Current Intensity Conductivity, Resistance and EMF in Electrical Circuit Systems Using Geogebra

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Abstracts: The COVID 19 pandemic spread worldwide, having considerable consequences in education, interrupting learning and increasing the great challenge that exists in the educational culture of building learning and teaching experiences that impact the learning results of the students more educated, vulnerable and disadvantaged. To do this, it seeks to link theoretical learning with real life through the use of digital tools that solve problems in science learning. The method used is simulation, it has been chosen to simulate electrical conductivity, the flow of electrical charges from electrical resistance, resistivity and Ohm's law through GeoGebra and the link it has with JavaScript to perform a simulation totally dynamic. As a result, it was possible to build a simple and combined electrical circuit to obtain the passage of the flow of electrical charges through the circuit and the intensity of the electrical current; Combinations of resistivity and resistance connected to a power source that is fed with a potential difference. Demonstrating that the electric charges move generating the intensity of continuous electric current and that they vary due to the variation of the electric potential generated by the battery. Arriving at the discussion in front of other research works by simulation that with GeoGebra it is also possible to obtain good results, which contributes to understanding the difference in electrical potential through simulations that promote quality education, equitable and that produces relevant learning results to improve theoretical and practical knowledge that promotes sustainable development.

Keywords: Electrical Circuit, Ohm's Laws, Electrical Resistance, Electromotive Force and Electrical Resistivity, Electric Conductivity.

1. INTRODUCTION

During the time of the COVIV-19 pandemic, safety regulations were implemented for student health care in school and vocational training centers (Vivanco,2020), requiring universities to promote new ways of teaching students. through mathematical digital tools to teach courses in Science, Technology, Engineering and Mathematics (STEM). For which a great challenge arises in the higher educational culture, that of carrying out an education based on projects and training of models of professional competencies through simulations that allow a mathematical representation of reality and these simulations that include the construction of what described the behavior of physical and mathematical processes (Lighezzolo et al,2019).

In relation to the simulations, the United Nations Educational, Scientific and Cultural Organization UNESCO provides methods to develop national science, technology and innovation plans (Sarthou,2021), In this way, each government develops its own policies encouraged by each government institution that makes it possible to cover the needs of students in science and technology. Likewise (Ojeda & Palacios,2021), mentions the changes that must be made quickly so as not to stop education and professional training, highlighting the leadership that teachers must develop in the use of technologies to carry out research and cover the gaps in the knowledge of different disciplines.

In this sense, modeling in physics is of great help to the development of the knowledge gap because it allows the results of experimental applied research to be achieved through computer simulation, laptops and other electronic devices. In reference to the subject (Sailema,2021), it shows that the modeling can be in many ways, attending to the needs of society, such as the prototype of rehabilitation for people with disabilities of their lower limbs that help them to walk, it is a way of carrying out a project that brings improvements to people's living conditions. In the same way (González,2021), he mentions that computer modeling helps the construction of prototypes, these works are carried out online, using different open source technological tools to reduce costs in the production of samples. Modeling with microcontrollers is another way of conducting research as referred by (Castro,2020) which implements programmable electrical circuits, uses the architecture and identifies the technical characteristics of each device.

Indeed, professionals must be able to develop new approaches and paradigms of doing research from the simplest to the most complex, as referred to by (Martínez & Garcés,2020), and (González,2021) For which, the importance of having digital skills to build new ways of doing and learning is highlighted (Cabero & Martínez,2019), considering that digital tools facilitate active and collaborative learning. Therefore, the objective of this research is to link theoretical learning with real life through the use of digital tools that solve problems in science learning. Therefore, the contribution of this research is to understand the difference in electrical potential through simulations that promote a quality, equitable education that produces relevant learning results to improve theoretical and practical knowledge that promote sustainable development.

This research describes the importance of being able to develop modeling and simulations (Moscoso,2021), to learn the subject of electric current, conductivity, resistivity, and the electromotive force that is responsible for feeding the circuit with a difference in electric potential.

