Student learning by experiment method for analyzing the dynamic electrical circuit and its application in daily life

E. Murdani¹, S. Sumarli²

¹,²Physics Education Department, STKIP Singkawang, Jl. STKIP, Singkawang 79251, INDONESIA

E-mail: ekamurdani@gmail.com¹, sumarliphysics@gmail.com²

Abstract. Resistor is an important component in electronics which function as the electrical resistance or resistor of electric current. In this experiment used 3 identical resistors, that means is having an equal resistance value which is 1000 Ω. From 3 resistors be made into 2 circuits. They are 3 resistors on the series and parallel circuit. The dynamic electrical experiment in an electric circuit used 3 resistors and voltage 3 V. The characteristics of resistance and electric current on the series circuit of 3 resistor is (3000 ± 250) Ω and (100 ± 2.5) 10⁻⁵ A and on the parallel circuit is (350 ± 25) Ω and (850 ± 25) 10⁻⁵ A. The application of learning is in daily life is a lamp for lighting a room. Has been characterized and analyzed the value of voltage and current for the circuit of 3 identical lamps series and parallel with Ohm's law. By using voltage 1.5 V, the electrical current in the circuit of series and parallel is (3 ± 2.5) 10⁻¹ A and (9 ± 2.5) 10⁻¹ A. The intensity of the light on the series of lights is dimmer than the parallel. This experimental testing is done directly by students on the learning process, so that learning can be effective especially on scientific attitude and knowledge transfer. Average Scores of pre-test is 4.5 and post-test is 10.1. Value of N-gain is 0.4, gives information that student learning by experiment method can improve cognitive learning outcomes is in medium criteria on the topics “dynamic electrical and Ohm’s law”.

1. Introduction

Based on the Regulation of National Education Minister is in Indonesian Republic at Number 22 of 2006 year about the Content Standard for Primary and Secondary Education, informed that the Natural Sciences (IPA) related to how find out about the nature systematically, so that science is not just mastery of a collection of knowledge in the form of facts, concepts, or principles, but also a process of discovery. Science education is expected to be a vehicle for students to learn themselves and the environment, and prospects for further development in applying science in daily life. Science learning process emphasizes providing direct experiences to develop competency to explore and understand nature around scientifically. Science education direct to inquiry approach and do something so that it can help a student to get a deeper understanding of the nature around. Natural Sciences needed in daily life to supply human needs with problem solving that can be identified. Application of Natural Sciences needs to be done wisely to keep and conserve the environment. In Junior High School (SMP/MTs) expected emphasis salingtemas learning (science, environment, technology, and society) in an integrated manner that is directed at the learning experience to design and create a creation by application the natural science concepts and wisely scientific attitude competencies.
Learning science should be taken of scientific inquiry (scientific inquiry) to develop thinking skills, scientific attitude (scientific attitude), and communicate them as an important aspect of life skills [1]. Therefore, science learning is in SMP/MTs emphasizes to get learning experience directly by application and development of skill process and scientific attitude. This research used an experiment method in learning process for getting learning experience directly and for developing student scientific attitude.

2. Experimental Methods
Based on the Regulation of National Education Minister in Indonesian Republic at Number 22 of 2006, Natural Science subject is in SMP/MTs aims for student have capabilities following: (1) increasing the religious beliefs to God based on God exist and God creation that is wonderful and stable, (2) Developing an understanding of natural phenomena, concepts and principles of science that are useful and can be applied in daily life, (3) Developing curiosity, positive attitude, and awareness of the existence of a relationship of mutual influence between science, environment, technology, and society, (4) Doing a scientific inquiry to develop the ability to think, act and communicate scientific (5) Increasing awareness to participate in take-caring, keeping and conserving the environment and natural resources, (6) Increasing awareness to appreciate nature and everything regularity as one of God's creation, and (7) Increasing the knowledge, concepts, and skills of science as a basis to continue their education to the next level. This research used an experimental method in the learning process to develop an understanding of natural phenomena, concepts and principles of science that are useful and can be applied in daily life. Natural phenomena are studied in this research is electricity. Natural Sciences concepts and principles are the dynamic electrical and Ohm's law. The application of learning is in daily life is a lamp for lighting a room.

Competency Standards (SK) and the Basic Competency (KD) of Natural Sciences (IPA) is in SMP/MTs is that the national minimum standards to be achieved by students and become a reference in the development of the curriculum in each educational unit. Achievement of SK and KD is based on empowering students to develop the ability, scientific work and knowledge itself facilitated by the teacher. This research was conducted in class IX in one of Junior High School (SMP/MTs) in Singkawang City. The application of the experimental method in SK: (3) Understand the concept of electricity and their application in daily life and KD: (3.2) Analysis the dynamic electrical experiments in the series and its application in daily life. SK and KD are referenced based on the Regulation of National Education Minister in Indonesian Republic at Number 22 of 2006 year about the Content Standard for Primary and Secondary Education. This research used an experiment method in learning process for getting learning experience directly and for developing student scientific attitude.

