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Teaching Learning Sequence About Green Chemistry and Eco-Batteries: A Results from Qualitative Content Analysis

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Abstract.
Batteries can generate electricity as direct current through and electrochemical process called and oxidation-reduction. Batteries can be converted into eco-batteries so that they are able to provide supplies for the community to create energy from renewable sources. This is in accordance to the aspect of green chemistry that can be integrated into learning. This study aims to obtain produce concept maps and Teaching Learning Sequences (TLS) from scientist's conceptions in the context of eco-batteries. The method used in this research is qualitative content analysis using literature analysis. The literature used in the qualitative content analysis is in the form of textbooks, review articles and research articles. The instrument used in this study includes a content analysis format, which is described descriptively to build students understanding of the principles of green chemistry in the context of eco-batteries. The results showed that the concept map and TLS agreed on the relationship between green chemistry, content and context were found that eco- batteries are an alternative to overcome pollutants from fossil fuels by utilizing the principles of green chemistry. TLS describes the learning flow with several sequencing, 1) fossil fuels, 2) definitions and components in batteries, 3) redox reaction materials 4) examples of Eco-batteries oriented to green chemistry. Eco-batteries in learning can integrate redox concepts that involve aspects of green chemistry, using renewable raw materials and safe chemical products. The results of concept maps and TLS in this study can be used as a basis for designing of teaching material and lesson design.

Keywords: Teaching Learning Sequence, Green Chemistry, Eco-Batteries

1. INTRODUCTION

Economic development is increasingly requiring large energy consumption, thereby accelerating the exploitation of natural resources. The continuous use of fossil fuels throughout the world, brings serious challenges to energy scarcity and climate change [1]. One of the phenomena that is often encountered is the use of vehicle fuel from motorcycles and cars, which results in the occurrence of pollutants [2]. One way to avoid this, governments around the world conclude that we must develop sustainable “green” economic and consumption policies, so that green energy can replace fossil fuels to meet future friendly energy needs [3, 4]. In addition, it can be done through the use of environmentally friendly materials [5]. such as alternative fuels that can convert solar and wind energy into electrical energy such as electric cars using environmentally friendly batteries and utilizing green energy sources (Green Chemistry) [6].

Environmentally friendly batteries are batteries that do not contain hazardous materials and do not pollute the environment. Batteries consist of one or more electrochemical cells which are devices that generate electricity through an electrochemical process [7]. The energy of the battery as an environmentally friendly material comes from a spontaneous redox reaction in which electron transfer is forced to take place through a connecting wire [6]. But many batteries use toxic electrodes, so environmentally friendly batteries play an important role in saving energy from renewable energy sources by utilizing sustainable green chemistry [7].

Batteries are one of the learning topics that can integrate the principles of green chemistry from the aspect of using renewable raw materials and safe chemical products. Integrated learning in green chemistry can provide content and pedagogical knowledge so as to increase environmental awareness, positive behavior to solve environmental problems and motivation in changing behavior towards a sustainable direction [8]. Learning should be designed in advance by making a concept map. A concept map is one that is used by teachers/lecturers in guiding students to develop systematic and structured learning concepts so that they can be seen from one concept to another [9]. Concept map is a simple and intuitive method of representing knowledge in a more flexibel and natural [10] In this study, the concept map serves as an initial description of the interrelationships between concepts that will be developed in TLS (Teaching Learning Sequences). TLS is a term to describe the sequence of stages of teaching and learning activities that have been adapted to the needs of students [11]. So that TLS is very important in learning in schools in order to know the sequence of teaching from beginning to end which is made using a concept map.

Based on several studies regarding teaching learning sequencing, shows that this teaching sequence allows students to participate more in learning chemical concepts with questions given according to TLS and the teaching sequence allows teachers and students to avoid misconceptions and overcome learning difficulties [12–14]. From these three studies, it can be seen that the preparation of the learning sequence is very necessary before the teacher teaches students. However, these three studies have not made TLS using a more specific chemical context and the TLS made has not included aspects of green chemistry in it. Based on this, the researcher is interested in conducting research with the title “Teaching Learning Sequence about Green Chemistry and Eco-Batteries: A Results from Qualitative Content Analysis”.

