Effectiveness of Dry Cell Microscopic Simulation (DCMS) to Promote Conceptual Understanding about Battery

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Abstract. Electricity is a concept that is abstract and difficult to see by eye directly, one example electric shock, but cannot see the movement of electric current so that students have difficulty by students. A computer simulation designed to improve the understanding of the concept of the workings of the dry cell (battery). This study was conducted to 82 students (aged 18-20 years) in the experimental group by learning to use the Dry Cell Microscopic Simulation (DCMS). The result shows the improving of students’ conceptual understanding scores from post test were statistically significantly of the workings of batteries. The implication using computer simulations designed to overcome the difficulties of conceptual understanding, can effectively help students in facilitating conceptual change.

1. Introduction
The battery is a device that can store chemical energy and make electricity when needed. The battery has been widely known in its use as an energy source electronic items such as toys, flashlights, and others. Excellence battery as a source of electrical energy is the ease to carry. Electricity generated by a battery arising from potential difference electrical energy both pieces of the electrodes. The potential difference is known as the cell potential or electromotive force. To complete the reaction within the battery needed a charge transfer media and an external circuit as the electric flow path.

Natural phenomena are formed when there is an interaction between matter (objects) with energy. So really it was studying the physics of matter, energy, and the interaction between them. For example
in everyday life are observable phenomena that is increasing the temperature of a substance when heated. This event is actually an interaction between substances with the effect of heat energy on the rising temperature of the substance. To be able to answer the questions above is necessary to study more fundamental to the microscopic level of the object. “Macroscopic system to answer and understand how important of the questions we ask about macroscopic systems” [16]. The simulation may be used as an alternative instructional tool, in order to help students to confront and constructed their basic of scientific conception and developed their understanding [14]. If the student has a certain conception and that conception is different from the scientific conception, then said to the student experience misconceptions [20]. Especially for materials which are microscopic physics. For example, a battery can work if the interactions between its constituent molecules.

The low level of understanding of the concept which achieved the detection of students and students who have misconceptions (misconceptions) allegedly closely associated with learning physics implemented is still conventional. Based on observations in the classroom and learning plan documents study, data showed that the learning process is carried still using the traditional pattern, which centered learning lecturer lecturing dominated by the verbal information so that students tend to be a listener.

To visualize the phenomenon of microscopic physics simulation or visualization media needed to model the phenomenon of microscopic invisible becomes as if viewable. For example, the temperature of a substance that microscopically illustrated by the level of the velocity of constituent particles. Simulation of the battery as well as that of the circuit being powered Allows determination of high performance and minimum energy operational modes [20]. The faster the movement of electrons moving from the positive pole to pole negative then the current generated is also getting stronger. Because of the size of the constituent particles of substances is very small and cannot be observed senses of sight, the movement also cannot be observed much less understood. If the movement of the particles of matter can be visualized it will be easy to understand. [2] states that "An instructional simulation Often involves concrete and abstract representations of objects". Learning physics by using virtual simulations can visualize abstract concepts become real.

Media simulated been learning physics concepts microscopic phenomena is needed both for learning the physics-oriented conception of construction and reconstruction of learning-oriented conception. Characteristics of learning physics oriented conception construction is learning physics in which there are the build process from the initial conception of physics do not understand the concept of being understood concept. Therefore, it takes a real step in the learning process to construct knowledge and correcting (reconstruct) the concept if not in accordance with the scientific context [21]. Evidence has been going on in a person's conception of construction can be seen from the level of understanding (level of understanding). Construction conception performed on the learning physics simulation using virtual calls for construction-related conception comprehension level (level of understanding) students and conception in reducing misconceptions [27]. Stages of construction of learning begins with the conception of preliminary activities, which consists of core activities (Prediction, Experience and Reflection) and cover. In the learning stages of construction conception of lecturers serving phenomena or events, which aired in the form of microscopic phenomena. Microscopic phenomena using the virtual simulation carried out in several stages of construction conception of learning. While the material studied and served in the learning-oriented conception construction on the concept of the battery.

However, look at the battery that requires media to be able to see the movement of electrical current needed a computer simulation designed to enhance understanding of the concept of working from dry cells (batteries). Because the particle size that size microscopic, small chance conceptual changes can be made by direct experience. So that the required simulation as a tool to visualize the concept microscopic, through virtual simulation. Virtual multimedia development stage that is done in this study included the analysis phase, the planning or design, production, and evaluation [15].

