Remediation of Students' Misconception Based On Their Learning Style Through Guided Conceptual Change Strategies in the Concept of Electrochemistry

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Abstract— **The problem of misconception in Chemistry is a very serious thing. Misconceptions that occur in the students' early learning, will become the source of misconceptions on the next material. This study will attempt to reduce or remedy such misconception through Guided Conceptual Change in the concept of electrochemistry, by paying more attention to the individuals' learning style. Therefore, the purpose of this study is to identify the change in the students' cognitive structure during this remediation process. The method used in this study is a mixed method which is a combination of qualitative and quantitative methods. The source of data for this study is two students selected from 90 students having high level of misconception in electrochemistry, who have balanced visual-verbal capability. The change in the remediation process is identified from the verbal and writing response to the questions and the body language given by the students. Overall, this study provides an illustration that the change in the cognitive structure of students occurs through several stages. Those stages are 1. Validation of students' misconception, 2. Creation of conflict condition, 3. Giving aid to achieve equilibrium, and 4. Reconstruction of the real concept understanding.**

Keywords—Remediation, Guided Conceptual Change, Learning Style, Electrochemistry

I. INTRODUCTION

Researchers from various countries have conducted assessments of chemical misconceptions, eg in Turkey [1], in Israel [2], in Taiwan [3], in Singapore and Malaysia [4], in Ireland [5], in Indonesia [6]. The material undergoing misconception is very diverse, including the concept of mol, atomic structure, kinetic theory, thermodynamics, electrochemistry, equalizing the equation of redox reactions and stereochemistry, chemical bonds, chemical solutions, covalent bonds, ionic bonds, metal bonds, intermolecular forces, and energetics [7]. [8] exemplifies misconceptions in electrochemical including (1) electrons can flow through aqueous solutions in the absence of ions; (2) the concentration of electrons at athe anode is high, since the electrons move toward the anode; (3) in anionic electrochemical cells and the cations attract one another and this affects the movement of the ions to the electrode; (4) the electrons enter the solution of the cathode, travel through the

solution and the salt bridge, and appear on the anode to complete the circuit.

Teachers are responsible for most misconceptions experienced by students [9]. Teachers with misconceptions will teach the wrong concept to students and students will accept the wrong concept. It is, therefore, necessary to ensure that there is no misconception of the teacher. This research will focus on prospective teachers. In the 6th semester onwards, students have received all the courses underlying the concepts used to teach chemistry at high school level. In the sixth semester of mastering the concept of chemistry that became provision to teach chemistry at high school level can already be detected. If there are misconceptions among students, there is a need to reduce them. This is so that when graduated and become a teacher, they will be free from misconceptions.

Reducing misconceptions in prospective teachers is an attempt to reduce or cure misconceptions experienced by the student. The characteristic of misconception in a person is specific, therefore the treatment is also done with specifically, according to individual characteristics. Learning that attempts to reduce or heal and be specific can be done by remediation. The remediation of misconception is an attempt to change the wrong concept by presenting a truly new concept. Individual characteristics of observed in this research are student learning style.

Learning styles are the best way one chooses when thinking, processing information, and explaining the information obtained [11]. While learning the chemistry concept, students will feel comfortable when the information comes in accordance with their learning styles. [12] divides learning styles into four dimensions: perceptual dimensions, input dimensions, processing dimensions, and understanding dimensions. [13] in his research concluded there is a significant influence of learning styles on learning outcomes. [6] in his study concluded that students with a balanced sensing-intuitive learning style (perceptual dimension), balanced visuals (input dimensions), moderate active (processing dimensions) and balanced global sequential (understanding dimensions) have difficult misconceptions to change. Remediation of misconception

students in this study focused on balanced (visual-verbal) learning style and moderate active processing. Students with balanced input learning styles feel comfortable when the information presented is oriented toward the visual and verbal representation in a balanced way. Visual inputs show more learning activities oriented to images, diagrams, and demonstrations while visual input is oriented to sounds, writing, words, and formulas. Students with an active learning style have a tendency to learn from experience compared to using their reasoning [14].