2. MATERIALS AND METHODS

The intensity of electric current is the flow of electric charges, which can be protons, electrons and/or ions that move through an electric conductor (Quinteros,2017). In the same way, the electrical conductivity of these moving charges produces a potential drop that the battery provides in the case of direct current (Rivera,2022). For this reason, GeoGebra is a highly diversified digital tool in its immediate application in science and mathematics courses that allows improving learning and teaching through physical and mathematical modeling such as the simulation of electrical conductivity in electrical circuits in series, in parallel, resistances and potential functions of the potential drop (Rubio & Ortiz Buitrago,2016). This allowed developing the research through the construction of simulations and programming in GeoGebra from basic to advanced level using JavaScript (García & Izquierdo,2017). About Hardware, a laptop with Intel CORE i7 processor, 11th generation i7-11370H, 16GB of DDR4 RAM, 4GB DDR6 Geforce RTX3050 video card and 512Gb of SSD storage was used.

The method that has been used is computer simulation to generate a physical system of electrical circuits and the construction of graphs or figures of the theoretical and experimental results on the intensity of current and electrical circuits with variable electrical resistances and emf. variables with the use of sliders, make this simulation a dynamic form of the behavior of the flow of current intensity and battery wear initially used in the simulator, which gives us the following results shown below.

3. RESULTS
3.1. Simulation in GeoGebra

Now the results of the investigation are presented, through GeoGebra which is linked to JavaScript for the construction of the electrical resistance simulator, the passage of electrical charges through the conductor and to obtain a basic modeling of the conduction of the flow. of electrons due to the difference in electrical potential injected by the electromotive force emf or battery.

3.2. Modeling 1 - Mixed Circuit (Integration with The Java Script Programming Language)

3.2.1. Step 1 - Defining The Initial Variables

Naming the variables to be used in the construction of the electrical circuit using the GeoGebra: V_{total}, V_{R1}, V_{R2}, V_{R3}, V_{R4}, V_{R5}, V_{R6}, I_{total}, I_{R1}, I_{R2}, R_{total}, R_1, R_2, R_3, R_4, R_5, R_6, R_a y R_b.

We then assign the following values to the initial variables as shown below: $V_{total} = 9$, $R_1 = 12$, $R_2 = 11$, $R_3 = 20$, $R_4 = 10$, $R_5 = 5$, $R_6 = 2$; also, the minimum and maximum values that can be assigned to each variable are stablished, all these variables are constructed in the slider icon as shown in Figure 1, for each voltage and resistance.
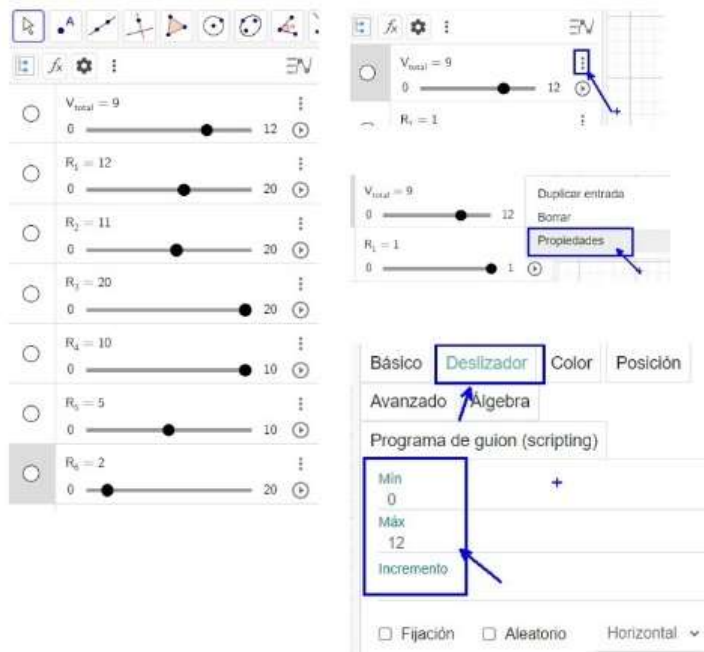

Figure 1: Creating variables and their configuration

The graph represents the creation of the initial variables to be used and their respective configuration to establish the value of its maximum and minimum values.

