnaire observation sheets and interview sheets that functioned to identify the causes of misconceptions that occurred to students. The data collection techniques in this research are three-tier diagnostic test questions, questionnaire sheet, and interview.

The Certainty of Response Index, or CRI, is a measure of respondents' confidence or certainty in their answers to each question (problem) provided. It was created to help differentiate between students who understood the concept and those who did not. CRI is a simple tool to use in identifying misconceptions because it includes a scale of respondents' confidence in their answers to questions or problems provided where the scale is on. The interpretation of the results of the three-tier diagnostic test has three levels according to the CRI (certainty of response index), namely level 1 is the answer, level 2 is the reason and level

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3 is the CRI value. The interpretation of the three-tier diagnostic test results can be seen in table :

Table 1. Interpretation of Three Tier Diagnostic Test Results

Level 1 (Answer)	Level 2 (Reason)	Level 3 (ValueCRI)	Description
Correct	Correct	>2,5	Understand the concept well
Correct	Correct	< 2,5	Understand the concept well but lack of confidence
Correct	Wrong	> 2,5	Misconceptions
Wrong	Correct	> 2,5	Misconceptions
Wrong	Wrong	> 2,5	Misconceptions
Wrong	Correct	< 2,5	Don't know the concept
Correct	Wrong	< 2,5	Don't know the concept
Wrong	Wrong	< 2,5	Don't know the concept

Table 2. CRI Criteria

Value	Percentage Of Answer	Description
0	100 %	Just guessing
1	75-99 %	More guessing
2	50-74 %	Not sure
3	25-49 %	Sure
4	0-24 %	Almost sure with no doubt
5	0 %	Very sure with no doubt

(Maryam, 2020)

Research Results and Discussion

The analysis of test instruments to measure students' understanding profiles is compiled based on the analysis to be carried out. The questions analyzed were in the form of multiple choice questions as many as 20 questions that were already valid. Student understanding per sub-concept is used to measure student misconceptions on the given sub-concept.

Table 3. Student Concept Understanding Level Test Sub Concept

Redox Material Sub Concept	Percentages			
	PK	Mi	TPK	PKTY
Oxidation-reduction reactions based on the binding and release of oxygen and electrons	31,25	29,67	37,55	5
Reduction and oxidation reactions based on the increase and decrease	12,5	33,02	56,71	3,57

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in oxidation number				
Determination of reductant and oxidizer	4,68	32,05	64,07	0
Redox reaction	9,37	28,1	62,5	0
Autoredox reaction	6,25	37,5	46,9	10
Name of compounds	3,12	43,8	53,1	0
Equalization of redox reactions by oxidation number method and ½ reaction/ion electron method	22,65	26,6	50,77	0
Average percentage (%)	12,83	32,96	53,07	2,65

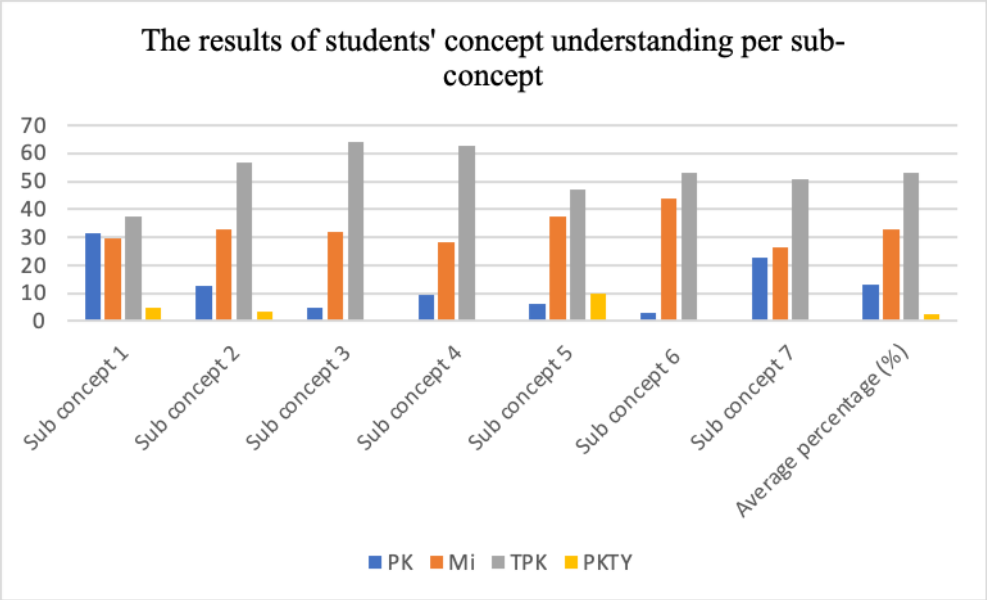

Figure 1. Diagram of Students' Concept Understanding Results of Sub Concepts

From figure 1, it can be seen that in sub concept 1, namely oxidation-reduction reactions based on the binding and release of oxygen and electrons, students do not understand the concept of 37.55%, followed by understanding the concept of 31.25% and misconceptions of 29.67% and students who understand the concept are not sure of 5%. In sub-concept 2, namely reduction and oxidation reactions based on the increase and decrease in oxidation number, students did not understand the concept of 56.71%, misconceptions of 33.02%, followed by students who understood the concept by 12.5% and students who understood the concept were not sure by 3.57. In sub-concept 3, namely determination of reductant and oxidizer, students did not know the concept by 45%, students who did not understand the concept were the highest at 64.07%, misconceptions by 32.05% and followed by students who understood the concept by 4.68%.