Reducing misconceptions is a process to reduce the burden of misconceptions experienced by students by changing the old wrong concept into a new correct concept. The strategy used is conceptual change, in accordance with the findings of [15] who stated that conceptual change based learning proved able to change student misconception into scientific conception. This Posner statement was reinforced by later researchers who claimed that conceptual change is a good way of implanting the chemical concept [16, 17]. The conceptual change mechanism used by Posner is a conceptual altering mechanism in accordance with Piaget's theory.

The conceptual change mechanism can be described as follows. The false conceptions that are fixed within the cognitive structure (schemata) of the individual are distilled together first to be subsequently reorganized, equilibrated into the correct conception. The process of disequilibration to obtain the correct concept is done by creating an atmosphere of conflict (cognitive conflict) on the students, so that the expected process of accommodation, which can produce a new conception is scientific. Creation of cognitive conflict can be done through the provision of counter-examples, analogies, demonstrations, and experiments. According to [15], there are four important conditions that must be met before accommodation occurs: (1) There must be dissatisfaction with existing conceptions by bringing anomalies, (2) New conceptions must be understood, testable with the ability to explore, metaphors (figuratively), (3) New conceptions should seem plausible, can be used to solve problems and consistency, and (4) New concepts must be believed to have the opportunity to support research programs. It means having the potential to be developed and opening a new inquiry path. This conceptual altering mechanism is in line with the information processing mechanism.

The purpose of this study is to identify the change in the students' cognitive structure during this remediation process. The research questions are: What is the progress of the change in student's understanding of conception while undergoing remediation process ?

II. METHOD

The method used in this study is the method of mixed methods (mixed methods) which is a combination of qualitative and quantitative methods. The combined model chosen is concurrent, which combines both qualitative and quantitative methods simultaneously. The strategy chosen is Concurrent Embedded Strategy. According to [18], Concurrent Embedded Strategy is a combination of qualitative methods and quantitative methods performed at the same time in which one method is the dominant primary method and the second method to be embedded into the

primary method. In this study as a primary method is a qualitative method to obtain the cognitive process data travel understanding of student concepts from misconception to obtain a correct understanding at each stage of remediation. Secondary method as supporter is quantitative method to get data of mastery level of student concept.

The research subjects consisted of 2 Unesa chemistry students selected using purposive sampling technique. This is done based on the existence of a specific purpose, not based on strata or random. Students selected are students with the following characteristics: 1) Students who have taken lectures at least 6 semesters 2) Students who have misconceptions on the concept of electrochemistry. 3) Students who have a balanced learning style of input (visual-verbal). Student selection is done with the help of Ionunesa Detector software.

III. RESULTS AND DISCUSSION

The study involved two students with a balanced verbal-visual learning style and was identified to have a high misconception burden on the electrochemical concept. The students were given initials M1 and M2. The two students were remediated separately. The remediation process is aided by worksheets, props, animation media, interactive media, and internet networks. Remediation is done by guided conceptual change with 4 stages: 1. Validation of students' misconception, 2. Creation of conflict condition, 3. Giving aid to reach equilibrium, and 4. Reconstruction of the real concept understanding.

Validation of students' misconception. This stage aims to ensure that there has been a misconception in students. At this stage, the researcher (Rs) proposes a statement and the student is asked to express his or her opinion and reason.

A. Remidiation Results For MI

1. Validation of students'

At initial identification, M1 has a misconception load of 70%. To assure that M1 misconception the Galvani cell concept, misconception validation is performed. At this stage, Rs filed a statement: The determination of Anodes and cathodes on Galvani cells is based on the physical placement of cells. Electrodes on left cell as an anode and right side as a cathode. What is your opinion? M1 does not agree that in the galvanic cell circuit, the left electrode is always the anode and the right electrode as the cathode. The concept of M1, the determination of the anode and the cathode is determined by the type of electrolyte present around the electrode. But M1 cannot explain what kind of electrolytes exist in the anode and cathode.

After the Galvani series images are shown from Raymond Change and Glencoe's book indicate that the left electrode as an anode, M1 begins to agree on the Rs statement, but is still in doubt. After viewing images of galvanic cell circuits on the internet, the majority of which present images with the anode on the left, M1 becomes convinced that the Rs statement is true.