3.2.2. Step 2 - Drawing the Mixed Circuit

We proceed to create segments and add texts with the values of the variables (R1, R2, R3, R4, R5 and R6) and additionally images of resistances and electromotive force are added, as shown in figure 2.
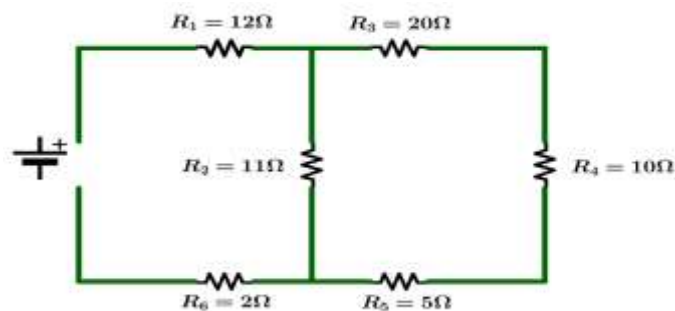

Figure 2: *Mixed circuit composed of resistors and electromotive force*

The graph represents the mixed circuit to be modeled in GeoGebra using points, segments, texts and images in which Ohm's law must be applied.

To create each segment, first two points are established using the GeoGebra command input as shown in figure 3, the electrical resistances are created graphically, and then the graphs are captured and exported to the dynamic sheet to create the electrical circuit, which will be linked to the resistance images as shown in figure 2.

Then the resistors and the e.m.f. are created in the dynamic sheet, to these points created automatically by the software, a current intensity is linked and applied to circulate through each resistor generating voltage by Ohm's law as shown in figure 3.
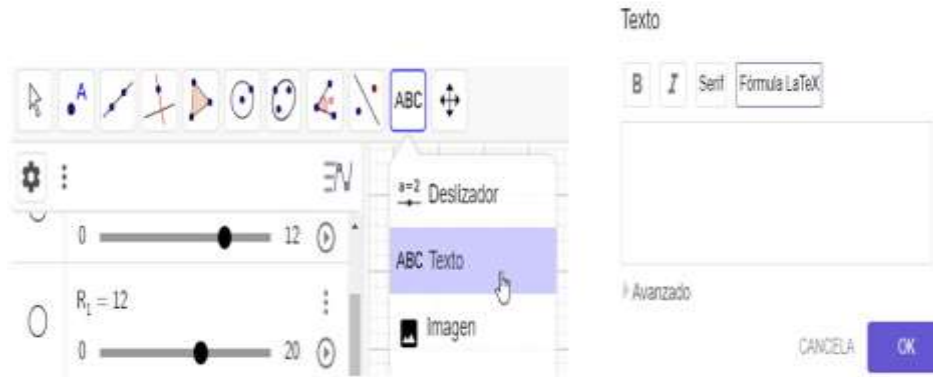
Figure 3: Text option in GeoGebra
The graphic represents the procedure for text integration in GeoGebra.

The values are assigned to the text for each resistance and voltage, according to the defined variables; to do so, go to the points option in Advanced, select the variables to be represented through text by means of their values. Figure 3 and Figure 4 show the order of the steps mentioned above.
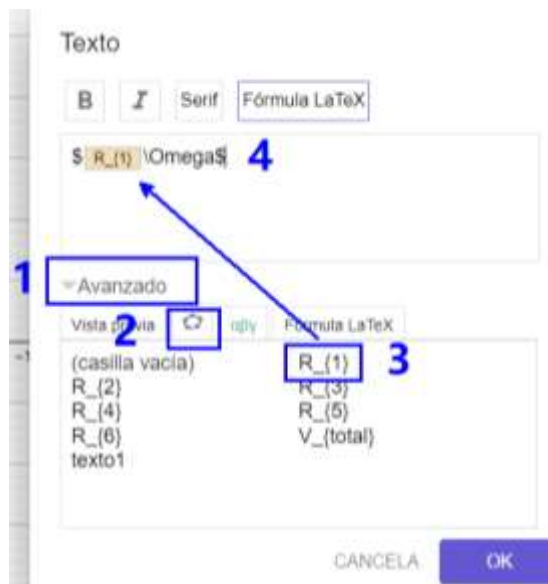

Figure 4: *Variable assignment as text*

Showing the values of the variables through texts.

3.2.3.   Step 3 - Obtaining the Total Resistance

Now the following variables are defined in GeoGebra, which are: Ra, Rb and Rtotal; These variables will have the sum of the values of the resistors that are in series and parallel (when it comes to a mixed circuit, what is sought is to simplify the amounts of resistors to obtain the total resistance and total intensity).

