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Diagnostic and Analysis Misconceptions in Learning Redox and Electrochemistry Topic in Chemistry Students

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Abstract

The research's objective to know student's misconceptions on redox and electrochemistry concept, the sources of student's misconceptions. Involved 30 students was studied general chemistry in chemistry department, Islamic State University of Syekh Ali Hasan Ahmad Addary Padangsidimpuan. Instrument of the research is diagnostic test with three tier question to know misconceptions on students, interview sheet to know sources of misconceptions. The result of research are The higher misconceptions founded on sub concept Different of redox reaction, diagram cell, description of reduction and oxidation, corrosion reaction on metal, equalization of redox reaction, potential cell or Nernst Equation, electrolysis concept and mass of substance on electrolysis cell. It was founded that students had misconceptions on redox and electrochemistry concept with percentage 52.6%. It was founded 3 sources that affect student's misconceptions on redox and electrochemistry, that are Students, have wrong interpreted from books and teacher, Internet that has many unbelievable sources, Friends that have wrong concept and sharing to other students.

1. Introduction

Chemistry is the subject of atoms, particles, molecules, and reactions in the universe. Chemistry are abstract concept difficult to explain chemical phenomena by using these concepts Because one cannot see directly the concept (Nahum & Hofstein 2004) Chemistry is a subject that is learned widely material, based on abstract concepts and therefore difficult to understand and learn, and difficult to make the student understand something that cannot register by senses (Milenkovic, et al., 2016). Chemistry is the scientific concept of matter and its changes. To explain chemical phenomena that happen in everyday life around us. The objectives of chemistry education students can understand fundamental concepts of chemistry so that students can relate chemistry concepts and the chemical processes behind everyday phenomena. Over the last few years, there have been studies and research focusing on the difficulties of students in learning and understanding concepts of chemistry. The research finds there are misconceptions about students learning chemistry (Kolomuc & Tekin,2011).

Misconception is students' knowledge and belief that it does not match with scientifically correct. Often, students come to class with already prior knowledge about scientific phenomena and it's not accurate (Turkmen & Usta, 2007). On the other side, language, prior knowledge, and cognitive development can be the cause of misconceptions related to the instructional process of the learning process (Bilgin, et al., 2003).

The breadth and depth of students' understanding of chemistry concepts can illustrate the conceptual knowledge that the student has. Conceptual knowledge is one important part that students must learn to solve problems (Sabella & Redish, 2007). Electrochemistry and redox reaction concepts have been some of the most difficult concepts for high school students. There are some misconceptions about this concept. Common assessments applied to this concept cannot be explored because students had never been assessed on their concept and scientific process understanding. In higher education, the concepts of redox and titration are studied in the course of Basic Chemistry Electrochemistry is the basic science of chemistry which explains how electrical energy can be chemical energy and how chemical energy can produce electricity (Widarti, et al., 2016).

Preventing misconceptions can be identified by asking some questions designed to test what has been studied (Adaminata & Marsih, 2011). Multiple choice two-tier tests became instrument the prevalent way of identifying misconceptions that happen in students. Two-tier tasks consist of two

parts test. The first tier contains the content problem, multiple-choice as usual while the second part contains a reasonable explanation of the problem presented in the first tier of the task. There introducing and considering the third tier in tasks provides valuable information about students' self-confidence. The third tier is to affirm the answer to the problem presented Namely, only those students who provide the correct answers in both tiers and the third tier indicate that they are sure of their answers and that students understand the content of the chemistry concept (Milenkovic et al., 2016).To diagnose misconceptions, the researcher could use various forms of tests, namely Open-ended Tests, Ordinary Multiple Choice Tests (MCT), Two-tier MCT, Three-tier MCT, and Four-tier MCT (Gurel et al., 2015).

According to Hammer (2005), misconceptions have characteristics, namely (1) a relatively strong and stable cognitive structure, (2) is different from the concepts that scientists have, (3) influencing how students understand scientific explanations, (4) must be addressed immediately, avoided, and eliminated to get the right concept (Duit et al., 2007).

2. Research Method

The research method consists of time location and research procedure

Time and Location

The research conducted in an undergraduate program that was learned general chemistry in 3rd semester (2020), semester 5 (2021), and semester 7 (2022) consisted of 30 participants from the Chemistry Department at Islamic State University of Syekh Ali Hasan Ahmad Addary Padangsidimpuan. On September-October 2023.

