Learning Media Based on Three Level Representation and Inquiry for Electrolysis Cell Materials

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Abstract. Research has been conducted aimed at designing three-level representation-based learning media in electrolytic cell material. The research product in the form of a model kit equipped with inquiry-based worksheets was developed through the stages of design based research. The model kits and worksheets produced have the characteristics: integrating macroscopic, submicroscopic and symbolic levels of representation, developing the ability of chemical representation and scientific performance. The submicroscopic and symbolic representations are explored using particle models made of magnetism to simulate the transfer of ions and electrons during an electrolysis reaction. Validation and testing of products and inquiry-based worksheets show the product is valid and feasible to use.

1. Introduction

The electrolysis cell is one of the chemical concepts that need to be studied and explained using three levels of chemical representation [1][2]. The level of macroscopic representation is related to chemical changes that can be observed in the electrolysis process. This level can be learned through experimental activities. An explanation of how electron transfer occurs is a sub microscopic level representation. The two levels of representation are then represented symbolically by writing down the equation of the reaction that occurs at both the electrodes and the calculation of the electrolyzed substances [3]. The principle of electrolysis cells is used for the prevention of corrosion through metal coating, metal refining, and separation of elements from their compound[4]. Electrolysis cell experiments in chemical learning are common. Generally, using tools that are available in the laboratory using detailed practicum guides such as 'cookbooks'[5]. Students are asked to assemble electrolysis cells based on images that are available on a worksheet. Electrolysis cell is composed of U tubes or beakers and both electrodes are dipped in an electrolyte solution. In this case, the macroscopic representation of electrolysis cells is explored through observing phenomena in the laboratory. Symbolic levels are usually asked after students finish lab work, that is, students are asked to write down the reactions that occur at the cathode and anode based on their observations. When learning, sub microscop levels are not directly explored, they learn from the handbook that does not explicitly explain how the electron transfer process occurs[2]. In addition, the tendency to use practical worksheets such as 'cookbooks' can result in students only doing lab work techniques, while the ability of inquiry and higher-order thinking is less developed[6][7]. The activities of students working in the laboratory are not just carrying out technical laboratory.
work, but they use methods and procedures to investigate a phenomenon, solve problems so as to develop higher-order thinking skills. Unfortunately, textbooks that are used as references in schools in Indonesia do not reveal the connectedness of the three levels of representation. Analysis of Chemistry textbooks used in High School: shows the tendency of presentation of content using deductive flow, macro phenomena not associated with sub micro level and visualization of the concept through images do not present the exact chemical correlation[8], [9], [10].

Learning practices as described above, showing the separation of representation macroscopic, sub microscopic and symbolic. In fact to understand well a chemical phenomenon, students must be able to connect the three levels of representation as stated by Johnstone[11]. That opinion is also strengthened by findings [12] and [13] which emphasize the importance of the connectedness of the three levels of representation in chemistry learning. Efforts have been made to improve students' ability to relate the three levels of chemical representation using multimedia for the concept of electrolysis, including using animation[5] and virtual laboratories[3]. The learning media is very good for visualizing sub microscopic aspects, but the development of students' macroscopic representation abilities through laboratory activities is not well developed. That is because of their use in fragmented learning. In learning, animation media presents electron transfer in the electrolysis process. The media is displayed after students complete practical activities. In a virtual lab, students can conduct virtual labs and observe the electron transfers that occur simultaneously, as well as the symbolic aspects. However, the use of virtual labs will eliminate aspects of scientific performance of students who need to be trained through practicum in a real lab[14]. Therefore there are two problems faced: 1) Learning electrolysis cells pay less attention to the connectedness of the three levels of representation; 2) The tendency to use practical worksheets such as 'cookbooks' can result in students only doing lab work techniques, while the ability of inquiry and higher-order thinking is less developed. To overcome these problems media and learning materials are needed to improve students' understanding of the electrolysis process by using the principle of inquiry and three levels of representation. This paper discusses the results of the development of electrolysis cell learning media based on three levels of representation and inquiry worksheets, which include: media characteristics and trial results.