The first circuit in series resistors that is found is that of R3, R4 and R5; we proceed to add these resistances with the intention of simplifying the circuit, said result of the sum will be assigned to the variable Ra. All this will be done through the GeoGebra statement area, as shown in figure 5 and figure 6.

$$R_a = R_3 + R_4 + R_5 \qquad (1)$$
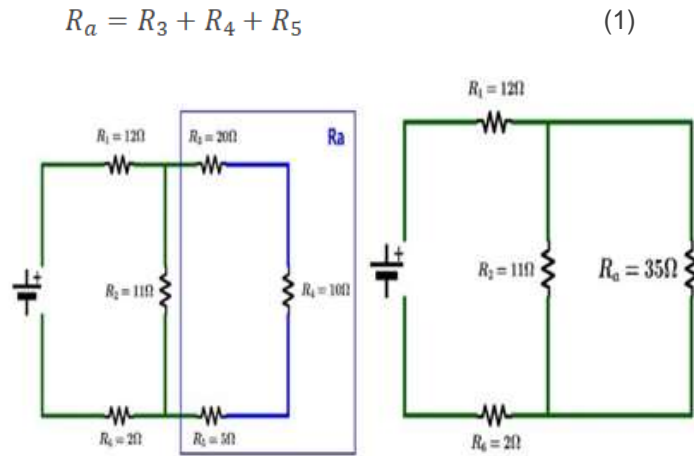
Figure 5: Series Resistors Simplified
Simplification of series circuits in order to obtain their total resistance.

Having simplified the first group of resistors in series, it can be seen that R2 and Ra are in parallel, for which the total parallel resistance can be obtained and assigned to the variable Rb using the following formula.

$$R_b = \frac{1}{\frac{1}{R_2} + \frac{1}{R_a}} \qquad (2)$$

All this is done through the GeoGebra statement area.
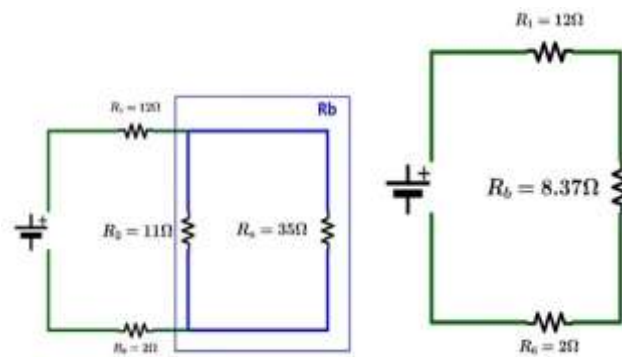
Figure 6: Simplification of resistors in parallel. Figure Simplification of parallel circuits in order to obtain their total resistance.

Finally, the total resistance of the entire circuit is obtained through the following formula. Said result is assigned in the variable Rtotal. All this is done through the GeoGebra statement area.

$$R_{total} = R_1 + R_b + R_6 \qquad (3)$$

3.2.4. Step 4 - Obtaining The Total Intensity

Having obtained the total resistance of the entire circuit, we proceed to assign the following formula to the Itotal variable through the command space in GeoGebra: Having obtained the total resistance of the entire circuit, we proceed to obtain the total intensity. This result is assigned to the Itotal variable in GeoGebra, and is represented by the following formula.

$$I_{total} = \frac{V_{total}}{R_{total}} \tag{4}$$

3.2.5. Step 5 - Obtaining the Various Voltages And Currents

Figure 7 will be taken as a guide. We proceed to obtain the voltage drops of each resistor in series; for which, through the area to enter sentences in GeoGebra, the following variables are defined with their respective formulas:

$$\begin{aligned}
V_{R1} &= I_{total} \cdot R_1 \\
V_{Rb} &= I_{total} \cdot R_b \\
V_{R6} &= I_{total} \cdot R_6
\end{aligned} \tag{5}$$

$$I_{R2} = \frac{V_{Rb}}{R_2}$$

$$\tag{6}$$

$$I_{Ra} = \frac{V_{Rb}}{R_a}$$

The following statements are assigned to obtain the remaining voltages:

$$V_{R3} = I_{Ra} \cdot R_3$$

$$V_{R4} = I_{Ra} \cdot R_4 \tag{7}$$

$$V_{R5} = I_{Ra} \cdot R_5$$

Now assign various texts with the values of the variables mentioned above. The procedure for assigning variables to texts was explained above.
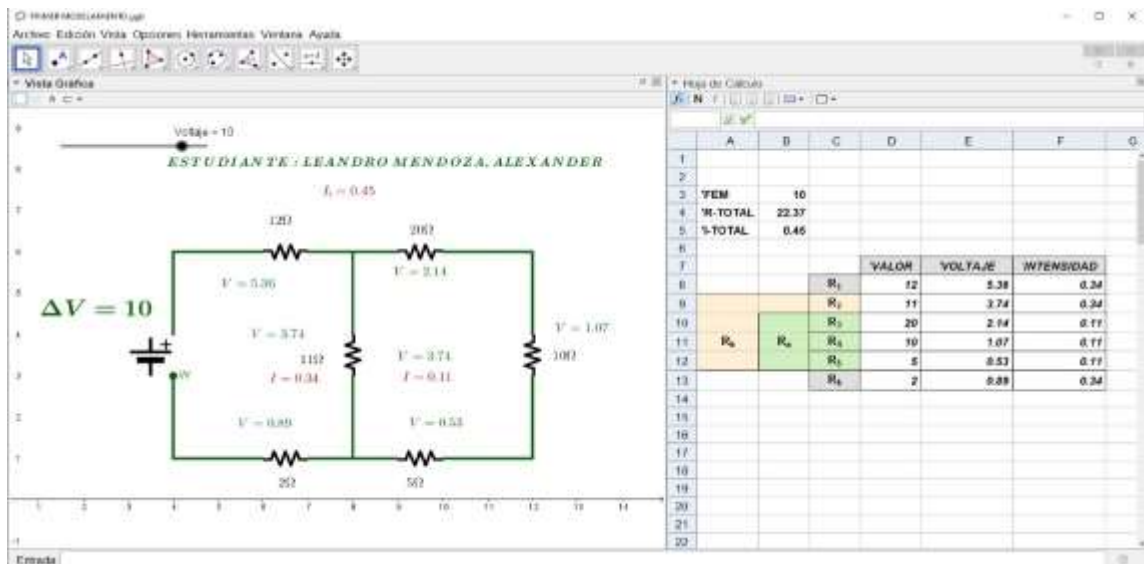

Figure 7: *Completed mixed circuit. Modeling of the mixed circuit applying Ohm's law, with variable voltage by means of a slider*

3.2.6. Step 6 - Integration with JavaScript

GeoGebra integrates the JavaScript programming language as a tool for the automation and animation of various objects designed in the graphical environment. Next, the steps to integrate JavaScript with GeoGebra are explained below

First, a button must be added. To do so, select the option shown in figure 8.
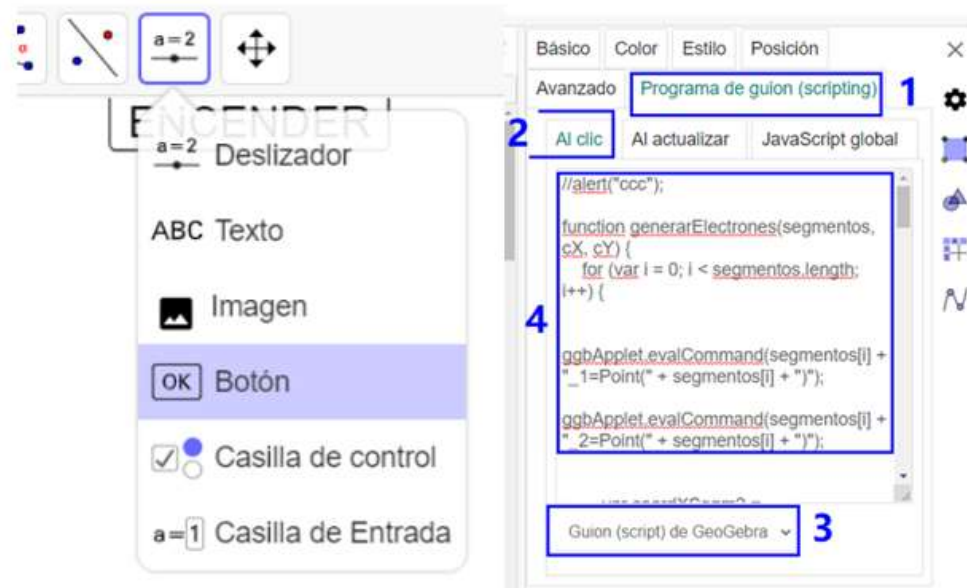
Figure 8: Linking the simulation from JavaScript. Option to access the programming area in JavaScript.