Research Procedure

The instrument consists of 25 three-tier questions. The first tier is multiple choice with 5 options in the electrochemistry topic. The second tier is a question with 5 options that relate to the first question. The third tier is an open question to affirm their answer to the question. using for pretest and posttest. For the first diagnostic use an instrument to know students' misconceptions that happen in electrochemistry topics. If a student has a wrong answer in the first and second tier it means the student does not understand about electrochemistry topic. After knowing misconceptions in electrochemistry topics, then analyze data to know a group of students. Classify into 3 parts: understand group, misconceptions group, and not understand group. After that also interviewed group misconceptions. This interview has a function to know sources of misconception

in students, from textbooks, the internet, or lack of their teacher and other reasons. In this interview, we will know some factor that makes the lack of electrochemistry topic in students. Research procedure like in Figure 1:

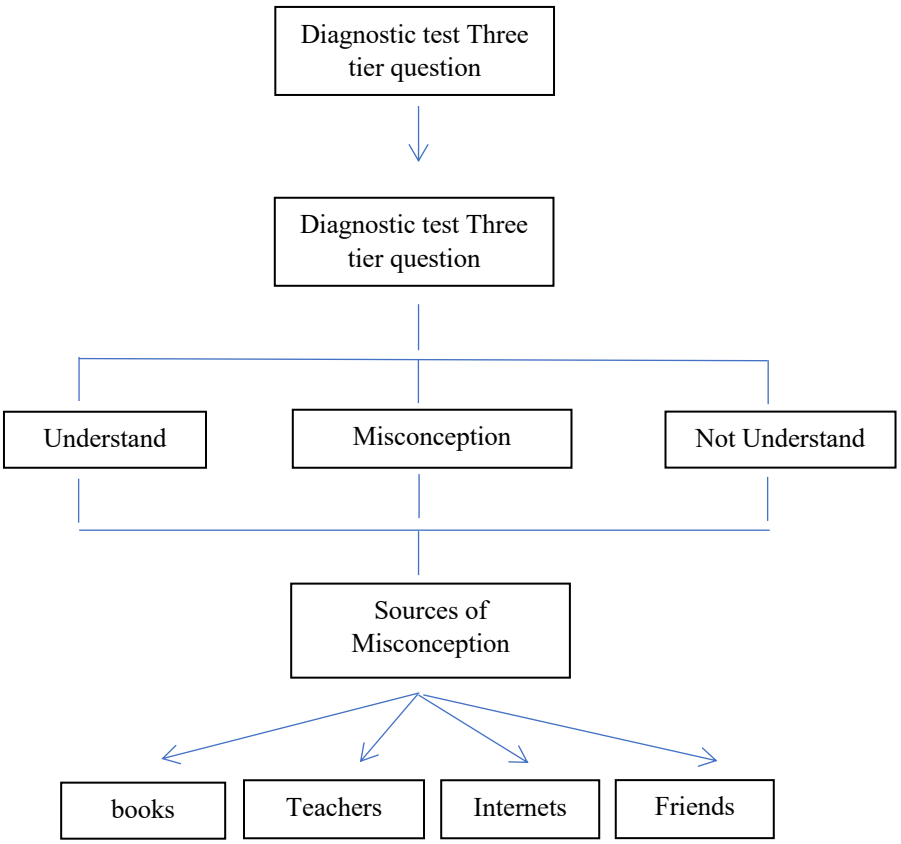

Figure 1. Research Procedure

For students' misconceptions, a pretest using three-tier questions was developed. the number of items is 25 three-tier with questions 5 options answer choices, 5 options in the second tier, and affirmation questions for their reason for choosing their answer. For identified misconceptions in each class, give 25 as a pretest. To get the misconception group of every class. this instrument item will be validated by an expert. The instrument of the research is shown in Table 1:

Table 1. Instrument of Diagnostic Test

Indicator	Description	Amount of Question
Description reaction of reduction and oxidation.	Based on decrease and increase of oxidation number.	2
	Based on release and binding of oxygen	-
	Based on take and give of electron	-
Different between redox reaction or not redox reaction	Based on the presence of redox reaction	3
Balancing of redox reaction	Half reaction method	2
	Redox equation method	3
Calculating potential cell of half reaction/ redox reaction or based on NERST Equation	Definition of Voltaic cells	-
	Standard Reduction Potential	3
	Potentials cells of Half Reaction	1
	Potential cells of Redox Reaction	3
	Concentration cells of NERST Equation	2
Writing cell diagram of redox reaction.	Writing cell diagram of half reaction	2
	Writing cell diagram of redox reaction	2
Description concept of electrolysis and the calculation.	Definition of Electrolysis	3
	Reaction in Anode and Cathode	3
Description of Corrosion reaction on metal.	Defenition of corrosion on metal	1
	Factors that influence of corrosion	1
	Preventing corrosion on metal	2
Calculating mass of electrode in electrochemistry based on Faraday Law	Faraday Law I	1
	Faraday Lawa II	1
Total		35

3. Result and Discussion

3.1 Students Comprehension

Student comprehension is divided into three categories, Specifically Understanding (SU) if students have the right answer in the first and second tiers and then are sure about their answer, Misconceptions (MC) if a student has the right in one of the tiers and is sure about their answer and Not Understanding (NU) if the student is not sure of their answer. Every question is divided into 3 categories. Based on the total of categories in every class get the average percentage with the formula total of students in each category divided by the total of students in Figure 2:

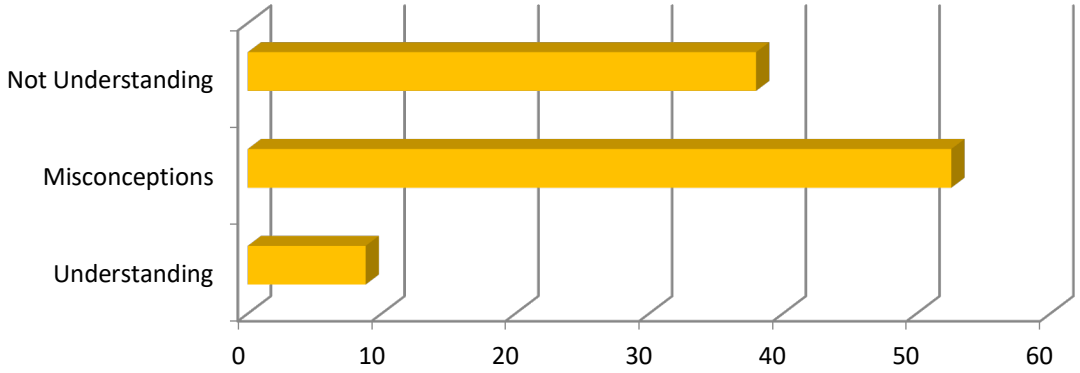

Figure 2. Percentage of students' comprehension

From the above figure, misconceptions are the higher category with a percentage of 52.6 %. Half of the students have the wrong concept and do not understand redox and electrochemistry concepts. Second is students not understanding about concept with a percentage of 38 %. It means a lot of students just know the theory but do not understand it. The last category is just a percentage of 8.8 % of students who know about the concept and understand it. So, just a little bit of students that have good knowledge about this concept.

3.2 Analysis of Misconception Based on Sub-concept of Redox and Electrochemistry.

From the analysis misconception on redox and electrochemistry, get the percentage and average of each sub-concept like in Table 2:

Table 2. Percentage of Student comprehension of sub-concept

Indicator	Understanding (U)	Misconceptions (MC)	Not Understanding (NU)
Description of reduction and oxidation reaction.	20.43	60.4	20.43
Different of redox reaction or not redox reaction.	27.95	66.3	5.38
Equalization redox reaction	17.56	51.52	31.89
Calculating potential cell of half reaction / redox reaction or Nernst Equation.	2.50	49.28	49.46
Writing redox reaction and diagram cell of reaction.	3.23	60.48	32.79

Description electrolysis concept and its calculation.	12.90	49.19	35.48
Description corrosion reaction on metal	14.32	54.83	31.18
Calculating mass of substance on electrolysis cell.	2.15	42.65	54.47

From analysis misconception on redox and electrochemistry, get the graphic of each sub-concept like in Figure 3:

