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IMPACT ON LEARNING IN PHYSICS WITH THE USE OF PHET SIMULATORS, A LOOK AT THE SOLUTION OF ELECTRICAL CIRCUITS

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Summary: Based on the use of PhET simulators, which in principle is used as a complementary resource or as a basis for a theoretical-practical class session (Gallego Joya, 2022) (Gallego Joya, 2022)it is important to see the impact on the development of class sessions mediated by this type of tools used recurrently in physics courses at the high school and university levels. The relevance of the concepts would be reflected in the results of the general tests and evaluations of each course, according to the programming of each curriculum respectively. Based on the different moments in which the notions are evaluated, according to the curriculum of the physics courses in the two educational institutions of reference, the evaluation results obtained are recorded and with time, they are continuously retaken as part of the academic process, and it is there where their impact is evidenced, in the way in which new concepts are assimilated starting from preconceptions, or previously obtained concepts, in this case, those of Electrical Circuits such as Ohm's Law and Kirchhoff's laws, which are fundamental to approach other electromagnetism topics that are seen later and to evaluate their impact of their use in teaching.

Keywords: simulators, evaluation, impact, electrical circuits.

IMPACTO EN LOS APRENDIZAJES EN FÍSICA CON EL USO DE LOS SIMULADORES PHET, UNA MIRADA A LA SOLUCIÓN DE CIRCUITOS ELÉCTRICOS

Resumen: Partiendo del uso de los simuladores PhET, que en principio se utiliza como un recurso de complemento o ser fundamento de una sesión de clase teórico – práctica (Gallego Joya, 2022), es importante ver el impacto en el desarrollo de las sesiones de clase mediadas por este tipo de herramientas usados de manera recurrente en los cursos de física en los niveles de educación media y universitaria. La relevancia de los conceptos se vería reflejado en los resultados de las pruebas y evaluaciones generales de cada curso, de acuerdo con la programación de cada currículo respectivamente. Con base en los distintos momentos en que se evalúan las nociones, acorde al currículo de los cursos de física en las dos instituciones educativas de referencia, se registran los resultados de evaluación obtenidos y con el tiempo, se retoman continuamente como parte del proceso académico, y es ahí donde se evidencia su impacto, en la forma en que se asimilan nuevos conceptos partiendo de preconceptos, o conceptos obtenidos previamente, en este caso, los de Circuitos eléctricos como Ley de Ohm y leyes de Kirchhoff, que son fundamentales para abordar otros temas de electromagnetismo que se ven posteriormente y evaluar su impacto de su uso en la enseñanza.

Palabras clave: simuladores, evaluación, impacto, circuitos eléctricos.

Introduction

The use of the different PhET simulators as a complementary and/or structural resource of the class, particularly those of physics, it is of vital importance to maintain a constant evaluation, not only of the concepts addressed, but also of the use of the different elements that are used for this purpose, in this case, with the electrical circuit simulator in the classes on this topic (Alburqueque & Vicente, 2022).

The factors to take into account in the use of resources are not only in the development of the activities around the simulator, but also in obtaining the results related to the evaluation (Rodríguez Hernández, 2010) (Rodríguez Hernández, 2010)it is also important to consider the importance of the use of resources and the achievement of the different ways that the teacher has to perform the evaluation, according to the use of the tools that are intended for this purpose (Zúñiga-Meléndez et al., 2020).

Particularly, the activity carried out has the simulator, on a par with the physical laboratory practice, that is, the virtual resource reinforces the development of the practice with the appropriate learning environment (a virtual environment), with the respective practice in a regular laboratory of natural sciences (Quijano Hernández, 2021). After obtaining the results through the corresponding report, we proceed to evaluate the knowledge of Circuit Analysis acquired by the students, taking into account their level of complexity (interpretation of resistive circuits in series, parallel and mixed, as well as Ohm's and Kirchhoff's laws).

