

**METHODS OF TEACHING THE CHAPTER "ELECTROMAGNETISM " IN PHYSICS  
USING DIGITAL EDUCATIONAL RESOURCES**

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**ABSTRACT**

In the state program "Digital Kazakhstan", approved by the Decree of the Government of the Republic of Kazakhstan №827, it was noted that "the new education will meet the needs of the digital economy, paying special attention to the development of information analysis skills and creative thinking, rather than memorizing data and formulas". The goal of modern education is to develop students' critical thinking along with creative abilities. In order to improve digital literacy at all levels of education, the issue of mastering information and communication technologies, the ability to effectively use additional educational content in the educational process along with audio and video materials becomes relevant. At the same time, in the proposed article, effective methods of using digital educational resources in the process of teaching a school physics course were proposed. The effectiveness of the proposed methods was tested in the course of experimental work with the aim of mastering by students of the 8th grade of the Nazarbayev Intellectual School of Chemical and Biological direction of Shymkent the educational material of the section "Electricity and Magnetism" in physics. Thus, as a result of the study, it was concluded that the use of digital educational resources in education improves the skills and practical skills of analyzing information of students, which, in turn, improves the quality of knowledge.

**Keywords:** Digital Educational Resources, Practical Skills, Virtual Program "The Beginning of Electronics", Program of Modeling Environment "Electronics Workbench", Electricity and Magnetism, Electric Current, BilimLand, PhET Colorado.

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## FİZİKTE "ELEKTROMAGNETİZM" BÖLÜMÜNÜN DİJİTAL EĞİTİM KAYNAKLARINI KULLANARAK ÖĞRETİLME YÖNTEMLERİ

### ÖZET

Kazakistan Cumhuriyeti Hükümeti №827 Kararnamesi ile onaylanan "Dijital Kazakistan" devlet programında, "yeni eğitimin dijital ekonominin ihtiyaçlarını karşılayacağı, ezberlemek yerine bilgi analizi becerilerinin ve yaratıcı düşüncenin geliştirilmesine özel önem verileceği" belirtildi veriler ve formüller". Modern eğitimin amacı, yaratıcı yeteneklerle birlikte öğrencilerin eleştirel düşüncelerini geliştirmektir. Eğitimin her kademesinde dijital okuryazarlığı geliştirmek için bilgi ve iletişim teknolojilerine hakim olma konusu, eğitim sürecinde ek eğitim içeriğini sesli ve görüntülü materyallerle birlikte etkin bir şekilde kullanma becerisi önem kazanmaktadır. Aynı zamanda, önerilen makalede, bir okul fiziği dersi verme sürecinde dijital eğitim kaynaklarını kullanmanın etkili yöntemleri önerilmiştir. Önerilen yöntemlerin etkinliği, fizikte "Elektrik ve Manyetizma" bölümünün eğitim materyali olan Çimkent'in Kimyasal ve Biyolojik yönü Nazarbayev Entelektüel Okulu 8. sınıf öğrencileri tarafından ustalaşmak amacıyla deneysel çalışmalar sırasında test edilmiştir. Bu nedenle, çalışma sonucunda, eğitimde dijital eğitim kaynaklarının kullanılmasının, öğrencilerin bilgilerini analiz etme becerilerini ve pratik becerilerini geliştirdiği ve bunun da bilgi kalitesini artırdığı sonucuna varılmıştır.

**Anahtar Kelimeler:** Dijital Eğitim Kaynakları, Pratik Beceriler, Sanal Program "Elektronğin Başlangıcı", Modelleme Ortamı Programı "Elektronik Çalışma Tezgağı", Elektrik ve Manyetizma, Elektrik Akımı, BilimLand, PhET Colorado.

### INTRODUCTION

The main task facing the education system is to increase the competitiveness of the quality of education, which, in turn, requires that citizens be competitive in any field. The state mandatory standard of general secondary education states that "education and self-education are focused on a graduate who understands the importance of life and work and can apply the knowledge gained in practice" [1].

The modern level of modern schools is characterized by the global informatization of the educational process.