In sub-concept 4, namely redox reaction, students did not understand the concept by 62.5%, students had misconceptions by 28.1%, and students who understood the concept by 9.37%. In sub concept 5, namely autoredox reaction, students do not understand the concept by 46.9% and misconceptions by 37.5% followed by students who understand the concept are not sure by 10% and students who understand the concept by 6.25%. In sub-concept 6, namely the name of compounds, students do not understand the concept by 53.1% and the

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highest misconception is 43.8% and students who understand the concept by 3.12%. In sub-concept 7, namely equalization of redox reactions by oxidation number method and ½ reaction/ion electron method, students do not understand the concept by 50.77%, misconceptions by 26.6% and understand the concept by 22.65%.

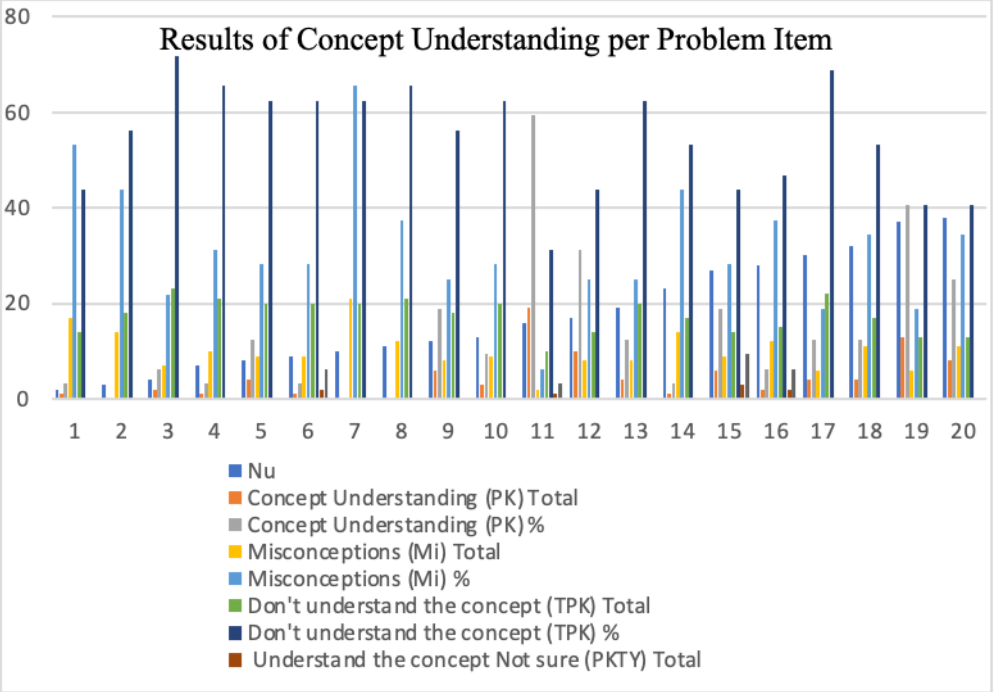

Figure 2. Diagram of Result of Concept Understanding per Problem Item

The subject matter in sub-concept 1 regarding oxidation-reduction reactions based on the binding and release of oxygen and electrons is found in questions number 2 and 16. The results of the analysis of student misconceptions found in each question show that the percentage of misconceptions from the highest is in number 2 at 53.125% and in number 16 at 6.25%. The average percentage of student misconceptions found on this concept is 29.67%. The results of this study are smaller than the results of research conducted by Wulandari, et al. (2019) who found the percentage of student misconceptions of 30.08% on the concept of oxidation-reduction. Meanwhile, research conducted by Prayunisa & Mahariyanti (2021) showed that the percentage of students' misconceptions of 20.2% was smaller than the results of the study, namely 29.67%.

The subject matter of sub-concept 2 regarding reduction and oxidation reactions based on the increase and decrease in oxidation number is found in question numbers 7,8,9,10,12,17,27. The results of the misconception analysis contained in each question show the highest percentage in number 10 of 65.625% with a high category, in number 7 of 31.25% with a medium category, in number 8 and number 9 of 28.125% with a low category, in number 27 of 28.125% with a low category, and in numbers 12 and 17 of 25% with a low category. The average percentage of student misconceptions found on this concept is 33.02%. The results of this study are still greater than the research conducted by Kamila, et al. (2020) of 14.6% on the concept of redox based on changes in oxidation numbers.