The levels of complexity mentioned above are two: the first one has to do with secondary education, and the second one at university level, specifically, in the third semester of engineering (Sandoval & Mora, 2009) (Sandoval & Mora, 2009). In one, the interpretative rigor transcends beyond the mathematical, it is in the conceptual more than anything else, and on the other, not only the conceptual, but also the mathematical rigor by using more complex elements than it would have at its level. What is common to both levels is the conceptual

approach, which should be similar, although with a different degree of depth (Wieman et al., 2014) (Wieman et al., 2014).

Method

The results of the different activities are reviewed, in particular, the PhET simulators on electrical circuits. The different tasks of each activity are being carried out with students in the eleventh grade of the Moralba Suroriental IED School and in the second academic semester at the Corporación Universitaria UNITEC in the telecommunications engineering program*(see appendix)*.

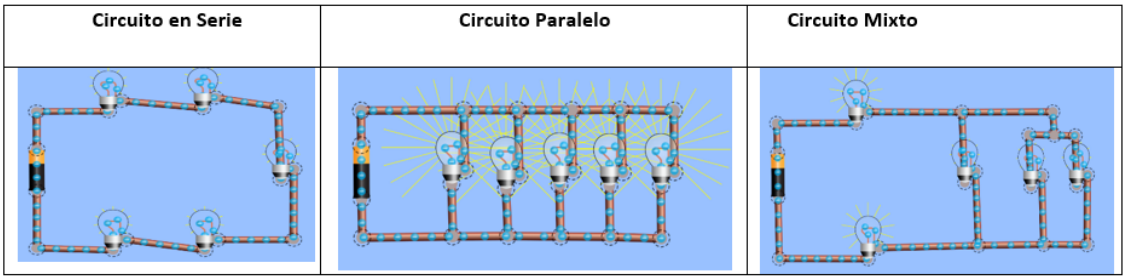
With eleventh grade, the corresponding explanation is made by developing circuits with series, parallel and mixed resistors using Ohm's law and Kirchhoff's laws, this would correspond to the first hour, in the second hour the practice is made together with the simulator, where the assembly is made on the board or protoboard (*See figure*). As they are carried out physically and measured, compare them with the results of the simulator and with the theoretical development.

With the Electromagnetic Physics course, the process is very similar, but with greater complexity, considering some other measurements directly obtained using multimeter, since an alternating current is not considered, it is not necessary to use oscilloscope to measure sinusoidal signals, only rectified or linear, i.e. direct current (Zúñiga-Meléndez et al., 2020). The topic is explained beforehand and exercises are carried out during the first hour. In the second hour, the activity begins using the simulator and laboratory elements and performing each of the practices mentioned in the guide*(see appendix*)

Some evaluation instruments are used in addition to the guide, already with the development of the theoretical and experimental practice, in annexes 2 and 3 the results of the procedures described above are shown. The circuits shown in Figure 1, where only five resistors are connected to each other, forming series, parallel and mixed circuits respectively.

Figure 1

PhET simulator. Circuit construction kit.



Note. PhET simulator. Circuit construction kit. https://n9.cl/v5qrquniversity of Colorado, 2022, screenshot of the laboratory practice (see attachments).

For the use of the simulator, two moments are considered, which are the ones applied in a previous guide (Gallego Joya, 2022):

Moment 1: Previous illustration of the subject.

The teacher explains the topics of the association of series, parallel and mixed resistors, Ohm's law and Kirchhoff's laws, based on the probing questions that are mentioned during the session:

- what are electric current, voltage and resistance and their units of measurement in the I.S.? how are series, parallel and mixed resistors connected? Explain how the equivalent resistance value is found in each case.
- what is the relationship between electric current, voltage and resistance? Explain that it has to do with Ohm's law.
- what are Kirchhoff's current and voltage laws? how are they used in the development of a circuit? Explains

After the explanation, the student answers the questions, and they are complemented as the experience progresses with the use of the simulator in the second moment.

Moment 2: Simulator application

Based on the guide (see annex 1), the simulator is applied for the different electrical circuits developed and based on the different elements used in the physical assemblies, so that complementarity is achieved in theory and practice (Montenegro, y otros, 2019). The virtual laboratory mediated by the PhET simulators "Circuit construction kit" is explained beforehand, after the theoretical development. During the development of the application, the teacher is constantly giving feedback on the topics in each practice.

