ANALYSIS OF THE RELATIONSHIP CONCEPTS OF VOLTAGE, CHARGE, CURRENT AND RESISTANCE IN CIRCUIT USING VIRTUAL LAB

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Abstract :
A virtual lab, also known as an online or remote lab, is a web-based educational tool simulating actual laboratory experiments and experiences in a digital environment. This virtual laboratory aims to provide students and researchers with a realistic and interactive learning experience without needing physical laboratory equipment and resources. This study aims to prove that the amount of electric current is inversely proportional to resistance or resistance, as Ohm's law applies by using a virtual lab. The approach used in this study is a quantitative approach to the experimental method. From this practicum, under Ohm's law, it is proven that the relationship between voltage and current is directly proportional. The greater the voltage, the greater the current, and vice versa. And also, the relationship between resistance and current is inversely proportional. The more excellent the resistance or resistance of a conductor, the smaller the current that will flow through the conductor. Conversely, the smaller the resistance of a conductor, the greater the current that will flow through the conductor. Therefore, the virtual lab is suitable to be used as an additional tool to increase students' understanding of Ohm's law and provide students with practical, engaging, and safe learning experiences. As technology advances, virtual laboratories are expected to become more sophisticated and blend with modern education.

Keywords: Ohm's law; Resistance; Voltage

INTRODUCTION

Physics education is part of the field of study related to the process of learning and teaching physics to students (Siboro, 2020). Physics education encompasses curriculum development, teaching methods, learning evaluation, and research in the context of physics education (Auliya, 2019). On the other hand, physics is also a branch of natural science that studies the properties of matter, energy, and the relationship between them. Physics focuses on understanding the universe through fundamental principles, laws, and theories that explain physical phenomena (Putri, 2023).

The main goal of physics education is to help understand the principles of physics, develop problem-solving skills, logical thinking, and utilize scientific methods (Anas, 2021). Furthermore,

physics education also plays a crucial role in developing practical skills, such as laboratory skills, understanding scientific instruments, and utilizing technology in physics experiments (Alatas, 2022).

Virtual laboratory is a concept in physics education where practitioners can experience and conduct physics experiments virtually through computer simulations or interactive software (Aulia, 2023). Virtual laboratory provides a practical experience similar to that encountered in a traditional physical laboratory but utilizing digital technology (Putra, 2023). In the virtual laboratory, practitioners can conduct physics experiments, observe phenomena, measure and analyze data, and observe experimental outcomes. The software used in virtual laboratories often provides animations, interactive simulatiodns, graphs, and measurement tools that allow direct interaction with physics concepts (Jannah, 2023).

In electrical circuits with flowing electric current, there are several reasons for the occurrence of resistance, such as preventing the circuit from exploding and ensuring that the electrical circuit functions properly (Yasu & Hadi, 2021). The theory concerning current, voltage, and resistance is discussed in Ohm's law. Ohm's law states that the magnitude of electric current flowing through a conductor is always directly proportional to the applied potential difference. A circuit can be considered to follow Ohm's law if its resistance value remains independent of the magnitude and polarity of the applied potential difference.

Ohm's law is one of the most fundamental principles in electronics and electricity. This law describes a strong mathematical relationship between four important concepts in the world of electricity: voltage, charge, current, and resistance (Ocvianti, 2021). In this article, we will understand how this relationship is explained in Ohm's law and why this concept is the basis for many modern technological applications (Iskandar, 2020).

Voltage, which is often referred to as potential difference, is the electrical energy produced by the difference in electric potential between two points in a circuit. Voltage is measured in Volts (V). When there is a difference in voltage between two points in a conductor, electric charges which are also called electrons will experience a push or pull force to move from one point to another (Ilmi, 2019). Electric current (I) is the amount of charge flowing through a conductor in one unit of time. The unit commonly used to measure current is the Ampere (A). Current is the flow of electric charge that flows from the voltage source to the load. Resistance (R) is the ability of a material or component to impede the flow of electric current through it. Resistance is measured in Ohms (Ω). The higher the resistance value, the less current can flow through the conductor at a certain voltage (Ilmi, 2019).