To be able to insert JavaScript code, right click on the button and select the properties option. Then, the options shown in figure 8 are selected.

You have to click on the numbering order as shown in figure 8, select the JavaScript option and then enter the corresponding codes.

Programming Codes Used in The Project

a. ggbApplet.evalCommand: Evaluates the given string as it would be evaluated when entered into the GeoGebra input bar. Returns whether the evaluation of the command was successful.

b. ggbApplet.getXcoord: Returns the Cartesian X coordinate of the object with the given name.

c. ggbApplet.getYcoord: Returns the Cartesian Y coordinate of the object with the given name.

d. ggbApplet.setPointSize: Sets the size of a point (from 1 to 9).

e. ggbApplet.setColor: Sets the color of the object with the given name.

F. ggbApplet.setAnimating: Sets whether an object should be animated.

g. ggbApplet.startAnimation Starts automatic animation for all objects with the animation flag set.

h. ggbApplet.stopAnimation: Stops automatic animation for all objects with the animation flag. established.

i. ggbApplet.deleteObject: Deletes the object with the given name.

Additionally, as in any programming language, variables declared in the programming language and structures such as conditionals, loops and arrays were used.

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3.3. Modeling 2 - Ohm's Law And Power

3.3.7. Step 1 - Defining The Initial Variables

The variables to be used in GeoGebra are identified: fem, r_i, R_1, R_2, R_3, R_4, R_5, R_{total}, V_{ri}, V_{R1}, V_{R2}, V_{R3}, V_{R4}, V_{R5}, I_{total} y P_{max}.

Then, the following values are assigned to the initial variables as follows: fem = 12, R_1=2, R_2=2, R_3=0.5, R_4=3 y R_5=1.5; Then, the minimum and maximum values that can be assigned to each variable are established (the steps are similar to the previous modeling), in this way it is possible to observe the decay of the current intensity when the voltage is worn due to the flow of electrical loads that occur when the electrical system is connected. This simulator allows to make variations of the voltages, creating current intensity for each case in the circuit, managing to vary the initial values of the resistors as shown in Figure 9 and Figure 10.
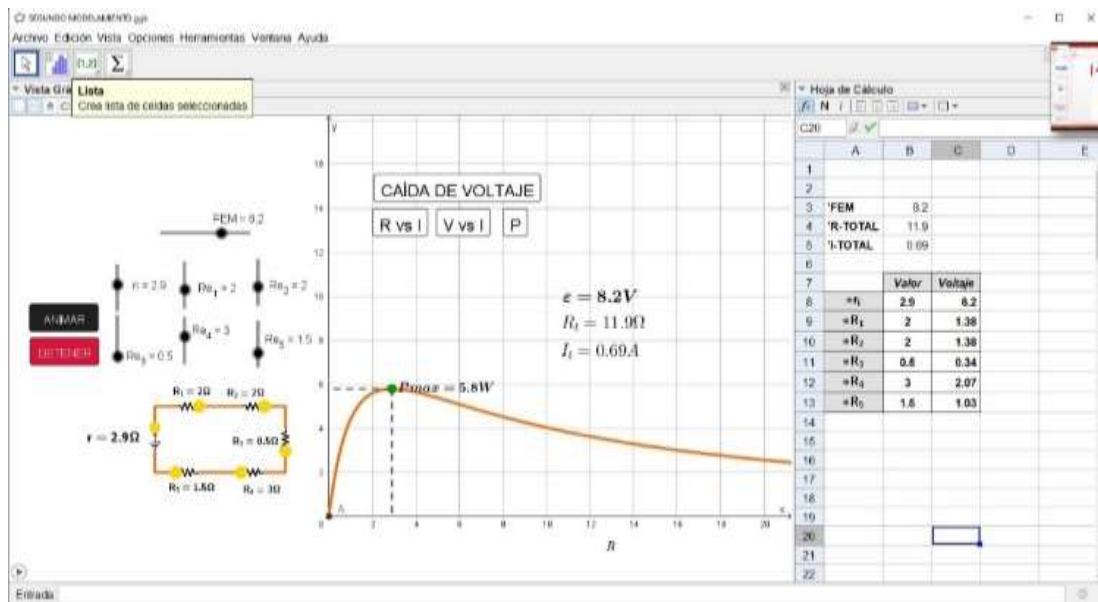