One software application that can be used to create a virtual simulation is Macromedia Flash 8.0. Some of the advantages possessed by this simulation can combine text, animation, sound and color.
Based on the description that has been stated above, then the formulation of the problem in general is: "What Dry Cell Microscopic Simulation (DCMS) to Promote Conceptual Understanding about Battery?". Research problems above can be translated into research questions as follows: (1) How DCMS characteristics developed for learning the physics-oriented conception construction? (2) Is the use of learning physics DCMS has developed highly effective in constructing scientific conception in the minds of students? "

2. Microscopic Virtual Simulations in Physics Learning

Modern service systems are complex, multifactor systems of a distributed nature. For teaching and studying how interactions, decisions, and collaboration of different parties are managed when designing and deploying complex systems, and simulations for learning approaches are gaining popularity [31], [28]. Some virtual media related teaching materials have been developed partly physics at the University of Colorado PhET Simulation in the form that can be accessed and downloaded for free by the public. The use of virtual simulation of microscopic phenomena in physics learning, some researchers have published the results of its investigations both learning physics oriented conception construction or reconstruction of conception. [3], [4] the use of virtual media can change the conception of students who have misconceptions through in-depth restructuring concept. Besides virtual media can also give way scientific reasoning in studying the concept of thermal expansion and heat transfer. research results [17] and [9] the use of virtual media can assist students in building-related conception velocity and acceleration in the motion of projectiles. [1] the use of computer simulations in learning Newton's laws of motion can help remediate misconceptions that occur on college campuses. [5] that the use of simulation media on material climate change could facilitate construction of the transformation in the conception in the minds of students. Results of research [11] learning with media simulation can reduce the quantity of student misconceptions in the optical material. [34] the use of media simulation of light and color dispersion is effective in helping students to construct its conception so that the ability to understand can be improved; [21] that the use of virtual simulation media on the concept of light waves to enhance understanding of the concept of wave and help the process of changing the conception (Conceptual Change) students to the scientific conception. Simulation battery performance of a digital circuit [19].

3. Understanding of the Concepts

In recent decades, research have publicized that students move toward to science lessons by instructional conceptions and ideas concerning the phenomena and concepts to be academic that are not in harmony amid knowledge views. Besides, conceptions and ideas are firmly held and are resistant to change [12], [13]. The first was [10] dictum that the most important single factor influencing learning is what the learner already knows and hence to teach the learner accordingly. The second theoretical perspective was Piaget’s idea of the interplay of assimilation and accommodation.

His clinical interview method deeply influenced research on investigating students’ conceptions [33]. By the end of the 1970s and the beginning of the 1980s preliminary conceptual change ideas addressing students’ conceptions were revealed in the various studies that developed. [32] identify four possible strategies within this theoretical framework:

1. Integrating students' existing conceptions with scientific conceptions,
2. Differentiating existing conceptions into separate but more clearly defined conceptions to show the students that their alternative ideas are not plausible in related situations (not general).
3. Exchanging the entire alternative conception for the scientific conception after demonstrating the explanatory and predictive power of the scientific conception, and
4. Conceptual bridging (described as bridging analogies above).

Most conceptual change strategies were designed based on students’ alternative conceptions [7]. Conceptual change texts that can be used to overcome some common misconceptions regarding
“sound intensity” and “how fast sound travels” [22]. It is suggested that combining different conceptual change methods such conceptual change text/refutation text, argumentation with the intervention may be more effective in reducing student alternative conceptions [6]. Development of conceptual change in the teaching of aspects important the nature of science [25].

However, teaching with analogies is an effective teaching method for higher learning achievement and in preventing misconceptions [26]. Conceptual change strategy was designed based on students’ alternative conceptions. Consistency conception of the students in this study includes the pattern of student answers using the same concept models in answering a series of questions asking the same concept. This data was obtained through the conception consistency test instruments tested one by asking questions with the same concept more than once.

In this research, Conceptual change based on students’ alternative conceptions reduce with DCMS. Because DCMS of battery is the ability to make normally unobservable occurrences plainly visible for the student. These may be processes that:
1. are microscopic such as particle,
2. have many complex sub-processes such as moved electron
3. computer simulations can be credible representations of reality, and
4. remediation produced significant conceptual change in those students holding alternative conceptions.

4. Method

4.1. Research Design
The purpose of the present study is to investigate the effects of Dry Cell Microscopic Simulation (DCMS) to Promote Conceptual Understanding about Battery. Quantitative study design used is one-group pretest posttest design with a scheme according to [8]. Tests of understanding the concept of the experimental class applied using One group posttest only design as shown in Figure 1.

![Figure 1. Design One Group Posttest Only](image)

Information:
O: The test conceptual understanding of physics of microscopic phenomena
X: Treatment in the form of Interactive Learning Lecture Demonstration using DCMS experimental group.