2. RESEARCH method

The method used in this study is qualitative content analysis, with the type of literature analysis [15]. This research flow scheme follows the stages of qualitative content analysis [16] which can be seen in Figure 2.

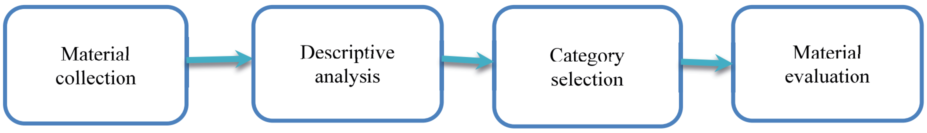

Figure 1: Qualitative content analysis stages.

This research procedure starts from the first stage, namely the collection of materials. Content material for analysis was collected from various sources such as textbooks, monographs, review articles and research articles. At the literature collection stage, several things need to be considered, namely (1) the sources used must be following the context being analyzed, (2) the reputation of the article must be considered, (3) books and articles should be in English [17], and (4) choosing the latest articles is least 10 years and under. Over all the number of books and journals analyzed must be at least 5. This aims to obtain an explanation and design of a more directed learning sequence. Tables used in Instruments contain title, author, year of publication and code. Next is the descriptive analysis stage.

The descriptive analysis stage contains activities to describe the contents of the analyzed and collected sources. The instruments used are presented in the form of Table 1. The results of the analysis of several sources are reduced to produce a basic text that describes the content being analyzed. The instrument used is a qualitative content analysis format which is shown in Table 2. The next stage is the category selection stage, the activity of structuring the results of content analysis. At this stage, the researcher incorporates the pedagogical and didactic aspects of the content being analyzed. The last stage is the material evaluation stage, which is the stage of reviewing research material from beginning to end so that it can be translated into a systematic concept map and TLS. More detailed research, can be seen in Figure ??.

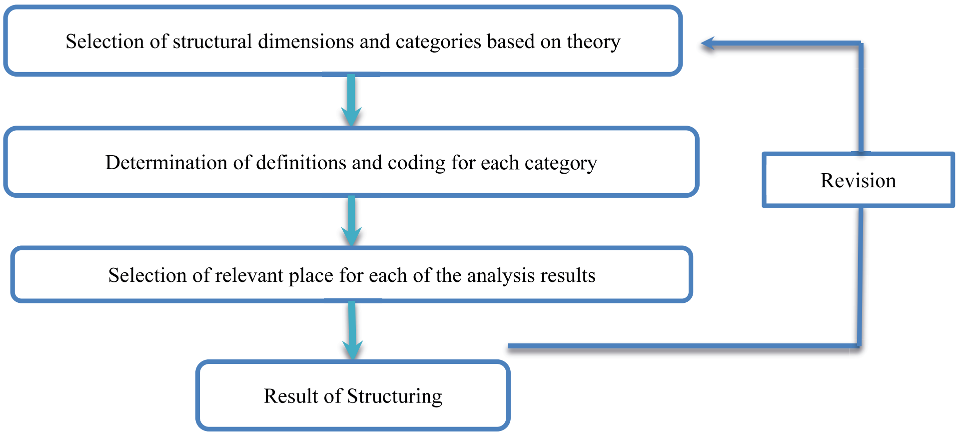

Figure 2: Structuring process of content analysis results.

The instrument in this study is the format used at the material collection and descriptive analysis stages. The instrument format at the material collection stage shows the titles of several sources along with the year of publication and the author is equipped with the code used in the analysis results. The format of the instrument can be seen in Table 1.

TABLE 1: Material collection instrument format.

Title	Year	Author	Code
.....	....	....	....
.....	....	....	....

This instrument used in the descriptive analysis stage is a content analysis format that contains a summary of results of the analysis. The format of the descriptive analysis instrument can be seen in Table 2.

TABLE 2: Descriptive analysis instrument format.

Content	Analysis Results
....	....

3. result and discussion

3.1. Material Collection

The first stage is the collection of materials. Sources of literature used in collecting materials came from textbooks, review articles and research articles. The search for various literature sources was carried out using the help of the pages https://scholar.google.com, https://www.journals.elsevier.com, https://www.springer.com/gp. The literature sources are used as reference material in compiling the content analysis. The results obtained are as many as 7 literatures that are suitable for analysis. The literature obtained consists of 2 sources from books, 4 from review articles and 1 research articles.