2. Creation of conflict condition

At the end of identification, the misconception is known that M1 believes that in the galvanic cell circuit, the left electrode is the anode and the right is the cathode. At this

stage of the conflict presented electrochemical simulation software. This software can provide information about the value of E^0, anode position, cathode, positive cover, negative cover, oxidation-oxidation reaction, and electron direction.

The first simulation experiments assemble the galvanic cell with the left cell Cu^{2+}/Cu and the right Zn^{2+}/Zn obtained the result: the cathode in the left position and the anode in the right position. The second simulation repeats the string of galvanic cells with the left-hand cell Cd^{2+}/Cd and the right side Ag^+/Ag, the results obtained: Anode on the left and the cathode on the right. Looking at the data, M1 realizes that the determination of the anode and cathode is not based on the cell position. In the Galvani cell, the electrode on the left cell is not always as an anode and the right is not always the cathode. Based on these facts on self M1 conflict occurs with the level of conflict 2.7. The degree of conflict is recognized by the recognition that is written on the instrument of the level of cognitive conflict. The level of conflicts experienced by M1 fall into the medium category, it is possible that the data provided is always small.

To be more convincing, more simulation repetition is done, but electrode selection is done by software at random. The worksheet provides tables for two repetitions, but M1 feels dissatisfied and simulates again. The first simulation of left cell IO_3^-/I_2 with Pt electrode, right cell F_2/F^- with Pt electrode, obtained left anode do and cathode on the right side. Simulation of the two left-sided cells $S_4O_6^{2-}/S_2O_3^{2-}$ with Pt electrode, Ca^{2+}/Ca right cell with Ca electrode, the right anode does and the cathode to the left are obtained. The first simulation of Ag^+/Ag left the cell with Ag electrode, right cell H_2O_2/H_2O with Pt electrode, obtained left anode do and cathode on the right.

With this repetition, M1 is increasingly aware that the determination of anodes and cathodes is not based on cell position. Also with this repetition, the level of conflict increased to 3.7.

3. *Giving aid to reach equilibrium*

At the beginning of this stage, M1 believes that the determination of the anodes and cathodes in the galvanic cell is not determined by the position of the cell where the left cell is the anode and the right cell is the cathode. To provide aid for the occurrence of equilibration in order to form a new concept of how to determine anodes and cathodes, electrochemical simulation software is used. With such simulation media, M1 is directed to find the relation between price E^0, electrode type, reaction type, pole type, and direction of an electron.

At the end of the simulation media usage, M1 accepts the fact that:
a. Electrode with E^0 is greater always as a cathode
b. Electrode with E^0 is greater always as positive pole
c. Electrons always flow from electrode with smaller E^0 to big E^0
d. There is always a reduction in electrode with E^0 greater

After accepting the facts, M1 concludes that: Cells with a higher E^0 value, acting as a cathode, charged$^+$, experience a reduction reaction and a moving electron from a smaller Eo to a larger E^0. Cells with a smaller E^0 value, acting as an anode, charged - (negative), undergoing

oxidation reactions and electrons move from larger E^0 to smaller Eo.

To strengthen the occurrence of equilibration, use of interactive media that displays macroscopic, symbolic, and submicroscopic representations are packaged in the form of animation and text interactively. With the interactive media, M1 can understand other processes related to the determination of anodes and cathodes, namely: (1) the greater the value of Eo the more easily the reduction, the smaller the value of Eo the more easily oxidized; (2) As the voltaic process progresses, the number of Cu electrodes increases, the number of Cu^{2+} ions decreases. The number of Zn electrodes decreases, the number of Zn^{2+} ions increases; (3) Anode is a negative cover, while catoda as positive pole. The electrons from the anode to the cathode move through the outer circuit.