In 2011, the National Center for Informatization developed a standard for the preparation of digital educational resources for the e-learning system in general secondary education institutions. It is a set of pedagogical, psychological, technical and design-ergonomic requirements for the preparation of digital educational resources for the e-learning system in general education institutions and is used for all digital educational resources intended for developers of electronic publications and developed for the e-learning system [2].

Depending on the structure of each physics lesson, using computer technology in explaining new material, conducting evaluation work, i.e. fixing the topic during the lesson, using new pedagogical methods and techniques in the survey of homework, tracking the correct choice of information resources, solving problems and conducting experimental work, analyzing and

discussing ways to effectively use methods Feedback assessments of the problem of optimizing the educational process are published in the works of E. V. Ospennikova [3].

An important pedagogical process in the education system is the use of e-learning resources in the study of physical phenomena and processes, solving problems, conducting experiments. One of the prerequisites for the full development of the discipline by students is the use of useful resources and the achievement of the effectiveness of experiments. New pedagogical methods, in addition to their effectiveness, are aimed at increasing the interest and activity of students. Proper and systematic planning of the learning process, having competence in the use of computer technologies are the main requirements of a modern teacher [4].

The focus should be on improving the creative and critical thinking of students according to new pedagogical requirements. Students should know well what to read, how to study. To this end, good changes are taking place in the training system. It is difficult to imagine the process of pedagogical education without ICT. Now there is a question of providing ways to effectively use ICT in the classroom. Research work aimed at solving such a problem gives its results [5].

The role of experimental work carried out in physics lessons is great. There is an undeniable need for experimental, laboratory work in improving students' knowledge of physics, the application of theoretical knowledge in practice. The ability to effectively organize the learning process in this direction and achieve successful results requires the highest pedagogical skills. To motivate the assimilation of theoretical material in physics, the following applied tasks are proposed: tasks selected from high-quality and professionally oriented life situations. The learning process is based on the principles of didactics. One of them is the principle of applied orientation. The principle of applied orientation determines the application of the acquired physical knowledge in solving applied problems and the formation of an applied way of thinking, which is aimed at understanding the real connection of physics with life [6].

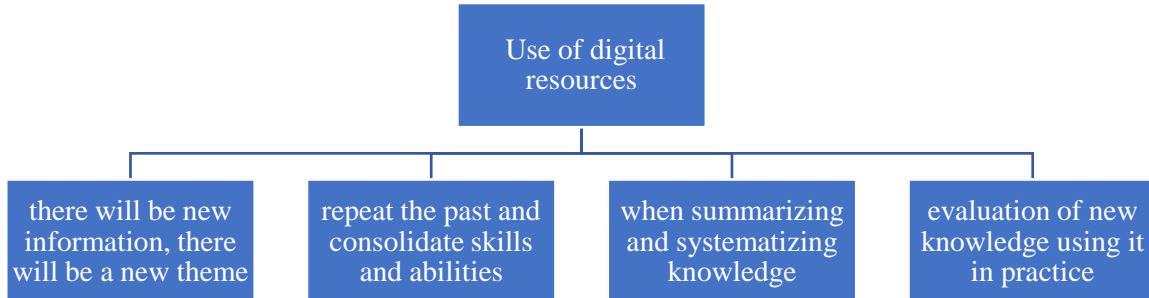
Learning by displaying models of physical phenomena on a computer screen helps to achieve the main goal. It is important that students understand the basic laws of physics and can use them to analyze various situations. Understanding not only the external side of the phenomena occurring, their essence, causes of occurrence is important in teaching natural sciences and allows you to attract the attention of students.

Digital educational resources are one of the components of the e—learning system that determine the content of education. The active use of the DER of the younger generation in the educational process to ensure high quality of education today is one of the urgent problems of the pedagogical community within the framework of this program (Fig.1).

The methodology of the study involves identifying its impact on the quality of education using the capabilities of educational platforms using traditional training and special electronic programs.

An important stage of the research is a pedagogical experiment. In order to solve the tasks set and determine the reliability of the scientific forecast, our experimental work was carried out at the Nazarbayev Intellectual School of Chemical and Biological direction in Shymkent.