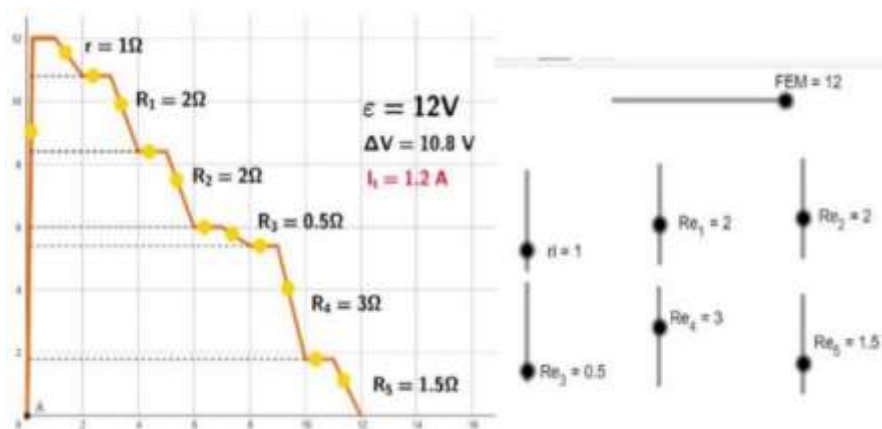**Figure 9**: Series circuit plus emf and internal resistance.

Figure 10: Voltage drop when the circuit is connected to emf. and the passage of electric charges that produce current intensity occurs

3.3.9. Step 2 – Plotting Resistance Versus Current As A Function

In order to represent the resistance versus intensity through a function, we have to apply the formula of Ohm's law, which is as follows:

$$I = \frac{V}{R} \tag{8}$$

In the input bar B.E of the software, the resistance is considered as x (independent variable) and the intensity as f(x), while V is considered as a constant, so that V is assigned the value of the variable fem previously defined in GeoGebra.

From the above mentioned, the following formula is entered in GeoGebra.

$$f(x) = Si\left(0 \le x, \frac{fem}{x}\right) \tag{9}$$

We use the function "if" to graph the positive integer part of the function, in the same way we have figure 11 that shows that the intensity of current is inversely proportional and this demonstrates what is obtained experimentally when studies are carried out with electrical resistances, to prove Ohm's law.
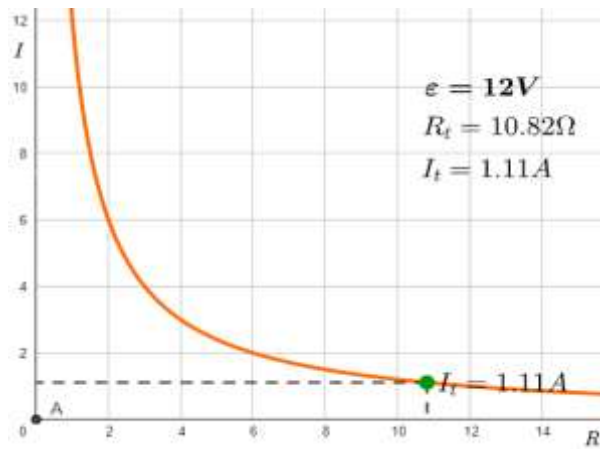
Figure 11: *Resistance versus intensity*

3.3.9. Step 4 – Graphing Voltage Versus Current as A Function

To represent through a function the voltage versus current, the formula of Ohm's law has to be applied, which is the following:

$$I = \frac{V}{R} \tag{10}$$

In this case, the voltage is considered as x (independent variable) and the current is considered as g(x), while R is considered as a constant, for this purpose, R is assigned the value of variable.

R_{total} ; la variable R_{total} has the value of the sum of all the resistance variables defined above.