3. Results and Discussion
Learning is done by experiment can build students' knowledge, so students become active and critical in solving problems [2, 3]. One of the learning that can be done by experiment is a dynamic electrical circuit. In daily life, each electronic component always uses a resistor [4-7]. Resistor is used as a resistance of incoming current [5]. In this learning, students are asked to do an experiment about characteristics of resistance, voltage and current in the resistor circuit. In this experiment, they make own circuit of series and parallel resistor. Then, they measure directly of the voltage, electrical current and the equivalent resistance for each circuit. The First, the research is done by making the concept of the experiment in the form of handy guides or lab manual. The purpose of the experiment referred to SK: (3) and KD (3.2). The purpose of the experiment is to analysis the dynamic electrical circuit and its application in daily life. Dynamic electrical circuit is a circuit that is flowed by direct current. This circuit consists of a DC voltage source and resistance. The resistance used in experiment is resistors and lamps. By analysis the characteristics of the circuit resistor series and parallel, student get the characteristics of voltage, equivalent resistance and electric current. The application of the dynamic electrical circuit in daily life is a lamp for lighting a room.
From 3 resistors be arranged into 2 circuits (Fig. 1). They are 3 resistors on the series circuit and 3 resistors on the parallel circuit. Based on Ohm’s law, the research methods used in this experiment is by giving electric potential difference on the resistor then an electric current will flow, the electric current will flow from high potential to low potential [7-11].

![Resistors Circuit](image)

**Figure 1** Resistors Circuit of (a) Series Resistors, (b) Parallel Resistors

The first experiment was 3 pieces Resistor Series circuit. With step experiments are: (a) Take three identical resistors (has a resistance equal of 1000 Ohm), (b) row three resistor in series, and then measure the equivalent resistance to 3 resistors with an ohmmeter, (c) Give 3 volt electrical potential difference at the two ends of the series resistor wire, measuring the voltage in each resistor using a voltmeter, and the current flowing using ammeters, and (d) Replace series circuit into parallel circuit, do the same thing at series circuit for parallel circuit.

In the first experiment used three identical resistors, that means having an equal resistance value which is 1000 Ω. Resistor of 1000 Ω is used to minimize the influence of the internal resistance of the AVO Meter because it will be used as an instrument to measure of the resistance, the voltage and electric current in the resistor circuit. The characteristic of resistance, voltage and electric current has been tested experimentally. By using 3 V voltage, the expected results of resistance and electric current characteristics be measured by students is (a) $(3000 \pm 250) \ \Omega$ and $(100 \pm 2.5) \times 10^{-5} \ A$ for the series circuit of 3 resistor and (b) $(350 \pm 25) \ \Omega$ and $(850 \pm 25) \times 10^{-5} \ A$ for the parallel circuit of 3 resistor. This experimental testing is done directly by students on the learning process, so that learning can be effective especially on scientific attitude and knowledge transfer.

The second experiment is applying voltage or electric potential difference on the lamp circuit and analysis the electric current and lamp intensity. The application of learning is in daily life is a lamp for lighting a room. Has been characterized and analysis the value of voltage and current for the circuit of 3 identical lamps series and parallel with Ohm's law (Fig. 2). By using 1.5 V voltage, the electrical current in the circuit of series and parallel is $(3 \pm 2.5) \times 10^{-1} \ A$ and $(9 \pm 2.5) \times 10^{-1} \ A$. The intensity of the light on the series of lights is dimmer than the parallel because the electrical current flowing on the series is smaller than the parallel.

![Lamps Circuit](image)

**Figure 2** Lamps Circuit of (a) Series Lamps, (b) Parallel Lamps
The Second, the author collaborated with science teacher at a junior high school in Singkawang City to apply an experiment in learning. Writers and teachers jointly create learning scenarios or RPP for SK (3) and KD (3.2). Indicators of learning are: (1) Mention component electrical circuit, (2) Describe the function of electrical components, (3) Mention the type of electrical circuit, (4) stringing and determine the characteristics of resistance, voltage, and electrical current in the resistor circuit, (5) Mention Ohm's law, (6) Writing Ohm's law formulas, (7) Calculate the electric current with Ohm's law and compared with the results of ammeters, (8) explain the definition of electrical resistance, and (9) Applying voltage or electric potential difference on the lamp circuit and analysis the electric current and lamp intensity.

Learning Outcome by experimental methods is student can analysis the dynamic electrical experiments in the series and its application in daily life. Learning scenarios in the preliminary activities is the teacher gives apperception and pre-test. At the core activities, the teacher gives the material shortly, experimental modules distributed and students perform experiments. Students fill in the table observations and answered questions on the experiment module. At the closing, the teacher gives the post-test and reinforcement material or students concluded the teaching material together with the teacher [2, 3].

Pre-test: (1) There are three pieces of identical resistors of 1000 Ohm, arranged on series, connected with a voltage of 3 volts. Determine: (a) the equivalent resistance of the circuit in the series, (b) voltage on each resistor, and (c) the electric current flowing in each resistor with Ohm's law, (2) Determine the same thing if the resistor is parallelized, and (3) Which is brighter: 3 lamps series or 3 lamps parallel? Post-test: (1) There are three pieces of identical resistors of 100 Ohm, connected with a voltage of 6 volts. Determine: (a) the equivalent resistance of the circuit in the series, (b) voltage on each resistor, and (c) the electric current flowing in each resistor with Ohm's law, (2) Determine the same thing if the resistor arranged in parallel, and (3) Which is brighter: 3 lamps series or 3 lamps parallel? Why? [3].