In the 8th grade, experimental work was carried out, consisting of three stages (identification, search and formation) in order to determine the effectiveness of the teaching methodology for the section "Electricity and Magnetism" using DER.



**Figure 1: Scope of Digital Educational Resources**

### **METHODS AND MATERIALS**

At the I stage, based on the analysis of textbooks, educational programs, teaching aids in physics in order to determine the level of the real state of the problem being studied, the level to which students can combine theoretical knowledge gained in physics subjects with practice was determined. At the same time, the essence and positions of the concepts of "application of the Central Bank" are analyzed and analyzed. For the purposes of the experiment, students of grades 8 "A" and 8 "B" of the Nazarbayev Intellectual School of Shymkent were selected. There are 12 students in each class. The levels of knowledge were determined with them through interviews and test and control work. A comprehensive analysis of the textbook for grades 8 has been carried out.

At the II stage, a preliminary discussion of the educational process was held with a subject methodologist and a subject teacher. In the 8th grade, work was carried out to familiarize with the curriculum of lessons conducted according to the calendar-thematic plan, drawing up samples of a short-term plan, preliminary analysis of possible problems; issues of improving the effectiveness of the educational process of students are planned.

A lesson plan has been drawn up in advance. Methodological guidelines and a short-term plan have been developed.

During the experiment conducted at the III stage at the Nazarbayev Intellectual School, in grades 8 "A" and 8 "B", in accordance with the curriculum of the subject "Physics", experimental work was carried out in the process of teaching the chapter "electric current" in order to determine effective ways of teaching using traditional and DER. For students of grade 8 "B", i.e. the control group, during the lesson in the section "electric current" in accordance with the curriculum, traditional teaching methods were used, i.e. a school textbook and posters related to the topic were used for class students, and cards with noodles were distributed when solving problems. The conditions of the report were explained with chalk on the blackboard.

Homework is accepted in the form of oral questions and answers, tasks are accepted in the form of checking students' notebooks. Demonstration visual aids and laboratory work were carried out with the help of school devices.

For students of grade 8 "A" in the development of new material under the chapter "electric current" in accordance with the curriculum, the following DER were used:

- Interactive whiteboard, presentation;
- Online portal "BilimLand", network "YouTube"; information network "Google";
- Interactive model virtual laboratory "PhET Colorado";
- Virtual program "The Beginning of Electronics";
- Spreadsheet "Excel";
- Application "kahoot";

The training portal "BilimLand" has been developed, video information and presentations on the topic. When requesting homework, students were given notebooks in the form of paired work and asked questions about the kahoot and plikers applications on an interactive whiteboard. The virtual simulation environment was used for demonstration experiments. Laboratory work was carried out by students in laptops in the program "The Beginning of Electronics". The students were developed and given methodological recommendations for working with the program. At this stage, the process of education and training in general was carried out with the help of the Central Bank.

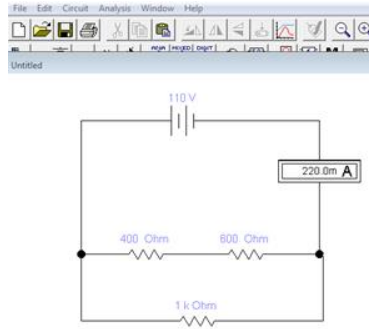
In the experimental group, i.e. in grade 8 "A", we listed the resources used in drawing up problem solving plans and solving problems on the topic "complex electrical circuits".

When solving the given tasks, students with the help of the "Electronics Workbench" program created a scheme in accordance with the specified conditions of the task. Then measurements and calculations are performed in the Excel computing program. Preliminary guidelines have been developed and issued to students. Special programs are pre-installed on laptops.

The students fully understood the topic of complex electrical circuits, familiarized themselves with the symbols and functions of each element and applied the formulas of Ohm's law for a complete circuit when solving problems.

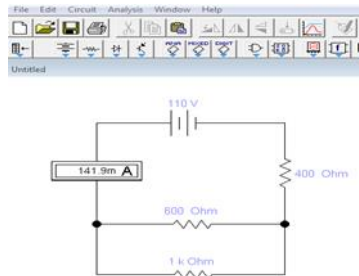
Below are examples from reports released in the Electronics Workbench simulation environment:

1. Find the ammeter and voltmeter readings in the diagrams shown in the figure. EMF  $E = 110 \text{ V}$ ,  $R_1 = 400 \text{ Ohms}$  and  $R_2 = 600 \text{ Ohms}$ , voltmeter resistance  $R_v = 1 \text{ kOhm}$ .