2. Method

Electrolysis cell learning media products aimed at developing the representation and inquiry abilities of students are developed using the Design based research stage as suggested by Barab & Squire [15]. Stages of research conducted, as follows: 1) Preliminary study in the form of analysis and mapping of content and context; 2) design products; making electrolysis cell media design in the form of a basic picture contained in a flow chart. Then it is developed into a product design with the help of image processing applications to fit the stated goals. Determination of inquiry indicators and three levels of representation. The Product design is used as a guideline for making electrolytic cell props. Student worksheets are developed based on inquiry indicators and representation ability. 3) Validation and feasibility test: Products are validated by three expert validators. The results of the product revision are used for a limited test to determine product eligibility. The feasibility test was conducted on 20 students of class XII in one of the senior high schools.

3. Result and Discussion

The product being developed is an electrolysis cell kit which is equipped with inquiry-based worksheet and visual submicroscopic model. Based on the analysis of representation, the electrolysis process is related to macroscopic representation, submicroscopic representation and symbolic representation. Therefore, researchers made two props designs, first for the macroscopic level, the second for the submicroscopic and symbolic levels. At the macroscopic level, electrolysis apparatus designs can be used for metal coating experiments. For submicroscopic and symbolic levels, a particle model made of magnetic chips is used. The magnetic strip is affixed to a sticker to mark the particle it represents. The use of magnets is intended to make it easier for students to manipulate the particle model so that it does not fall apart. For this reason, the bottom of the board visualizes an electrolysis cell chart using a material made of zinc-alloy plates mixed with iron. By using the magnetic particle...
model, students can simulate the transfer of electrons and the movement of atoms or ions in the electrolysis process. The visualization of the design of the two props can be seen in Figure 1 and 2.

Figure 1. Electrolysis experimental device (A model kit)

Figure 2. Particles model for visualization of submicroscopic

The use of electrolysis media kits is guided by a number of inquiry questions so students can find their own concepts. Student worksheets contain discourse, inquiry questions and performance assignments. The worksheet developed refers to the steps of guided inquiry [6]. Based on the principle of inquiry, the discourse presented on the worksheet is intended to encourage students to formulate problems and find solutions to problems. Student activities are directed through questions and inquiry assignments that must be completed. The questions and inquiry tasks presented in the worksheet are as follows:

1) Make a problem statement and hypothesis that is in accordance with the problem statement.
2) Determine the experiment variables (dependent, independent and control variables).
3) Designing experiments in the form of diagrams.
4) Predict the electrode which acts as an anode and cathode as well as possible reaction results based on standard reduction potential.
5) Drawing of electrolysis cell diagram.
6) Conducting experiments and write data observation.
7) Drawing submicroscopic processes based on observations of experiments conducted (using visualization models).
8) Write down the redox reaction equation and calculate the substances resulting from the electrolysis reaction

9) Concluded based on the results of data analysis

10) Write a report and present it to the class

The discourse on the worksheet presented is based on the metal coating context. The first to sixth inquiry tasks reflect the ability of macroscopic representation. The seventh inquiry task is a sub-microscopic representation and the subsequent inquiry task is a symbolic representation. As such, student worksheets have characteristics that correspond to tetrahedral chemistry as stated by Johnstone[16].

Student activities on the feasibility test using the model kit can be seen in Figure 3 and 4.

Figure 3. Student use the electrolysis cell experiment kit model on trial test

Figure 4. Student describe sub-microscopic processes

Data obtained from the results of validation and due diligence shows $r_{count}$ average count for products is 0.93 and 0.97 so that the product has high validity and is very suitable for use in chemistry learning.

4. Conclusion

The model kits and worksheets produced have the characteristics: integrating macroscopic, sub-microscopic and symbolic levels of representation, developing the ability of chemical representation
and scientific performance. The sub-microscopic and symbolic representations are explored using particle models made of magnetism to simulate the transfer of ions and electrons during an electrolysis reaction. Validation and testing of products and inquiry-based worksheets show the product is valid and feasible to use.

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