Ohm's Law states that the current (I) flowing through a conductor is directly proportional to the voltage (V) applied to the conductor, and vice versa, proportional to the resistance (R) of the conductor. Mathematically, Ohm's law can be expressed in a simple formula:

$$V = I \cdot R \qquad (1)$$

That is, if the voltage (V) increases, the current (I) flowing through the conductor will also increase if the resistance (R) remains constant. Likewise, if the resistance (R) increases, the current (I) will decrease if the voltage (V) remains constant (Aksan, 2023).

In the practicum v.lab we conducted we analyzed the resistance where in an electric circuit we analyzed the existing electrical resistance. This proves from Ohm's law theory that electrical resistance can be obtained by dividing the potential difference between the ends of the conductor and the current flowing in the circuit, or systematically it can be written as I=V/R (Rizaldi & Syahlan, 2020) This practicum aims to prove that the amount of electric current is inversely proportional to the resistance or resistance as Ohm's law applies.

RESEARCH METHOD

The method used in this study uses a quantitative method by processing statistical practicum data virtually, the data can be measured and calculated directly and the explanation is expressed in numbers or numbers. The technique used in data collection is by conducting several experiments and entering different variable values. The steps in this experiment are to adjust the voltage according to what will be analyzed and then retrieve data on the energy received and the speed at which the energy occurs, and then change the resistance value according to what will be analyzed and then retrieve data on the current that occurs, the speed that occurs and the energy received. The data taken is sourced from a virtual laboratory which contains components so as to produce a value for the energy received,

and the speed of the energy. Furthermore, a technique for interpreting an analysis of data is a descriptive technique.

RESULTS AND DISCUSSION

In the first experiment it was carried out to see how the influence of the voltage on the received energy and the current speed on a fixed resistance. As can be seen in Figure 1 as follows.
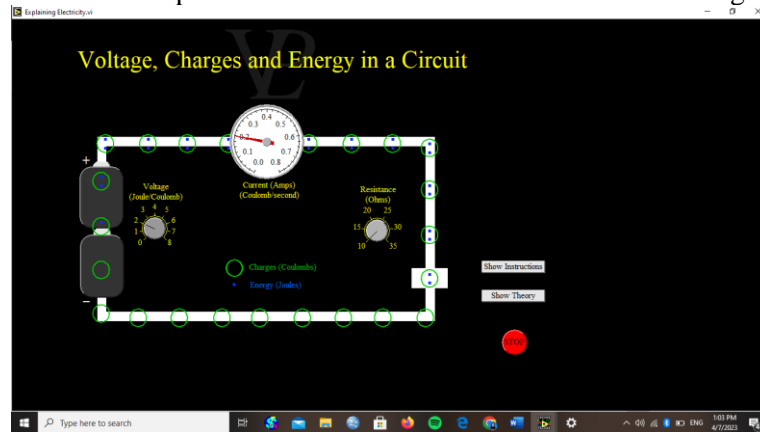

Figure 1. Schematic of the First Experiment

Table 1. Effect of voltage on received energy and current speed

Try To-	Resistance (Ohm)	Current (A)	Voltage (V)	Received Energy (Joule)
1		0,2	2	2
2	10	0,4	4	4
3		0,6	6	6
4		0,8	8	8

The experiment was carried out four times with a fixed resistance of 10 ohms against the voltage resulting in different amounts of received energy. The greater the voltage is increased, the energy received is also greater. When the voltage is set to 2 volts with a resistance of 10 ohms, the energy received is 2 joules. In the second experiment, the voltage value was increased to 4 volts with a fixed resistance value of 10 ohms, so the energy received was also greater, namely 4 joules. In the third experiment, the voltage value was increased to 6 volts with a fixed resistance value of 10 ohms, so the received energy was also greater, namely 6 joules. In the fourth experiment, the voltage value was increased to 8 volts with a fixed resistance value of 10 ohms, so the energy received was also greater, namely 8 joules. Therefore, the greater the energy received, the faster the current speed and the greater the value (Nerindra et al., 2020).