B	C	D	E	F	G	H	I	J	K	L	M	N
<p>Суретте көрсетілген схемаларда амперметр мен вольтметрдің көрсеткіштерін табыңыз. ЭҚК <math>E = 110</math> В, <math>R_1 = 400</math> Ом және <math>R_2 = 600</math> Ом, вольтметрдің кедергісі <math>R_v = 1</math> кОм. Нүкте гармониялық тербеліс жасайды. Тербеліс периоды 2 сек, амплитудасы 50 мм, ал бастапқы фазасы нольге тең</p>												
Берілгені			Шешуі									
$E = 110$	В	$R_{12} = R_1 + R_2 = 1000$		$I = \frac{\varepsilon}{R_{12V}} = \frac{110}{500} = 0.22$ А								
$R_1 = 400$	Ом	$R_{12V} = \frac{R_v * R_{12}}{R_v + R_{12}} = 500$										
$R_2 = 600$	Ом											
$R_v = 1000$	Ом											
$I = ?$	$U = ?$											

2. Find the ammeter and voltmeter readings in the diagrams shown in the figure. EMF  $E = 110$  V,  $R_1 = 400$  Ohms and  $R_2 = 600$  Ohms, voltmeter resistance  $R_v = 1$  kOhm.



B	C	D	E	F	G	H	I	J	K	L	M	N
<p>Суретте көрсетілген схемаларда амперметр мен вольтметрдің көрсеткіштерін табыңыз. ЭҚК <math>E = 110</math> В, <math>R_1 = 400</math> Ом және <math>R_2 = 600</math> Ом, вольтметрдің кедергісі <math>R_v = 1</math> кОм. Нүкте гармониялық тербеліс жасайды. Тербеліс периоды 2 сек, амплитудасы 50 мм, ал бастапқы фазасы нольге тең</p>												
Берілгені			Шешуі									
$E = 110$	В	$R_{12V} = R_1 + \frac{R_2 * R_v}{R_2 + R_v} = 775$ Ом										
$R_1 = 400$	Ом	$I = \frac{\varepsilon}{R_{12V}} = \frac{110}{775} = 0.142$ А										
$R_2 = 600$	Ом											
$R_v = 1000$	Ом											
$I = ?$	$U = ?$	$U = \varepsilon - IR_1 = 110 - 0.142 * 400 = 53,23$ В										

During the practical lesson, the students of the experimental group were able to quickly master computer programs and use time efficiently. He also showed interest in the subject and was able to hone his knowledge on the topic. When solving the selected tasks, which are among the difficult ones, the students performed measurements and calculations in special programs without any problems.

And when performing laboratory work, school devices were distributed to students of the 8th "B" class, i.e. the control group, and special programs installed on laptops were used for the 8th "A" class – the experimental group. The laboratory lesson was planned in advance, the students of the control group were provided with ready-made schedules, schemes and conditions for doing the work. The students of the experimental group were given instructions on how to work with the virtual program "The Beginning of Electronics ", samples of ready-made tables in an Excel spreadsheet for performing calculations.

"Application of Ohm's law for a part of a circuit with serial and parallel connection of conductors", "Experimental measurement of operation and current power" laboratory works were carried out using special devices and the virtual simulation program «The Beginning of Electronics".

In general, the two-graders have a very high level of knowledge in physics, which can be observed for their activity and perceptual abilities during classes. When conducting group and pair work with students, it is possible to highlight the support of students for each other, joint actions when performing assigned tasks.

As noted above, classes in the 8th "B" class on the chapter "electric current" were conducted using a traditional learning system. The school is well equipped with demonstration and laboratory equipment necessary for studying physics. When using these devices with Class 8 "B", there were no special difficulties. A sufficient supply of the necessary tools can be easily found at school, and the guidelines for their use are also ready. First of all, this is a great opportunity for a deep and comprehensive understanding of the lesson, conducting experimental work on the topic (Fig.2).