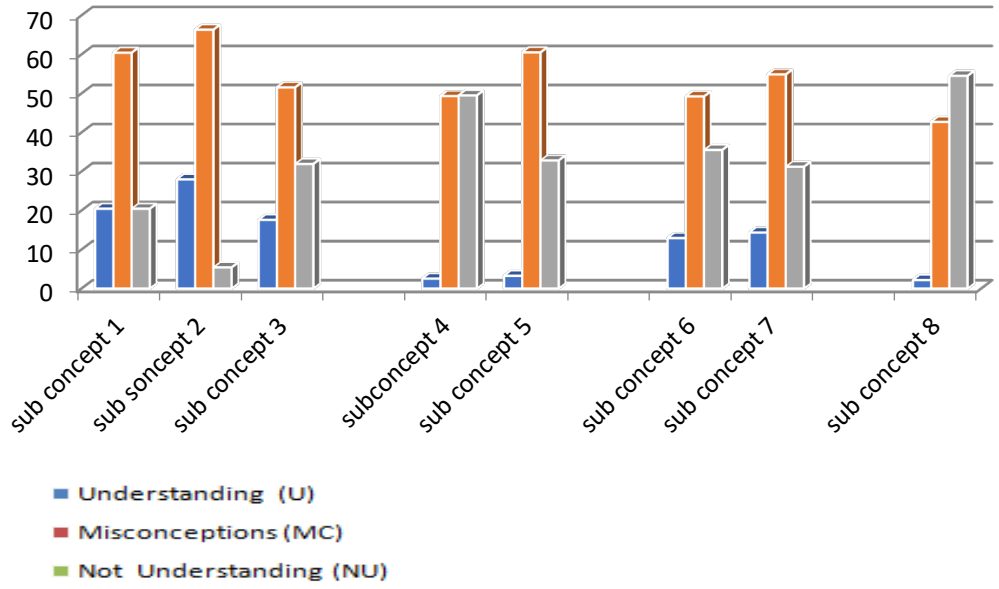

Figure 3. Percentage of students' comprehension of sub-concept

Description of reduction and oxidation reaction (sub-concept 1)

Reduction and oxidation topics have a high misconception with a percentage of 60.4 in 1 question. and the same percentage of Specifically Understanding and not Understanding. This means many students are misconceptions what the description of reduction and oxidation. In this topic, students are confused about the oxidation number of compounds, some compounds have some oxidation number. Students just focus on changing oxidation numbers.

Redox Reaction (sub-concept 2)

In this indicator, have higher misconceptions with a percentage of 66.3 in 1 question. Students regard redox reaction as a reaction in the reactant and the product has to change oxidation number but students don't care about reduction (decrease of oxidation number) and oxidation (an increase of oxidation number). It means many students have misconceptions about how to different redox or not redox. In this sub-concept, students just know the theory but do not understand it. 28 % of students that not understand this concept, just a little bit of students understand this concept.

Equalization of redox reaction (sub-concept 3).

In this sub-concept, have many misconceptions with a percentage of 51.52 in 3 questions. Students are still confused about different half-reaction methods and reduction and oxidation methods. Students must know the total of elements and ions of reactant and product is the same. This means half of all students are still confused about how to balance redox reaction and how to different half-reaction methods and oxidation number methods. 31.9 % still do not understand this concept. And just a little bit of students understand this topic.

Potential cell and Nernst Equation (sub concept 4).

This sub-concept has many misconceptions with a percentage of 47.28 in 6 questions. This means half of all students have misconceptions about this topic. Students have the wrong theory/knowledge in the potential reduction of substance, how to calculate it based on a redox reaction, and the relation of that. Students regard. The identity of the anode and cathode depends on the physical placement of the half cells and In an Ordered Table of reduction potentials, the species with the most positive E^0 Value is the anode. Is identity of the anode and cathode does not depend on the placement but potential electrode. Not all of the most positive E^0 is anode, most negative is cathode but each species has a specific identity. half of the students still do not understand this topic and just a few students understand this topic.

Diagram Cell (sub-concept 5)

In this sub-concept, have a high misconception with a percentage of 60.48 in 4 questions. Students regard in writing diagram cell is not put concentration or pressure of the species, just reaction of oxidation and reduction. To make a diagram cell of the redox reaction, put the concentration/pressure of the species. It means many students have misconceptions. Students have wrong knowledge and misconceptions about arranged diagram cells of redox reaction and how the relation. 33 % of students still do not understand diagram cells. Just 3.23 % understand it.

Electrolysis Cell (sub-concept 6)

In this sub-concept, have a high misconception with a percentage of 49.19 in 3 questions. It means half of all students still have misconceptions about electrolysis cell and their reactions. Students regard no reaction will occur if inert electrodes are used and in electrolyte cells, potential water is not reactive toward oxidation and reduction. If the electrode is inert, the compound is not reactive and water be oxidations. A compound is a reaction but E^0 water is bigger and makes water as the standard solution is a reaction.