4.2. Study Participants
A total of 82 student-respondents in their eleventh grade, age ranges from 18 to 21 years. The sample was randomly selected from second year student teachers undertaking an introductory physics course. A few parts of these students have already studied electricity and magnetism in physics lessons in high school; but the other students took this subject for the first time in their physics courses at university physics education, Universitas Sultan Ageng Tirtayasa, Serang City, Banten, Indonesia.

4.3. Instrument and Data Collection Process
An achievement test, developed by the researchers, about conceptual understanding about battery composed of 3 open-ended questions or items, was used as a data-gathering instrument. In the first part of the test, an everyday example or sample case was presented to students.

| Table 1. Learning Models and Instruments |
|----------------------------------------|
| Learning Variables                     |
| Construction of conception using the model | 1. Level of understanding |
| Interactive Lecture Demonstration (ILD) | 2. Model of understanding |
They were asked questions about the “sample case” that probed their ability to explain the sample case (Item A), determine the physics law explaining the sample case (Item B) and provide an additional sample case about related law (Item C). Overall, three questions were asked about conceptual understanding about battery, totaling nine questions in all. In the second part of the test, participants were asked three questions about defining conceptual understanding about battery (Item D). We introduce the test items below:

**Problem 1**

A. In everyday life often find dry battery, the flashlight, a toy children and remote. So we often define as an element batteries (cells) source of direct current which work by converting chemical energy into electrical energy. The dry battery components as shown in the figure.

![Dry battery components](image)

Try to explain why up to a microscopic level when a convert chemical energy into electrical energy?

B. The concept of physics what can be used to explain the relationship between chemical energy can be transformed into electrical energy is?

C. Try to put forward other examples in everyday life related to the physics concepts?

D. Based on the answers to the items of the previous question please you define the concept of physics?

**Problem 2**

A. When we use the dry battery mounted on a flashlight, when we are to the ON switch, the light goes on. The process of the lights on a chemical oxidation reaction occurs in the battery.

\[ \text{Zn} + \text{2MnO}_{2} + \text{2H}_{2}\text{O} \rightarrow \text{ZnO} \cdot \text{2MnO}_{2} + \text{2HM} \text{O} + \text{energy} \]

![Zn and MnO2 reaction](image)

Try to explain to the microscopic level of oxidation-reduction reaction process on a dry battery?

B. The concept of physics what can be used for explain the events mentioned above?

C. Try to put forward other examples in everyday life related to the physics concepts?

D. Based on the answers to the items of the previous question please you define the concept of physics?

**Problem 3**

A. When a dry battery has a battery inside the electric energy then there is the electron charge will always move.

B. The concept of what physics can be used to explain the above phenomenon?

C. Try to put forward other examples in everyday life related to the physics concepts?

D. Based on the answers to the items of the previous question please you define the concept of physics?

One researcher completed the data collection during introductory physics courses. Students were given 40 minute to complete the test and they were encouraged to freely express their thoughts. They were assured that it was not an examination and their answers were not to be used in order to evaluate their academic levels.

### 4.4. Data Analysis

Student responses were analyzed in two ways. The first identified the student level of understanding and the second identified the student model of understanding. The analysis of understanding level is a suitable analysis method, which gives a general view of the academic level of participants about each question on an achievement test. On the other hand, the student model of understanding helps to analyze a student’s answers to all questions about a subject, in other words, helps to analyze students
answers individually. In that way, one can find a link between the students knowledge about a subject. In other words, one can reach some clues about students mental model. Because mental models are used to construct new knowledge, it is important to reach some understanding about them. As there are mental models composed by the students behind the meaningful learning [12]. Data obtained from the instrument was analyzed to understand levels of understanding as suggested by [7]. Model of understanding were adapted from the Student’s Model of Understanding in Typology of Perceived Knowledge as suggested by [27].

5. Analysis

5.1. Development Dry Cell Microscopic Simulation (DCMS)
Virtual multimedia development stage that is done in this study included the analysis phase, the planning or design, production, and evaluation [15]. Analysis of the curriculum successfully selected thermal expansion of solids material with consideration of the material contains some abstract concept, so that very precise when made interactive multimedia that can simulate events that are difficult to observe by students and can simulate the dry cell (battery). Result it showed that the use of virtual media can change the conception of learners who have conceptual understanding through restructuring concept in depth [4].

Figure 2. Result Development of Dry Cell Microscopic Simulation of understanding Concept of battery

Figure 3. Reaction of zing electrode and carbon electrode for Dry Cell Microscopic Simulation
5.2. Students’ level of understanding

The findings from conceptual understanding test are presented using the headings students’ level of understanding and students’ model of understanding. The findings from the achievement test are presented below after analyzing each item about battery.