**Figure 2: Experiments Conducted at School**

And since the use of digital educational resources in the educational process is a modern requirement, the DER was used in the process of teaching the chapter "electric current" in the 8th "A" class. Students actively performed laboratory work on the program "The Beginning of Electronics", pre-installed on laptops. The guidelines for these virtual laboratory works were previously developed and passed on to the students.

The tutorial provides detailed information on how to use a virtual modeling environment.

In the course of laboratory work with the assistance of virtual modeling programs, the interest of students, their activity in classes has significantly increased, literacy in the use of computer programs has been developed.

Below is the plan and execution of a laboratory lesson on the topic "application of Ohm's law for a part of a circuit with serial and parallel connection of conductors" in the 8th "In" class (Fig.3).

*Success criteria:*

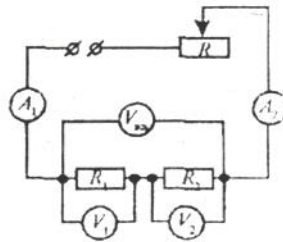
- It can connect conductors in series, determine current strength, voltage using tools, and calculate resistance using Ohm's law.;
- It can connect conductors in parallel, determine current strength, voltage using tools and calculate resistance using Ohm's law;
- We can draw conclusions by comparing part 2 of the practice;

*Laboratory work*

Task 1 "Study of the serial connection of conductors and checking the Ohm's law"

Necessary equipment: current source, connecting wires, 2 ammeters, 3 voltmeters, 2 incandescent lamps, a key. Progress of work:

Assemble the electrical circuit according to scheme 1 and fill in the table below according to the data received.



**Figure 3: Serial Connection Diagram of The Laboratory Device.**

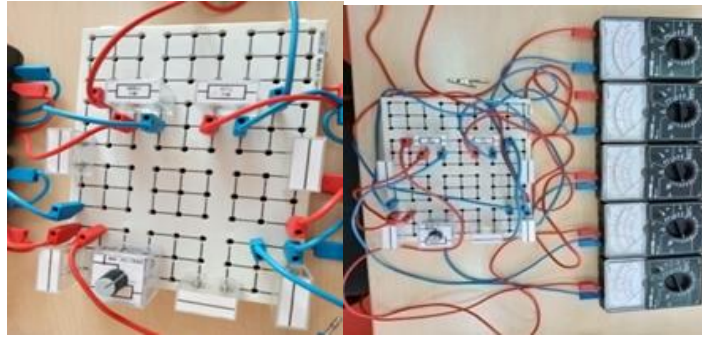
$I_1$	$I_2$	$I_t$	$U_1$	$U_2$	$U_{\text{ж}}$	$R_1$	$R_2$	$R'_t$	$R_t$
35mA	35mA	35mA	1,57B	3,67B	5,24B	47OM	100OM	147OM	151,14 OM

**Table 1**

1. What is the total current in an electrical circuit when connected in series (Fig. 4)?  
 $I_t = I_1 = I_2 = 35\text{mA} = 35\text{mA} = 35\text{mA}$
2. What is the total voltage in the electrical circuit when connected in series and compare it with the reading of a 3-voltmeter:  
 $U_t = U_1 + U_2 = 1,57\text{B} + 3,67\text{B} = 5,24\text{B}$
3. What is the total resistance  $R_t$  in an electrical circuit when connected in series? According to Ohm's law, determine the resistance  $R_t$  and compare the resistance of the  $R'_t$ :

$$R_t = R_1 + R_2 \quad I_t = \frac{U_t}{R_t} \quad R'_t = \frac{U_t}{I_t} \quad R'_t < R_t \quad 147 < 151,14$$

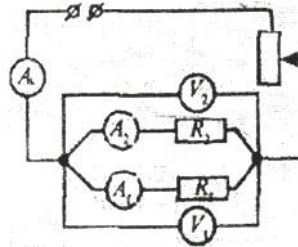




**Figure 4: Serial Connection of Laboratory Devices According to The Scheme**

Task 2: "Study of parallel connection of conductors and verification of Ohm's law".  
 Necessary equipment: current source, connecting wires, 3 ammeters, 2 voltmeters, 2 incandescent lamps, a key. Progress of work (fig. 5):

Assemble the electrical circuit according to scheme 2 and fill in the table below according to the data received.