And finally, in the work groups, they write down what they observed in each practice and then the answers are reviewed, contrasted with the results obtained and each result is complemented and fed back. The success of the activity depends on how feasible the subsequent use of the simulators is in each case in the achievement of the knowledge and its learning.

Results

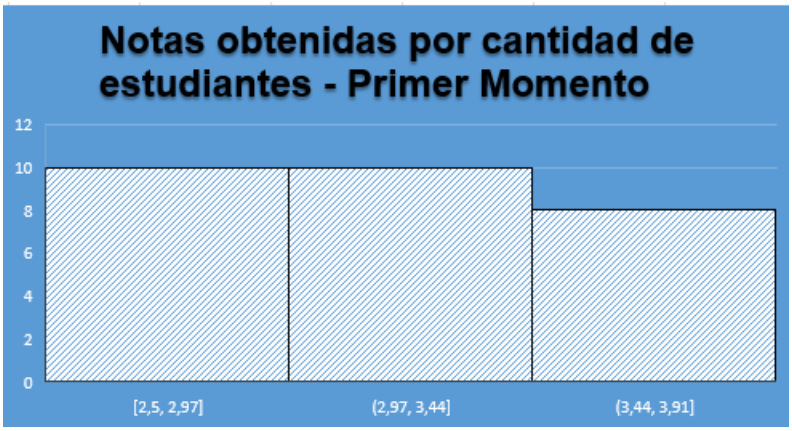
After the application of each resource, and taking into account the different intervals of each institution (1.0 to 5.0 in the school, being 3.5 the minimum grade, and from 0.0 to 5.0 in the university, being 3.0 the minimum grade), and considering the observations of each instrument, it is inferred:

Moment 1:

These are the results obtained in the first stage, in which the concepts are applied directly using the simulator:

Figure 2

Results with the students of the school (class 1102 morning session, year 2022)

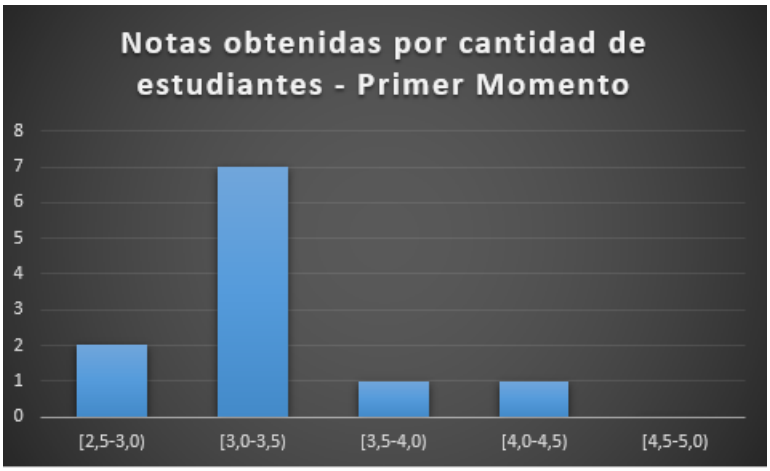


Note. Assessment scores were recorded at the school during the second half of 2022.

The school's results show that only 8 students obtained scores in basic and the rest in low, according to the evaluation scale of the educational institution. As the session continues, and with teacher accompaniment, clarification of the concepts addressed in the first part is intensified.

Figure 3

Results with university students (Physics II and laboratory, Telecommunications Engineering program, first academic semester, year 2022)



Note. Assessment scores were recorded at the university during the first half of 2022.