Pre-test score of 25 students is (1, 1, 2, 2, 2, 2, 2, 3, 3, 4, 4, 4, 4, 4, 4, 4, 5, 5, 5, 5, 5, 6, 6, 6, 6, and 7). Post-test score of 25 students is (6, 7, 8, 8, 8, 8, 9, 9, 9, 9, 9, 10, 10, 10, 11, 11, 11, 12, 12, 12, 12, 14, 14, 14, and 15). Average Scores of pre-test \(\bar{x}_i\) is 3.92 and post-test \(\bar{x}_f\) is 10.32. Maximum score \((x_m)\)is 20. Improved cognitive learning results obtained from the average score pre-test and post-test were normalized by testing the normalized gain (N-gain) using equation (1) [12].

\[
g = \frac{\bar{x}_f - \bar{x}_i}{x_m - \bar{x}_i}
\]

By \(g\) is normalized gain (N-gain). N-gain criteria are given by table 1.

**Table 1.** The criteria of N-gain [12]

| N-gain       | Criteria |
|--------------|----------|
| \(g \geq 0.7\) | High     |
| 0.3 < \(g < 0.7\) | Medium   |
| \(g < 0.3\)    | Low      |

Value of N-gain calculation by using equation (1) is 0.4. Based on Table 1, value 0.4 gives information that has been an increasing in cognitive learning outcomes by medium criteria. Student learning by experiment method can improve cognitive learning outcomes is in medium criteria on SK: (3) and KD (3.2) or on the topics “dynamic electrical and Ohm’s law”.
4. Conclusion
The dynamic electrical experiment in an electric circuit used 3 identical resistors and voltage 3 V. The characteristics of resistance and electric current on the series circuit of 3 resistor is $(3000 \pm 250) \Omega$ and $(100 \pm 2.5) \times 10^{-5} \text{A}$ and on the parallel circuit is $(350 \pm 25) \Omega$ and $(850 \pm 25) \times 10^{-5} \text{A}$. The application of learning is in daily life is a lamp for lighting a room. Has been characterized and analysis the value of voltage and current for the circuit of 3 identical lamps series and parallel with Ohm's law. By using 1.5 V voltage, the electrical current in the circuit of series and parallel is $(3 \pm 2.5) \times 10^{-1} \text{A}$ and $(9 \pm 2.5) \times 10^{-1} \text{A}$. The intensity of the light on the series of lights is dimmer than the parallel. This experimental testing and analysis is done directly by students on the learning process, so that learning can be effective especially on scientific attitude and knowledge transfer. Average Scores of pre-test is 3.92 and post-test is 10.32. Value of N-gain is 0.4, gives information that student learning by experiment method can improve cognitive learning outcomes is in medium criteria on the topics “dynamic electrical and Ohm’s law”.

5. References
[1] Permendiknas 2006 Peraturan Menteri Pendidikan Nasional Republik Indonesia Nomor 22 Tahun 2006 tentang Standar Isi untuk Satuan Pendidikan Dasar dan Menengah Jakarta 377-384
[2] Isliyanti A. Murdani E. et al. 2010 Pembelajaran Praktikum Fisika Berbasis Penelitian: Karakteristik Kawat pada Sekering Pengaman Prosiding Seminar Nasional Fisika 2010 Bandung 471-480
[3] Murdani E. 2015 Student Learning by Experiment for Testing Characteristics of Resistance Voltage and Current in the Resistor Circuit Proceedings International Conference on Mathematics Sciences and Education University of Mataram Lombok 130-133
[4] Murdani E. Sutarno D. 2011 Karakterisasi Kawat untuk Sekering Pengaman Prosiding Symposium Nasional Inovasi Pembelajaran dan Sains (SNIPS) Bandung 164-167
[5] Murdani E. 2016 Characterization of Copper and Nichrome Wires for Safety Fuse J. Phys. Conf. Ser. 776 12099
[6] Ismail B. 1995 Rangkaian Listrik Jilid 1 ITB Bandung 20-35
[7] Soeharto 1992 Fisika Dasar II Listrik-Magnet PT Gramedia Pustaka Utama Jakarta 101-120
[8] Young H.D. and Fredman R.A. 2004 Physics for University 2 Tenth Edition Erlangga Jakarta 222-232
[9] Giancoli D.C. 1998 Physics 2 Fifth Edition Erlangga Jakarta 94-107
[10] Sears F.W. Zemansky M.W. 1994 Physics for University 2 Bina Cipta 257-271
[11] Tipler P.A. 1996 Physics for Science and Technic Third Edition Erlangga Jakarta 154-184
[12] Hake R.R. 1999 Analyzing Change/Gain Scores Department of Physics Indiana University USA 1-4