**Figure 5: Diagram of Parallel Connection of The Laboratory Device**

$I_1$	$I_2$	$I_{\text{ж}}$	$U_1$	$U_2$	$U_{\text{ж}}$	$R_1$	$R_2$	$R'_{\text{ж}}$	$R_{\text{ж}}$
48mA	22mA	70mA	2,5B	2,5B	2,5B	47оМ	100оМ	31,9оМ	31,9 оМ

**Table 2**

1. What is the total current in an electrical circuit when connected in parallel?

$$I_t = I_1 + I_2 \quad I_t = 48\text{mA} + 22\text{mA} = 70\text{mA}$$

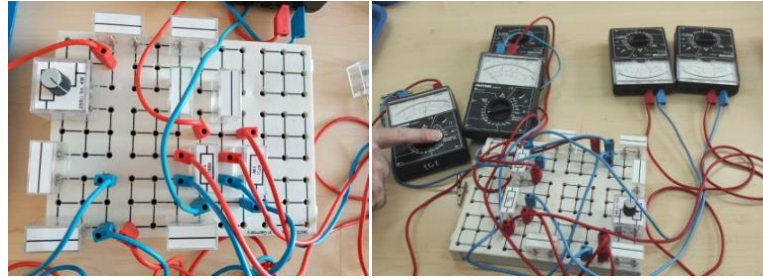
2. What is the total voltage in the electrical circuit when connected in parallel and compare it with the reading of a 3-voltmeter (Fig. 6):

$$U_t = U_1 = U_2 \quad U_t = 2,5 \text{ B}$$

3. What is the total resistance  $R'_t$  in an electrical circuit when connected in parallel? Using Ohm's law  $R_t$  to determine the resistance  $R'_t$  to compare the resistance:

$$R_t = \frac{R_1 R_2}{R_1 + R_2} \quad R_t = \frac{47 * 100}{47 + 100} = 31.9 \text{ Ом}$$

$$R_t = \frac{U_{\text{ж}}}{I_{\text{ж}}} \quad R_t = \frac{2,5}{0,07} = 35,7 \text{ Ом}$$



**Figure 6: Parallel Connection of Laboratory Devices According to The Scheme**

### **CONCLUSION ON THE WORK**

When the circuit is connected in parallel, the total current strength is equal to the sum of the current forces in the branches. The total voltage is equal to the other voltages. When connected in series, the current strength in the branches is the same, and the voltage is equal to the sum of the voltages in the branches.

Laboratory work on the topic "application of Ohm's law for a part of a circuit with serial and parallel connection of conductors" was carried out using the program "The Beginning of Electronics " Grade 8" A" (Fig.7).



**Figure 7: Students Perform Tasks in a Virtual Laboratory Using a Program Installed on Laptops**

**Task 1:**

"Studying the serial connection of conductors and checking Ohm's law" (Fig. 8)



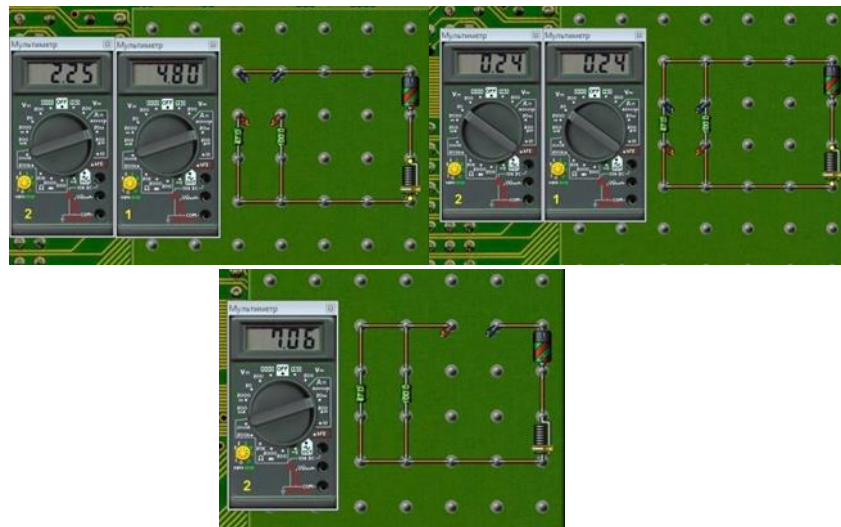
**Figure 8. Serial Connection of Conductors in The Electronics Program**