The literature collected was published in 2009-2021. After being collected, it was entered into the format of the material collection instrument by giving a code to distinguish the sources obtained. Codes B1, and B2, were used for literature from books, and codes RV1. RV2, RV3 and RV4 for review journal and than codes RS1 for research articles. For more details, see Table 3 showing a list of literature and codes used for analysis related to environmentally friendly batteries

Table 3: The sources of material analyzed.

Title	**Year**	**Author**	**Code**
Chemistry Innovations in Sustainable Development	2011	Desha, C., Hargroves, K. & Farr, A.	B1
Chemistry The Molecular Nature of Matter	2012	Brady,J. E., Jespersen, N. D., & Hyslop, A.	B2
Lithium-ion batteries: outlook on present, future, and hybridized technologies	2019	Taehoon.K, *et al.*	RV1
Li-ion battery materials: Present and future	2015	Nitta, N., Wu, F., Lee, J. T., & Yushin, G	RV2
Erratum: Contribution of li-ion batteries to the environmental impact of electric vehicles	2010	Dominic, A. *et al.*	RV3
Toward Green Battery Cells: Perspective on Materials and Technologies	2020	Dühnen, S. *et al.*	RV4
Eco-Friendly Batteries from Rice Husks and Wood Grain	2021	Nurjamil, A. M. *et al.*	RS1

3.2. Descriptive Analysis

The second stage is descriptive analysis, in this stage the literature sources that have been obtained in the first stage are then analysed and described. Table 1 analysis was carried out through an inductive approach. From the 7 literatures obtained scientists' conceptions including the phenomenon of fossil fuels, battery definitions, components, redox reactions of reaction processes in batteries and examples of environmentally friendly batteries, some of the results from the analysis of this stage are presented in Table 2.

TABLE 4: The results of the analysis of eco-batteries content from various literature.

Content	Analysis Results
Eco-Batteries	Environmentally friendly batteries have become a renewable resource by utilizing green energy sources as portable devices that replace fossil fuel sources (B1) [3]. Batteries consist of one or more electrochemical cells which are devices that generate electricity through an electrochemical process (RS1) [6]. The battery component consists of 4 components starting from the positive electrode (cathode), negative electrode (anode), electrolyte and separator [18]. An example of an environmentally friendly battery is a lithium ion battery (M1, M2) [19, 20]. Lithium ion batteries have a good combination of energy and density making them the technology of choice for portable electronics and hybrid vehicles. Li-ion batteries have an unrivalled combination of high energy and power density. The element lithium is the most electropositive metal and also the lightest metal. Lithium ion battery is one technology that is able to meet the requirements as a source of rechargeable energy and its environmental impact, namely the sustainability of batteries for the future. There are several examples of environmentally friendly battery materials, namely the manufacture of wood and rice husks as an absorber of electrolyte solutions in batteries, lithium ion battery anodes using green tea (RS2) [21].
Redox Reaction Materials	Oxidation-reduction (redox) reactions are electrons transferred from one substance to another, which are collectively called electron transfer reactions. Oxide describes the loss of electrons by one reactant whereas reduction describes the gain of electrons by another. Redox reactions occur because one substance must accept electrons from another substance (B1) [3]. Redox reactions are based on electrochemical processes (B2) [6]. Electrochemical cells consist of a galvanic cell which is a spontaneous redox reaction to generate electricity and an electrolytic cell, which is a non-spontaneous redox reaction to generate electricity. To produce useful electrical energy, it involves two half-reactions consisting of an oxidation half-reaction and a half-reaction at the anode which loses electrons and a reduction half-reaction at the cathode which accepts electrons. The full reaction can be completed if there is an external electrical circuit connected to the cathode. The link is called a salt bridge. A salt bridge is a tube filled with a salt solution consisting of ions that are not involved in the cell reaction. The principle of the galvanic cell is that the solution in both cells must remain constant, which is expressed by cell notation (B1, B2) [3, 6].