Based on the experimental results that the greater the voltage, the greater the energy received. This is in accordance with the context of electric charge, when the applied voltage increases, the energy received by the charge will be greater. It is based on the basic principle of electric potential energy. (Early, 2020) In an electric field, electric charges can have potential energy that depends on their position relative to the electric field (Iqbal et al., 2020). Electric potential energy can be calculated using the following formula.

$$E = q \; x \; v \qquad (2)$$

Where E is potential energy, q is electric charge, and V is voltage or potential difference (Halliday et al., 2005; Halliday & Resnick, 2005).

By increasing the voltage or potential difference, the potential energy of the electric charges crossing the electric field also increases. This can be viewed in the same way as a charge is considered as an elevated body in a gravitational field. The higher the object is raised, the greater the gravitational potential energy it has (Julianto & Supriyadi, 2013). So, the greater the voltage applied to the charge, the greater the energy received by the charge, as presented in graph 2 as follows.
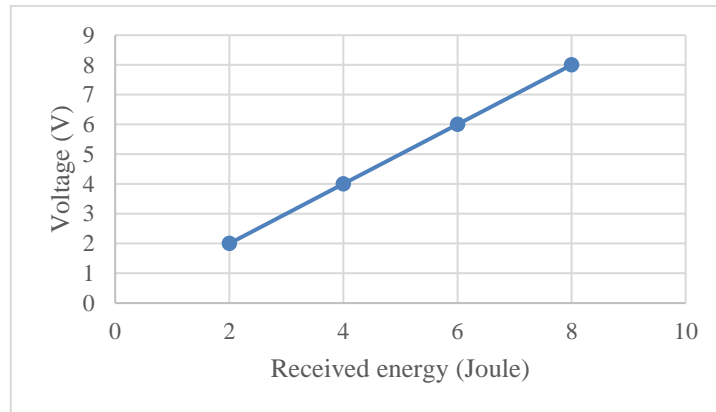
Figure 2. Graph of the effect of voltage on the received energy

The graph above shows a curve that goes upward, which means that the greater the voltage, the greater the energy received. Conversely, the smaller the voltage, the less energy received. This is reinforced by the results of previous research according to (Alfraidila et al., 2022) This can happen because the voltage and energy are directly proportional to the same value. Just like when charging a cellphone, if the cellphone battery is charged with high voltage, the faster the current flowing in the battery will be fully charged. (Dwi Nata et al., 2021; Sinulingga et al., 2020)

One volt will give each coulomb of one joule of energy charge. The charge will then travel around the circuit, but will only dissipate that energy when it encounters resistance in the circuit. once the charge is depleted of its energy it returns to the battery to receive another energy clearance. (Suyoso, 2007)

Whereas in the second experiment the current value is generated from a circuit that is assembled using the variable voltage, current, and resistance, through this you will get the flowing charge and the amount of energy received by each charge.
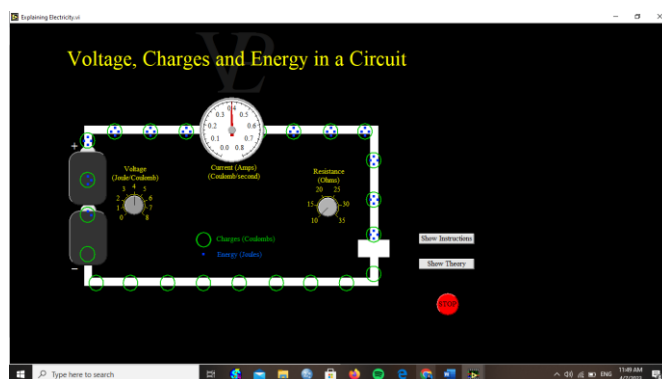

Figure 3. Schematic of the Second Experiment

This experiment was carried out by changing the resistance value as much as 6 times to find out how the current value or the speed of the moving charge with the voltage value is set at 4 volts. In this experiment the amount of energy received by each charge is 4 Joules. Based on the experimental results in the virtual lab practicum activities, the table is presented as follows.