**Table 2. Students’ level of understanding**

| Level Understanding          | Indicator                                                                 | Concept Battery | Average |
|------------------------------|---------------------------------------------------------------------------|-----------------|---------|
| [4] Understanding the Whole (UW) | Correctly answered all the questions in a matter of                        | 40 49 38 46 36 44 46 |
| [3] Understanding the Majority (UM) | Answering the questions correctly in part on a matter                      | 24 29 25 30 22 27 29 |
| [2] In Erroneous Understanding (MSK) | With all the questions answered on a question but the answer is not clear, or the answer is wrong | 10 12 11 13 13 16 14 |
| [1] Not Understand (UN) | Answered all the questions on a problem but the answer given is not appropriate (irrelevant) with any questions. | 6 7 6 7 8 10 8 |
| [0] No Answer (NA) | Does not provide answers to all the questions on an items | 2 2 2 2 3 4 3 |

Based on Table 2 obtained information that in consecutive average level of understanding of each concept battery from high to low after the application of learning physics conception construction by using DCMS. The average percentage of Understanding the Whole (UW) of level medium.

5.3. Students’ Model of understanding

The findings from the achievement test are presented below after analyzing each item about battery.

**Table 3. Students’ Model of Understanding**

| Model Understanding          | Characteristics Answer Students                                                                 | Concept Battery |
|------------------------------|--------------------------------------------------------------------------------------------------|-----------------|
| Optimal Model (OM)         | Correctly answered the questions A, B, C, D on a matter                                          | 30 28 26       |
| Model Not Creative (MNC)   | Correctly answered only the questions C course at a problem                                       | 19 21 23  |
| Theoretical models (TM)    | Correctly answered only the questions A, B, D only on a matter.                                  | 13 9 13        |
Model Understanding | Characteristics Answer Students | Concept Battery
--- | --- | ---
Practical Model (PM) | Correctly answered only the questions A and C only in a matter of a question on an items | Σ & % 13 (16) 8 (12) Σ & % 8 (10) 9 (11) 2 (10) 3 (11) Σ: Total of students who experienced levels of understanding (the total number of students) %: The percentage of students who experienced the level of understanding 1: Battery Energy Concept 2: The concept of oxidation reduction reaction in the battery 3: The concept of battery function
Memorizing Model (MM) | Correctly answered only the questions D alone on a matter | 8 (10) 9 (11) 2 (10) 3 (11)
Not Have Model (NHM) | Not answered correctly all the questions A, B, C, D on a matter | 2 (2) 3 (4)

5.4. Effectiveness of Using DCMS in Learning Electric Concept
Effectiveness of the media virtual simulation developed in learning physics student oriented conception construction on the concept of battery, the quantity is determined by the percentage of students Understanding the Whole (UW) concept battery. Meanwhile, the effectiveness of the use of DCMS on construction of learning physics oriented conception in helping students construct understanding on the concept of battery.

Table 4. Percentage of quantity Understanding Whole (UW) concept of battery

| Label Conception | Quantity Understanding Whole (UW) % | Category |
| --- | --- | --- |
| KI | 49 | Medium |
| KII | 46 | Medium |
| KIII | 44 | Medium |
| Average | 46 | Medium |

Information:
KI: The concept of Battery Energy KII: Concepts of oxidation reduction reaction in the battery KIII: Concept of battery function

Based on Table 4, obtained information that the average percentage of the quantity of understanding as a whole (MSU) of electrical material after use DCMS in physics oriented learning concept of battery conception construction is 46 %. This percentage when with DCMS effectiveness criteria according to research [21] obtained the criterion of being. It can be concluded that the progression DCMS developed in the battery material "more effective" in the construction of student understanding.

Based on the data, obtained information that that students construct sensible and coherent understandings of phenomena and concepts as seen through Reviews their own eyes that do not match the views that are Universally accepted by the scientific community [14]. Media simulation is effective in helping students to construct its conception so that the ability to understand can be improved [34]. Use of virtual simulation media on the concept improve understanding of the concept of process of changing the conception (Conceptual Change) students towards scientific conception. Learning physics simulation that uses electric magnetic media can change the conception of a student who is not scientific to the scientific conception.
6. Conclusion
This study demonstrates Effectiveness of Dry Cell Microscopic Simulation (DCMS) to Promote Conceptual Understanding about Battery. The results suggested that incorporation of learning by DCMS has the potential for the development of students’ conceptual understanding in science through the mechanical Process of conceptual change. Based on the results of research and discussion of the conclusions of this research are the results presented here show that students working with virtual simulation exhibited significantly higher scores. Our findings strongly support that DCMS can be used as an alternative instructional tool, in order to help students develop an understanding of physics concepts.

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