4. *Reconstruction of the real concept of understanding*

The purpose of this stage is to facilitate the formation of concept networks associated with the anodes and cathodes in galvanic cells. The worksheet provides an incomplete image of the galvanic cell range. M1's job is to complete the drawing. The first step of the M1 is "If no sequence or value of E^0 is found to be unworkable". This question indicates that the conception of M1 is correct. Having found the data E^0, M1 complete it smoothly and correctly.

To further reinforce the reconstruction of the understanding of component linkages in galvanic cells, students were asked to draw Galvani cell sequences along with their descriptions, with Ag^+/Ag and Mg^{2+}/Mg electrodes. M1 smoothly finish it. To further reinforce the occurrence of reconstruction of understanding, M1 is required to describe orally the components contained in the galvanic cell. M1 can explain fluently and correctly. Finally reinforced by showing the application of galvanic cells in everyday life, namely the series of galvanic cells from the fruiting fruit with a nail (iron) and coin (copper) electrodes. M1 can identify with the anode, cathode, electron flow, the reaction occurs. At this stage shows that M1 already has an understanding of the galvanic cell components correctly. M1 believes that the concept will continue to be remembered until the teacher later. M1 feels very understanding of galvanic cell components.

5. *Retention Test*

After 2 months from the remediation stage, tests are performed to determine the burden of misconceptions. The misconception load experienced by M1 is 0%.

B. *Remediation For M2 Obtains*

1. *Validation of students' misconception*

At initial identification, M2 has a misconception load of 85%. At the beginning of identification, M2 forgets the term galvanic cell, after being given scaffolding, M2 knows that the galvanic cell is the same as the voltaic cell. When asked about how to define anodes and cathodes on galvanic cells, M2 looks thought long enough and states "do not remember at all". After trying to understand, M2 states disagree that the left electrode is always the anode and the right is always the cathode with a reasonable confidence level, but M2 cannot explain the correct way to determine the anode and cathode. Finally, M2 agrees that the left electrode is always

the anode and the right is always cathode in the hope of not writing down the reason.

To uncover M2's conception, the Galvanic cell image from Raymond Chang's Chemistry book and Glencoe's publication shows that both drawings represent the anode on the left. M2 is not sure, the anodes are left in either book by chance or indeed the rules. Next M2 is welcome to open the internet to see pictures of the Galvani cell series. It was found that almost all images of galvanic cell circuits on the internet, placing the anode on the left. Based on the drawings, M2 agrees with the concept of Anode is the electrode on the left and the anode on the right.

2. Creation of conflict condition

After viewing images of galvanic cell circuits in books and the internet, M2 believes that in the galvanic cell circuit, the left electrode is the anode and the right is the cathode. At this stage of the conflict presented electrochemical simulation software. This software contains information about the value of E^0, anode position, cathode, positive cover, negative cover, oxidation-reduction reaction, and electron direction. The first and second simulators, M2 perform experiments as M1 does. By looking at the data M2, there is a cognitive conflict at level 4 and M2 realizes that the determination of the anode and cathode is not based on cell position.

The level of conflicts experienced by M2 falls into the very high category. M2 is very surprised at the misconceptions that the possession of the galvanic cells is. M2 is affected by the pictures in books and internet that often put the anode on the left is not a rule. To be more convincing, more simulations are repeated, but electrode selection is done by software randomly. The first simulation of left cell NO_3^- / NO_2 with Pt electrode, right cell F_2 / F^- with Pt electrode, obtained anode on left and cathode on the right side. The simulation of the two left Co^{2+} / Co cells with Co electrode, right cell Zn^{2+} / Zn with Zn electrode, obtained right anode do and cathode on the left. With this repetition, M2 is increasingly aware that the determination of anodes and cathodes is not based on cell position.