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The subject matter in sub-concept 3 regarding Determination of reductant and oxidizer is found in questions number 3, 4, 11, and 19. The results of the analysis of student misconceptions found in each question show that the percentage of misconceptions from the highest is in number 3 of 43.75% with a moderate category, in number 11 of 37.5% with a moderate category, in number 4 of 21.875% with a low category, and in number 19 of 25% with a low category. The average percentage of student misconceptions found on this concept is 32.05%. The results of this study are greater than the results of research conducted by Irawati & Astutik (2023) who found the percentage of student misconceptions of 30.16% on the concept of reductors and oxidizers.

The subject matter in sub-concept 4 regarding redox reaction is found in question number 13. The results of the analysis of student misconceptions found in the question show a percentage of misconceptions of 28.1% in the low category. The average percentage of student misconceptions found in this concept is 28.1%. The results of this study are smaller than the results of research conducted by Irawati & Astutik (2023) who found the percentage of student misconceptions of 44.44% on the concept of oxidation-reduction reactions.

The subject matter in sub-concept 5 regarding autoredox reaction is found in question number 28. The results of the analysis of student misconceptions found in the question show a percentage of misconceptions of 37.5% in the moderate category. The average percentage of student misconceptions found on this concept is 37.5%. The results of this study are greater than the results of research conducted by Yuniarti & Elvinawati, (2020) who found a percentage of student misconceptions of 30% on the concept of autoredox.

The subject matter in sub-concept 6 regarding the name of compunds is found in question number 23. The results of the analysis of student misconceptions found in the question show a percentage of misconceptions of 43.75% in the moderate category. The average percentage of student misconceptions found in this concept is 43.8%. The results of this study are greater than the results of research conducted by Yuniarti & Elvinawati, (2020) who found a percentage of student misconceptions of 40% on the concept of name of compounds.

The subject matter in sub-concept 7 regarding equalization of redox reactions by oxidation number method and ½ reaction/ion electron method is found in questions number 30, 32, 37 and 38. The results of the analysis of student misconceptions found in the questions show the highest percentage of misconceptions in numbers 32 and 38 amounting to 34.75% in the medium category, in numbers 30 and 37 amounting to 18.75% in the low category. The average percentage of student misconceptions found on this concept is 43.75%.

Table 4. Percentage Level of Factors Causing Student Misconceptions

Nu	Factor	Number of Values	Percentage (%)
1	Students	484	**20,43**
2	Teacher	505	**21,32**
3	Teaching Method	504	**21,28**
4	Book	480	**20,27**
5	Context	395	**16,68**
	Total	**2368**	**100%**

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From the results of the questionnaire, it is known that students experience misconceptions in all factors, with varying percentage levels. The most dominant factor that causes students to experience misconceptions is the teacher factor with a percentage of 21.32%, the teaching method factor of 21.28%, the student factor of 20.43%; the book factor of 20.27%; and the context factor of 16.68%.

According to the findings of the student survey, the main reasons why students have misconceptions are elements related to the professors and the ways in which they instruct their students. This may be brought about by teachers primarily using the lecture approach, asking students to read and memorize content, infrequently holding group discussions, and not using a diversity of learning resources. It may also result from a lack of emphasis on concepts in material that students do not grasp (Izza et al., 2021). Because it prevents students from voicing their thoughts and tends to reinforce preconceived notions that they have already encountered, the lecture technique is likely to lead to misconceptions among pupils (Guswina & Mufit, 2020).

Conclusion

Based on the research results, analysis of research results and discussion, it is concluded that the level of misconceptions that occur in students of class XII SMA N 2 Percut Sei Tuan in the 2023/2024 academic year on the concept material of redox reactions is 31.718%, while students who experience incomprehension of the concept is 54.687%, students who understand the concept is 13.906% and understand the concept is not sure 1.25%. The percentage of student misconceptions in each concept of redox material is on the concept of name of compounds by 43.8%, on the concept of autoredox reaction by 37.5%, on the concept of reduction and oxidation reactions based on the increase and decrease in oxidation number by 33.02%; on the concept of determination of reductant and oxidizer by 32. 05%; on the concept of oxidation-reduction reactions based on the binding and release of oxygen and electrons by 29.67%; on the concept of redox reaction by 28.1% and on the concept of equalization of redox reactions by oxidation number method and ½ reaction / ion electron method by 26.6%. The causes of student misconceptions are in the teaching and learning process the teacher does not provide sufficient concept emphasis in the teaching and learning process activities, learning methods that are not appropriate, students pay less attention to the explanations given by the teacher in the learning process, students' wrong intuitions and perceptions, and students' lack of ability.

Suggestion

Based on the research that has been completed teachers really have to reinforce the origin of the material taught before students get the next more complicated material to prevent misconceptions, it is necessary to conduct a diagnostic test using a three tier multiple choice diagnostic test instrument that has been tested for item feasibility to identify misconceptions in students in function material and It is expected that further analysts can conduct further research by expanding the material and the number of samples.

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