$I_1$	$I_2$	$I_t$	$U_1$	$U_2$	$U_t$	$R_1$	$R_2$	$R'_t$	$R_t$
3,55mA	3,55mA	3,55mA	0,16B	0,35B	0,52B	470M	1000M	1470M	146,40M

**Table 3**

**Task 2:**

"Study of parallel connection of conductors and verification of Ohm's law" (Fig. 9)



**Figure 9: Parallel Connection of Conductors in The Electronics Program**

$I_1$	$I_2$	$I_t$	$U_1$	$U_2$	$U_t$	$R_1$	$R_2$	$R'_t$	$R_t$
4,8mA	2,25mA	7,06mA	0,24 B	0,24B	0,24B	47 $\Omega$	100 $\Omega$	31,9 $\Omega$	33,9 $\Omega$

**Table 4**

The topic of the laboratory lesson conducted by the following experiment is called "operation and power of electric current". In accordance with the purpose of the work, students experimentally measured the performance and power of the computer.

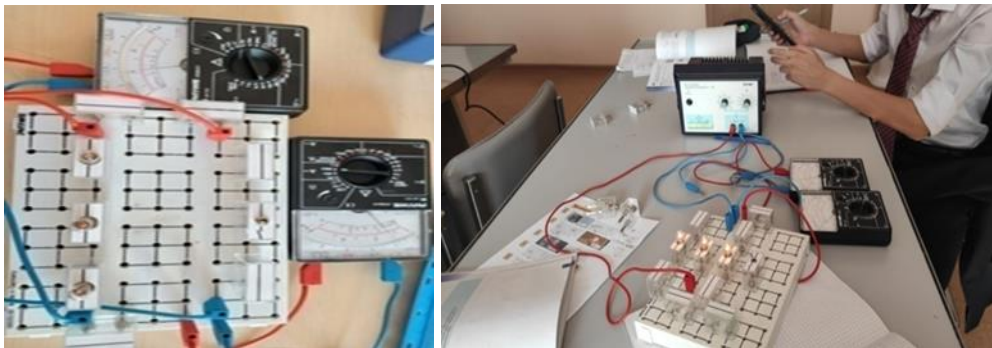
This lesson was also conducted in the control group, i.e. in the 8th "B" class, when the work was performed by students using laboratory devices, while experimental students of the 8th "A" class were divided into pairs using a virtual simulation program (Fig.10).

**Figure 10: Experimental Measurement of Operation and Current Power**

The purpose of the work: to experimentally determine the operation and power of an incandescent lamp.

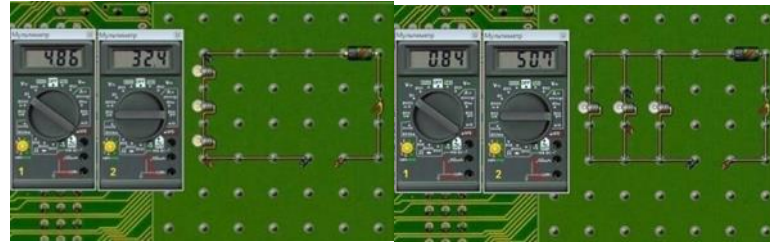
Equipment: current source, incandescent lamp, ammeter, voltmeter, key and wiring.

Question: does the operation and power of the current depend on the current strength, voltage, duration of connection to the power grid (Fig. 11)

**Figure 11: Serial and Parallel Connection of Luminaires According to The Scheme Using Devices**

The students of the control group, connecting the circuit in series and in parallel, changed the values of current and voltage, determined the operation and power of the incandescent lamp using the formulas  $P = I \cdot U$  and  $A = P \cdot t$ , and drew conclusions.