3. Giving aid to reach equilibrium

M2 has been convinced that the left cell as the anode and the right cell as the cathode. To provide aid for the occurrence of equilibration in order to form a new concept of how to determine anodes and cathodes, electrochemical simulation software is used. The focus of the software is to find the relationship between the price of E0, the type of electrode, the type of reaction, the type of pole, and the direction of the electron. At the end of the simulation media usage, M2 recognizes the fact that:

a. Electrode with E^0 is greater always as a cathode
b. Electrode with E^0 is greater always as positive pole
c. Electrons always flow from electrode with smaller E^0 to big E^0
d. There is always a reduction in electrode with E^0 greater

After acknowledging that fact, M2 concludes that: Cells with E^0 are larger, acting as cathodes, charged +, undergoing a reduction reaction and moving electrons from smaller E^0 to E^0 are greater. Cells with a smaller E^0 value, acting an anode, charged - (negative), undergoing oxidation reactions and electrons move from larger E^0 to smaller E^0. Equilibration is

reinforced with an interactive medium that presents macroscopic, symbolic, and sub-microscopic representations that are packaged in interactive animations and text. With the interactive media, M2 better understand the way of determination of anode and cathode.

4. Recontruction of the real concept of understanding

The purpose of this stage is to facilitate the formation of concept networks associated with the anodes and cathodes in galvanic cells. M2 can complete an incomplete grid image of a galvanic cell. M2 questioned that to complete the series of images, required Eo data. This question indicates that the conception of M2 is correct. Having found the data E^0, M2 complete smoothly and correctly. Reinforcement was continued by drawing Galvani cell sequence along with its description, with Ag^+ / Ag and Mg^{2+} / Mg electrodes. M2 smoothly finish it. M2 is then required to describe orally the components present in the galvanic cell. M2 can explain fluently and correctly.

Finally reinforced by showing the application of galvanic cells in everyday life, namely the series of galvanic cells from the fruiting fruit with a nail (iron) and metal (copper) electrodes. M2 can correctly identify the anode, cathode, electron flow, the reaction that occurs. At this stage indicates that M2 already has an understanding of the galvanic cell components correctly. M2 believes that the concept will continue to be remembered until the teacher later. M2 is very happy to follow this remediation. When offered for the second remediation, M2 immediately agreed.

5. Retention Test

After 2 months from the remediation stage, tests are performed to determine the burden of misconceptions. The misconception load experienced by M2 is 0%.

C. Discussion

M1 and M2 are students with a balanced visual-verbal learning style and have good academic skills. Both can pass in 7 semesters with GPA 3.52 and 3.32. When identified the understanding of the concept of electrochemistry M1 has a load of misconceptions 70% and M2 85%. This suggests that misconceptions can be experienced by clever students.

At the beginning of validation misconceptions both feel no problem with understanding the concept of electrochemistry. After identification, both have a weak understanding of the concept of determining the anode and cathode on galvanic cells. Understanding these weak initial concepts are easily transformed into other concepts with images from reliable sources. The repetition of the pictures in the famous book and the internet will be the justification that the picture pattern is the correct rule and must be followed. Images in books and the internet often place an anode on the left. Students with a weak understanding will conclude and believe that in the electrochemical cell, the left cell is the anode. This is the source of the misconception. This condition needs to be considered by book publishers to vary the position of the images of galvanic cell circuits. Both of them pay more attention to the pattern of the image than reading the text that reads on the book or internet.

The Creation of conflict condition is performed by presenting the fact that the anode is not always in the left of the galvanic cell. The facts are presented with the use of

electrochemical simulation software. M1 takes less time compared to M2 to reach the condition that the old concept has been wrong. After seeing these facts, in students, cognitive conflict occurs with different levels. M1 experiences cognitive conflict at level 2.7 whereas M2 is 4. This indicates that the higher the students' misconception burden, the higher the level of cognitive conflict.

The equilibration and reconstruction stages of the real concept of understanding M1 and M2 can travel smoothly. Both can determine the anode and cathode positions based on data E0. Both can also determine the relationship between the Eo data with the electrode cover and the direction of the electron movement. At this stage, it can be shown that if the level of cognitive conflict experienced by students is at a high level, then the equilibrium and reconstruction process of the real concept understanding goes faster.

IV. CONCLUSIONS

The change in the cognitive structure of students occurs through several stages. Those stages are 1. Validation of students' misconception, 2. Creation of conflict conditions, 3. Giving aid to achieve equilibrium, and 4. Reconstruction of the real concept understanding. Each stage has a different path. Students with a balanced verbal-visual learning style, more easily influenced by visual regularity.

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