From the above mentioned, the following formula is entered in GeoGebra.

$$g(x) = Si\left(0 \le x, \frac{x}{R_{total}}\right) \tag{11}$$

The "if" function is used to plot the positive integer part of the function, as in Figure 12.
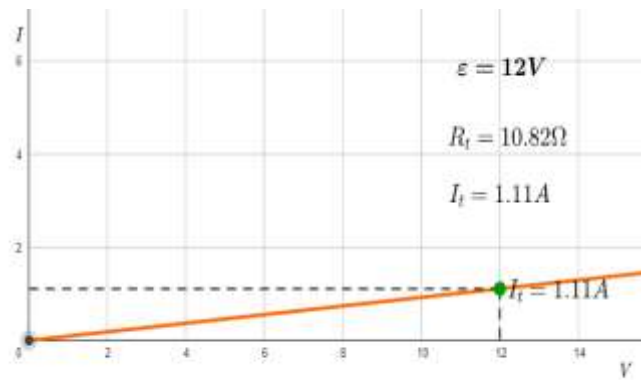
Figure 12: V*oltage versus current (intensity)*

3.3.10. Step 5 – Representing Power Graphically

According to the effect of Joules' law, it is known that for each resistance where a current intensity circulates there is the phenomenon of heat dissipation or thermal radiation and to represent through a function the generated power, the following formula has to be applied inside the input busbar (B.E).

$$\mathcal{P} = \frac{V^2 R}{(R+ri)^2} \tag{12}$$

In this case, the variable R is considered as x(independent variable) and P as h(x), while V and ri are considered as constants, for this purpose to V, is assigned the value of the variable fem and to ri, the value of the variable ri.

From the above mentioned, the following formula is entered in GeoGebra

$$h(x) = si\left(0 \leq x, \frac{fem^2 x}{(x+ri)^2}\right) \tag{13}$$

The function "if" is used to plot the positive integer part of the function.

4. DISCUSSION

According to the researches given by the synchronous virtual education, it is possible to develop physical and mathematical modeling without having an experimental laboratory where the measurements of current intensities and the variation of resistances in simple and complex electrical circuits are carried out [15], in this way the digital transformation allows vocational training centers to develop experimental research work [14] and a construction of knowledge similar or equivalent to the use of digital tools is obtained. through physical modeling as in the case of this research.

Within this research, it is possible to obtain very defined results such as the construction of electrical circuits [6], in series and in parallel, which experience the conduction of electrical charges, and the development of Ohm's law, which allows show the electrical power [11], experienced by each resistance and data is obtained on how the electrical potential varies, allowing the data analysis process to be shown to obtain the electromotive force curve emf (electromotive force) and the electrical resistance, showing the behavior of the intensity of current and the electrical resistance of being inversely proportional due to the decay of the voltage as the electrical charges move, generating the Joules effect that emits thermal radiation which, when dissipating heat, generates a loss of energy, as shown in figure 9, 10 and 11.

Few works show this process of comparison as shown in Figure 9, where there is a table with the values of electrical resistances, voltage, but here it is shown, the construction of the modeling, obtaining the database and

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analyzed to obtain the curves shown in Figures 9, 10, 11, and 12 that are obtained by recreating data manually inserted into the sliders, creating parameters within intervals that can be manipulated by the student or whoever has the interest to experience the changes of voltages, electrical resistances and current intensities, obtained in the development of time as it is achieved in a real and experimental work as mentioned [13].

CONCLUSION

It is concluded that the development of physical modeling in electrical conductivity allows to show how electrical charges move, generating the intensity of continuous electrical current and that it manages to vary due to the variation of the electrical potential generated by the battery installed in the circuit, this This is because when the flow of electrical charges passes through an electrical resistance, they experience conduction and resistance due to electrical resistivity, producing the Joules effect or heating of the circuit. Likewise, we can conclude that the use of this technological tool achieves quantitatively and qualitatively show the construction of knowledge within professional training in the field of engineering for its better understanding within electronic devices.

Due to the development of the modeling, it is clear that Ohm's law is the result of the behavior of electric charges in motion and that it manages to show the electrical conductivity and define that the intensity of the electric current is directly proportional to the voltage and that its resistance and current intensity are inversely proportional, showing through the curves found in its development.

These models allow students to improve their knowledge of electricity and electrical induction because during the construction of the simulation, the knowledge received in class is reinforced through meaningful learning.

Acknowledgments

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Conflicts Of Interest

There is no conflict of interest to declare.

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