Description of corrosion reaction on metal (sub-concept 7).

In this sub-concept, have high misconceptions with a percentage of 54.83 in 3 questions. It means more than half of all students still have misconceptions. Students have the wrong theory about corrosion, what the definition and cause of that. Some students have misconceptions about corrosion and just a little bit of students understand it. Students regard corrosion as the influence of corrosion is water and air but do not understand how can water and air make corrosion and corrosion just depends on the E^0 of the compound corrosion depends on the potential of metal and the reaction.

Calculating the mass of substance on electrolysis cell (sub-concept 8)

In this sub-concept, have a lower misconception of all indicators with a percentage of 42.65 in 3 questions. It means some students still have misconceptions. Students regard the directions of the electron flow in concentration cells as not dependent on the relative concentrations of the ions and the cell's potential in concentrations cells is not dependent on the relative concentration of the ions. The concentration of cells depends on the concentration of ions, the direction of the electron is on the ion concentration.

3.3 Sources of Misconceptions on Redox and Electrochemistry

Sources that affect misconceptions in every class are different, every indicator has different factors that make misconceptions as shown in Table 3:

Table 3. The average percentage of Source misconceptions

Sources	Percentage
Students from Books	53.68
Students from Teacher	32.98

Internet	8.05
Friends	5.3

The graphic of Sources of misconception is shown in Figure 4:

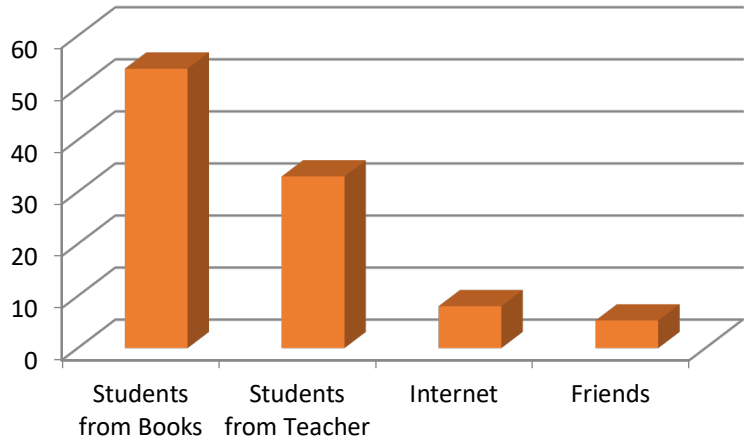

Figure 4. Average percentage of Source Misconceptions

From the above table, we can conclude higher factor that makes misconceptions of all indicators is books, books are the main source of the learning process. Books are important media for students to improve their understanding of concepts. Books contain all of the concepts in learning, but students have different interpreted based on their thinking and their understanding. It creates misconceptions about concepts when the teacher does not clear their misconceptions. This means books are the main factor that makes misconceptions is also the cause of students. So, books mean students, because students have wrong interpreted from books

The second factor is the teacher. The teacher explains the concept but students do not understand and students do not ask more. It makes students have misconceptions about this topic. So, teacher means students, because students have wrong interpreted of the teacher's explanations

The third factor and fourth factors are the fewer factors that create misconceptions about this topic. Now, the Internet is also a source of learning but the internet has many unbelievable sources that make students understand concepts, but wrong concepts and wrong theories about redox and electrochemistry. so just a few students know the concept from the internet. same with friends, students just ask their friends if they do not understand the concept. Friends do not always really understand the concept and make some wrong interpreted and misconceptions.

4. Conclusion

Based on the result of the research, can conclude that: It was found that students had misconceptions about redox and electrochemistry concepts with a percentage of 52.6%. Students have a low understanding of redox and electrochemistry concepts from 8 sub-concepts, the higher misconceptions are different of redox reaction, diagram cell, description of reduction and oxidation, corrosion reaction on metal, equalization of redox reaction, potential cell or Nernst Equation, electrolysis concept and mass of substance on electrolysis cell. It was founded on 3 sources that affect students' misconceptions of redox and electrochemistry, that are Students, who have wrong interpreted from books and teachers, the Internet which has many unbelievable sources, and friends who have wrong concepts and sharing to other students.

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