The students of the experimental group did this work using the program "The Beginning of Electronics " installed on laptops (Fig.12).



**Figure 12: Serial and Parallel Connection of Lamps in a Computer Program According to The Scheme**

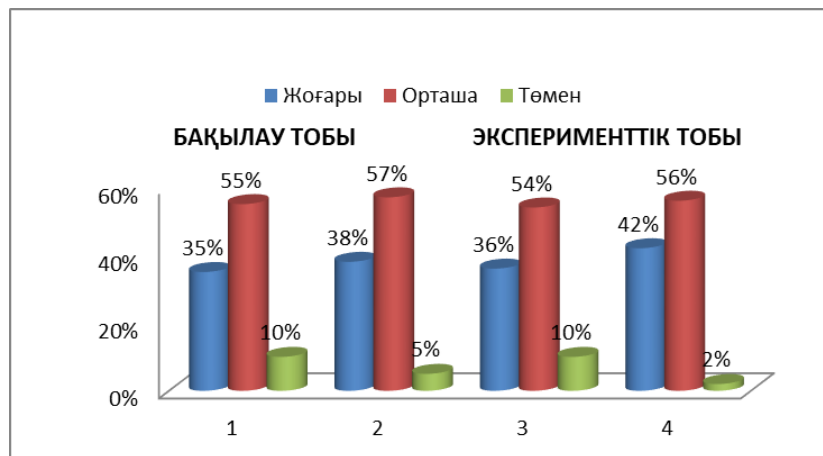
**RESULTS AND THEIR ANALYSIS**

The main purpose of our research was to improve the practical skills of students using modern digital educational resources in physics lessons. The results of the experimental experiment are presented in Table 5.

**Table 5: Practice Results**

Indicator of the level of practical skills of students	CONTROL GROUP		EXPERIMENTAL GROUP	
	Traditional teaching		the use of DER in the classroom	
	Before the experiment	After the experiment	Before the experiment	After the experiment
High	35%	38%	36%	42%
Average	55%	57%	54%	56%
Low	10%	5%	10%	2%

The results of the experiment show that the level of knowledge of the students of the experimental group was higher compared to the level of knowledge of the students of the control group. It is specified that the high level of practical skills of students in the control group increased by 3%, the high level of students in the experimental group-by 6%, the average level of students in both groups-by 2%. While the low level of practical skills of the control group students decreased by 5%, the low level of practical skills of the experimental group students decreased by 8% (Fig. 13)



**Figure 13: Results of The Experiment**

The results of the experiment showed that with the use of DER in the educational process, we achieved the following results.

1) when explaining new material or fixing a new lesson with the help of animation, video clips, graphic images, sound files, to provide students with a deeper understanding of physical phenomena, laws, visual representation of various natural processes, etc.;

2) when organizing DER observations in various directions (input, split, current, final), the work on testing students using a computer is optimized, time is saved;

3) in solving problems under the chapter "electric current", when solving problems using the Electronics Workbench modeling program, students independently assembled circuit diagrams for the conditions of each task on a laptop screen, which reduced difficulties in understanding the conditions of the task. It also saved time when compiling reports, as well as increased the ability to review and create more reports.;

4) time was also saved when performing laboratory work with the virtual program " The Beginning of Electronics ", since the children worked in pairs, there were enough laptops with the installed program. The works also had high visibility, and data calculations were also fast.

When working with school devices, there were obstacles such as lamp malfunction, current source malfunction, failure of some devices, even with the correct assembly of the circuit in accordance with the circuit. There were students who also took a long time to assemble the chain, and they were unable to complete the lab work until the end of the lesson.

## CONCLUSION

Digital educational resources do not replace the teacher, but provide additional materials to the teacher, i.e. they fill the lesson content with new multimedia capabilities of information and communication technologies, focus students' attention on the most important educational topics, if necessary, focus students' attention on the features of the studied manifestations, demonstrate them clearly, evaluate the lesson content taking into account the changes taking place in society, life experience, allows you to provide communication with interests, etc. phenomena.

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