3.3. Category Selection

This stage is the category selection stage. Based on the findings from the previous stage, the results of the content analysis need to be structured. Structured aims to see the pattern of relationships and interactions of the components involved. From the analysis results are categorized into 4 parts consisting of 1) Fossil fuels, this section includes examples of fossil fuels, benefits to the impact of fossil fuels 2) Alternative fuels using batteries , this section describes the battery starting from the definition of the battery and the components contained in the battery 3) redox reaction materials, the third section describes redox reactions and electrochemical cells consisting of galvanic cells and electrolysis cells and 4) examples of environmentally friendly batteries using the principle of green chemistry, illustrates examples of environmentally friendly batteries, their principles and advantages.

3.4. Material Evaluation

The concepts that have been obtained from the previous stage can be described into a concept map and TLS. The results of the concept map and TLS can be seen in Fig. 3. Each concept that has been compiled is connected with questions that will show the relationship between each stage. The first stage starts with What are the fossil fuels that we use and how does it impact life? This question will be answered in stage 1 which discusses fossil fuels. And to connect stage 1 with stage 2, the question is asked “what should be done to reduce the risk of environmental damage and climate change due to pollution from motorcycle and car fuels?”. The questions asked will be answered in stage 2 which discusses alternative fuels using batteries. At this stage, the definition of a battery will be discussed, the battery components consisting of a positive electrode (anode), a negative electrode (cathode), electrolyte and a separator. After that, to connect stage 2 with stage 3, the question “What chemical reaction occurs in the battery?”. The third stage describes materials related to batteries, namely redox reactions in which an electrochemical cell consisting of a galvanic cell and electrolysis will be described. Starting from the definition, cathode anode galvanic cell and electrolysis to the principle. Then for stage 4 or the last stage related to the question “what are examples of environmentally friendly batteries that can be used in electric vehicles? This question will be answered by explaining an example of an environmentally friendly battery, namely a lithium ion battery in which it will be related to the principle of green chemistry, namely chemical products that are safe and use renewable raw materials.

4. CONCLUSION

The conclusion of this study shows that the analysis can be carried out through 4 stages: material collection, descriptive analysis, category selection and material evaluation. The resulting concept map and TLS show that eco-batteries can be used as examples in a contextual learning process that involves the principles of green chemistry and sustainability aspects. TLS describes the learning flow with several sequencing, 1) fossil fuels, 2) definitions and components in batteries, 3) redox reaction materials 4) examples

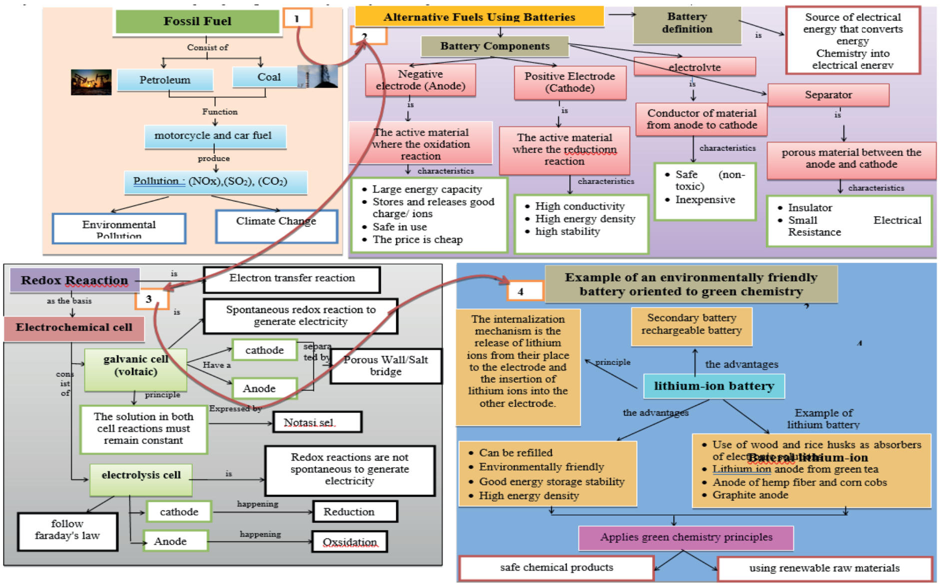

Figure 3: Concept map and TLS.

of Eco-batteries oriented to green chemistry. This concept map and TLS will be further developed and used as the basis for making teaching materials and lesson design.

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