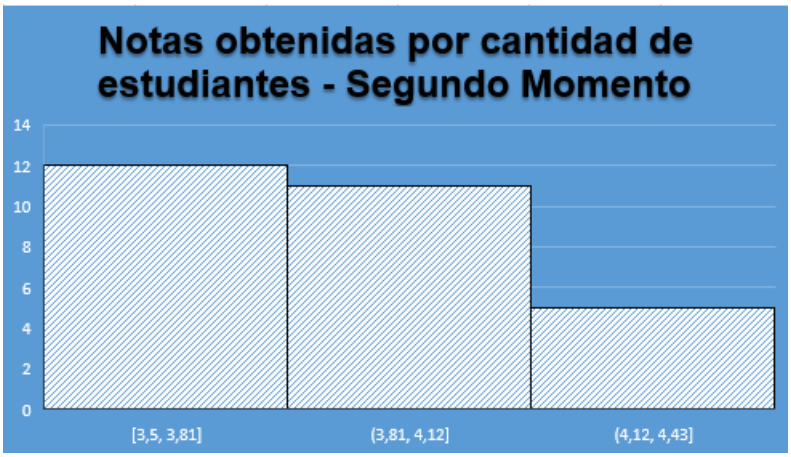
In the university, according to the evaluation criteria, there were very similar results, with a panorama of improvement that would be expected at the academic level, however, there are still conceptual shortcomings that are expected to be strengthened as the mediated session progresses with the theoretical-practical and practical component of the simulators and laboratory elements.

Moment 2:

These are the results of the second moment of the post-simulator practice activity:

Figure 4

Results with the students of the school (class 1102 morning session, year 2022)

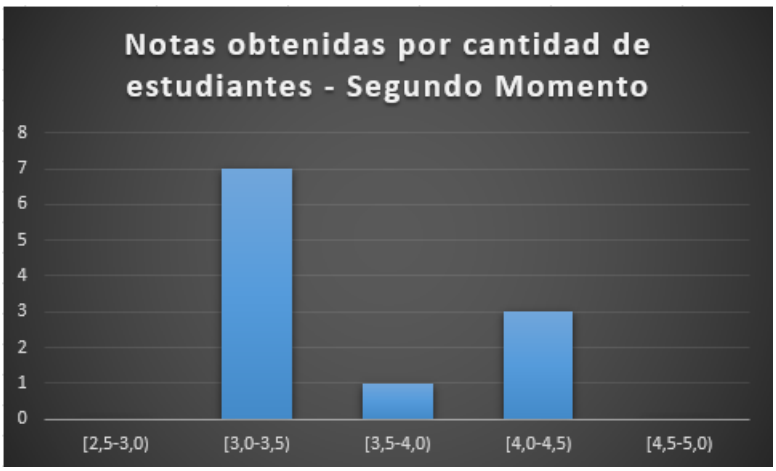


Note. Assessment scores were recorded at the school during the second half of 2022.

After the second activity, the results are better than the initial ones; at the end, the improvement is perceived with the use of the simulator together with the laboratory practice. According to the graph, there is a better assimilation of the concepts when the practical part is carried out, and an improvement in the grades obtained is observed.

Figure 5

Results with university students (Physics II and laboratory, Telecommunications Engineering program, second academic semester, year 2022)



Note. Assessment scores were recorded at the university during the first half of 2022.

And in the university, in this same part, the expected improvement is achieved, with greater rigor and constant accompaniment of the teacher during the process of elaboration of the theoretical-practical activity with the simulator and the physical laboratory practice, using the corresponding elements.

Discussion and conclusions

With the results obtained, the importance of the practical part in the development of learning in the scientific field can be inferred. This proves once again that the added value offered by the support of simulators, and in conjunction with practice. It is essential to recognize in a virtual practice which real objects it represents? how do you represent it? does it represent it in accordance with scientific theories? Recognizing variables and the phenomena being addressed (Villegas & Benegas, 2020).

It would already be the beginning of the learning process, pointing to the contribution of the simulators, which would be a resource that complements and/or reinforces the concepts in the classroom exercise. Classroom practice is evaluated on a continuous basis, and the results obtained indicate the relevance and accuracy in the use of each work and evaluation tool. Research on the use of digital resources in the teaching of science, particularly physics, little is said about the potentialities of the development, especially the use of simulators for learning (Pacheco Aguilar et al., 2021)it is necessary to work on this criterion every time the use of this type of virtual tools is tested.