Table 2. Observational data results on the relationship between resistance and current

No	Voltage (V)	Resistance (Ω)	Energy (J)	Current (A)
1		10		0.4
2		15		0.25
3		20		0.2
4	4	25	4	0.15
5		30		0.13
6		35		0.1

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Table 2 shows that in the 6 experiments that have been carried out, when the resistance value is increased the current value decreases. In other words, if we look at the speed of the charge as shown in Figure 1, when the resistance is increased, the moving charge is slower. This is in accordance with Ohm's law theory which can be systematically formulated as follows. (Yasu & Hadi, 2021; Yusuf Lubis et al., 2020)

$$I = \frac{V}{R} \qquad (3)$$

With I being the electric current, V being the voltage and R being the resistance or the amount of electrical resistance. (Halliday et al., 2005; Halliday & Resnick, 2005)

From the results of experiments and observations that have been made, it can be analyzed that the amount of electric current is inversely proportional to the resistance or resistance as in accordance with Ohm's law that applies, which can be seen in equation 1 above. (Muhammad & Choiril, 2021) When the resistance in an electric circuit is increased, the current flowing through the circuit will decrease. This can affect the speed of movement of electric charges in the circuit. (Juwariyah & Djaya, 2018; Saefullah et al., 2018) In other words, if the resistance value increases, the resulting current will decrease, this can be presented in graph 1 as follows.
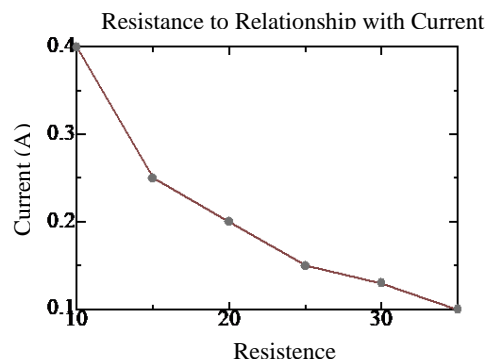

Figure 4. The relationship between resistance and current

So the greater the resistance or resistance of a conductor, the smaller the current that will flow through the conductor, even though the voltage applied to the conductor remains the same. (Salamiyah & Kholuq, 2020) Conversely, the smaller the resistance of a conductor, the greater the current that will flow through the conductor if the applied voltage remains the same.

This study combines the use of Virtual Lab to analyze the relationship between the concepts of voltage, charge, current, and resistance in a circuit. The use of this technology provides an innovation in a more flexible and efficient experimental approach. The use of Virtual Lab has several limitations compared to live physical experiments. For example there are certain aspects of physical measurement or interaction that cannot be fully replicated in a virtual environment. Also, this research is limited to relatively simple circuits, so it cannot cover all aspects and complexities associated with voltage, charge, current, and resistance in more complex circuits.

The implications obtained from this research are in the context of learning and teaching. The use of Virtual Lab can increase students' understanding of the concepts of voltage, charge, current, and resistance through controlled and repeatable practical experiences. Meanwhile, in the analysis of the relationship between these concepts, this research can help develop a better understanding of how voltage, charge, current, and resistance affect each other in a circuit. This can be useful in designing, analyzing and repairing electronic circuits.

CONCLUSION

Electric charge with flowing current voltage and resistance becomes the cause of resistance, where based on a laboratory experiment, it is concluded that the larger the voltage, the greater the received energy because voltage is directly proportional to the same value. In other words, if the electrical power is high, then devices requiring high electrical power can function properly.

Conversely, the larger the resistance of a conductor, the smaller the current that will flow through the conductor, even if the applied voltage remains the same. On the other hand, the smaller the resistance of a conductor, the larger the current that will flow through the conductor if the applied voltage remains the same.

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