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Annex 1:

ALCALDÍA MAYOR DE BOGOTÁ D.C.
SECRETARÍA DE EDUCACIÓN

COLEGIO MORALBA SUR ORIENTAL

Jornadas Mañana y Tarde

Resolución de Aprobación No. 04-0123 del 16 septiembre de 2009 de la SED.

NIT 830.115.387-0

Código Postal 110431

Guía de laboratorio

Nombres: _____ **Curso:** _____

Tema: Circuitos eléctricos

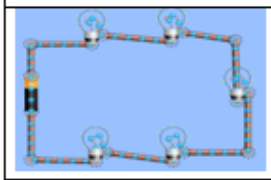
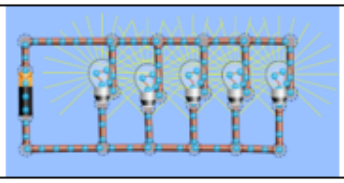
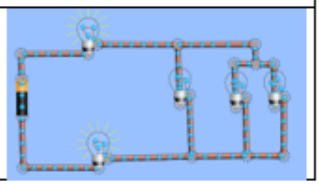
Objetivo de Aprendizaje

- Explicar las relaciones eléctricas básicas en circuitos en serie y paralelo.

Materiales: Kit de Construcción de Circuitos: CD de Simulaciones Interactivas PhET, además de una protoboard, resistencias de diferentes valores, una batería de 9 voltios y multímetro.

Procedimiento

1. Considera las imágenes de cada uno de los circuitos realizados con bombillas y lo explicado en clase usando el simulador, luego responde las preguntas a continuación.

Circuito en Serie	Circuito Paralelo	Circuito Mixto
		

a. De los circuitos anteriores, predecir qué bombilla (o bombillas) será la más brillante. ¿Por qué piensas eso?
b. Describe cómo fluirá la corriente en los diferentes tipos de circuitos anteriores.
   - Circuito en serie:
   - Circuito en paralelo:
   - Circuito Mixto:

2. Construya en la protoboard los circuitos realizados en el simulador, usando 5 resistencias de diferentes valores, no tan distintas entre sí, utilizando la tabla de colores (Ver imagen)

3. Mide los valores de Voltaje y de Corriente eléctrica en cada resistencia para cada circuito (serie, paralelo y mixto) como se indica (Tabla 1) y complete cada tabla:

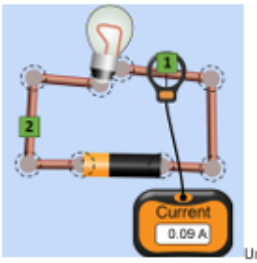
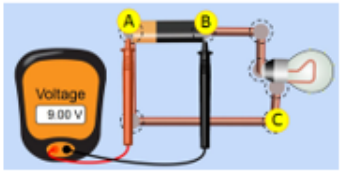
Corriente de Medición	Voltaje/Tensión de Medición
 Un amperímetro mide el corriente abriendo el circuito y conectándolo en serie, en el simulador, solo se coloca en un punto donde se desee medir	 "Voltaje" es una medida de la diferencia en el potencial eléctrico entre dos puntos. El voltímetro mide esta diferencia colocando los dos cables en paralelo, tanto en la protoboard como en el simulador.

Tabla 1. Medición de Voltaje y corriente

Serie

	RESISTENCIA	VOLTAJE	CORRIENTE
R1			
R2			
R3			
R4			
R5			

Paralelo

	RESISTENCIA	VOLTAJE	CORRIENTE
R1			
R2			
R3			
R4			
R5			

Mixto

	RESISTENCIA	VOLTAJE	CORRIENTE
R1			
R2			
R3			
R4			
R5			

Análisis de Resultados

1. Elabora la gráfica de Voltaje – Corriente para uno de los circuitos, usando los valores de una de las tablas obtenidos en cada medición:

2. Responde:

- ¿Qué gráfico se obtuvo y que comportamiento tiene la relación entre ambas variables? Explique

- Explica si la relación de la Ley de Ohm v=ir es coherente con el resultado obtenido

		Tema: Análisis de circuitos eléctricos			Rango calificación 1-5	
	1102 - 2022	Resultados Actividad de clase			Mín aprobación 3,5	
	Nombres				1er momento	2do Momento (prueba final)
1	BERNAL	FUENTES	JUAN	CAMILO	2,5	3,5
2	CAGUA	TORRES	KAROL	JULIETH	2,6	4
3	DUEÑAS	DIAZ	FELIPE		2,8	3,5
4	FIRIGUA	LUGO	MICHAEL	STEBAN	3	3,8
5	GUERRERO	MESA	HEIDY	NATALY	3,2	4,2
6	HOYOS	ZULUAGA	LUISA	FERNANDA	3	4
7	MARTINEZ	SUAREZ	ALISON	YEANNET	3,2	4
8	MONTIEL	BUSTAMANT	YAIR	ELIAN	3	3,7
9	MOSQUERA	HERNANDEZ	LAURA	CAMILA	2,5	3,5
10	NOVOA	RODRIGUEZ	JUAN	DIEGO	3	3,6
11	OSORIO	QUINTERO	JESHUA	DAVID	2,5	3,5
12	OSORIO	QUINTERO	JOSHUE	DANIEL	2,5	4
13	PERDOMO	GOMEZ	SANTIAGO		2,5	3,7
14	PERDOMO	SANDOVAL	MARIANA		3	3,9
15	PIMENTEL	LUGO	FRAURYMAR	ALECXANDRA	3,1	4
16	POVEDA	PAEZ	JOEL	MATEO	3,6	4
17	RODRIGUEZ	BENAVIDES	LUNA	SOFIA	3,3	4,2
18	RODRIGUEZ	HERNANDEZ	AMMY	KARIME	2,6	4
19	RODRIGUEZ	SANDOVAL	JEIMMY	SOFIA	2,8	3,5
20	ROLDAN	MARTINEZ	KAROLL	JOUZETHWOU	3,7	4,3
21	SATOBA	PIÑEROS	JOHAN	SEBASTIAN	3,5	3,5
22	SEPULVEDA	MONTAÑA	CATALINA		2,5	3,5
23	SIERRA	RODRIGUEZ	SERGIO	IVAN	3,5	3,7
24	TELLEZ	GUEVARA	LUISA	FERNANDA	3,3	4
25	VELASQUEZ	IPUZ	BRAHIAM	STIVEN	3,5	4
26	VICTORIA	PRADA	KELI	TATIANA	3,5	3,9
27	VIDES	ROMERO	LUISA	FERNANDA	3,6	4,2
28	ZAPATA	GRANADOS	ARIANA	SOFIA	3,5	4,3

		Tema: Solución de Circuitos resistivos	Rango calificación 0-5	
	Física II y laboratorio	Resultados prueba final	Mín aprobación 3,0	
N° est	NOMBRES		1er momento (Etapa Conceptual)	2do Momento (Evaluyación actividad)
1	BARRERA RAMIREZ NICOLAS		2,6	3,3
2	BARRETO GARZON ANGIE VALENTINA		2,8	3,1
3	CUEVAS GONZALEZ WILLIAM FERNEY		3	3
4	GIL TOVAR MIGUEL ANGEL		3	3,4
5	HERNANDEZ RIVERA DANIEL FELIPE		3,1	3,2
6	MATIZ CÁRDENAS CESAR MAURICIO		3	3,3
7	OROZCO GIRALDO JUAN ESTEBAN		3,4	3,3
8	PARRADO ALFONSO CAMILO EDUARDO		3,4	3,7
9	RAMIREZ MANRIQUE SANTIAGO NICOLAS		3	4
10	REYES APONZA CAMILO ANDRES		3,5	4
11	VASQUEZ BRIJALDO OMAR ENRIQUE		4	4