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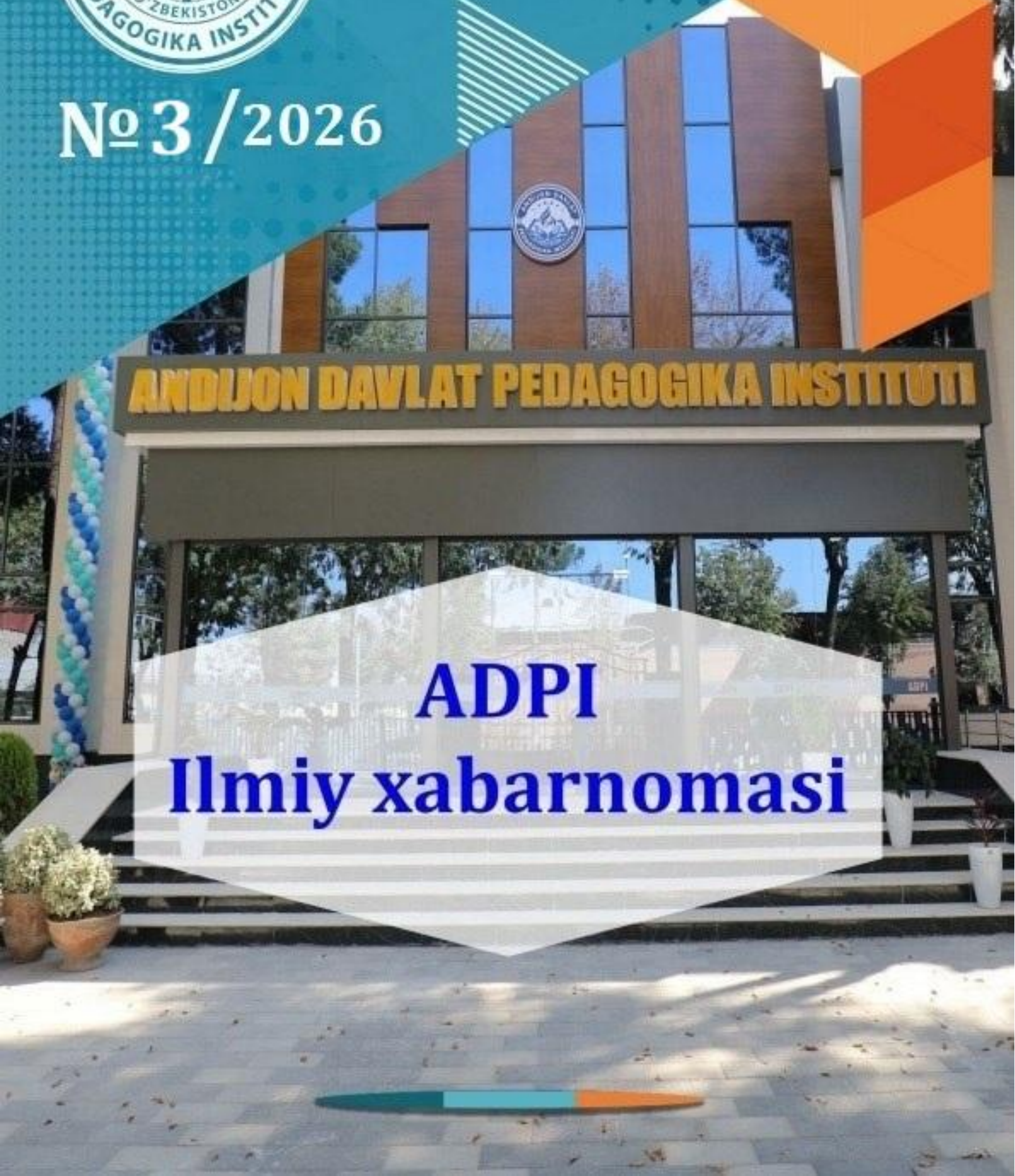

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EVALUATING THE EFFECTIVENESS OF PHYSICS TEACHING THROUGH A COMPARISON OF TRADITIONAL AND CASE STUDY METHODS

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Annotatsiya.
Mazkur maqolada fizika fanini o'qitishda an'anaviy va Case study metodlarini qiyoslash asosida ta'lim samaradorligi tahlil qilingan. Tadqiqot 8-sinf o'quvchilari ishtirokida olib borilib, Joul–Lenz qonunini o'qitish misolida ikki xil yondashuvning natijalari solishtirilgan. Nazorat guruhida mavzu an'anaviy tushuntirish, savol-javob va mustahkamlash usullari orqali o'tilgan bo'lsa, tajriba guruhida muammoli vaziyatlar, guruhli tahlil, muhokama va amaliy holatlarga asoslangan Case study darslari tashkil etilgan. Darsdan oldingi va darsdan keyingi diagnostik testlar yordamida o'quvchilarning boshlang'ich bilim darajasi, mavzuni tushunishi hamda bilimni amaliyotga qo'llash ko'nikmalari baholangan. Olingan natijalar Case study metodini qo'llagan guruhda o'zlashtirish ko'rsatkichi sezilarli ravishda yuqori bo'lganini ko'rsatdi. Ushbu metod o'quvchilarda tanqidiy fikrlash, mantiqiy tahlil, mustaqil xulosa chiqarish va muammoli vaziyatlarni hal etish ko'nikmalarini rivojlantirgani aniqlandi.

Kalit so'zlar:
fizika ta'limi, an'anaviy metod, Case study metodi, Joul–Lenz qonuni, interfaol ta'lim, tanqidiy fikrlash, muammoli vaziyat, konseptual bilim, o'qitish samaradorligi, eksperimental tadqiqot.

Аннотация.
В данной статье анализируется эффективность обучения физике на основе сравнительного изучения традиционного метода и метода Case Study. Исследование проводилось среди учащихся 8-х классов, а в качестве экспериментальной темы был выбран закон Джоуля–Ленца. В контрольной группе тема преподавалась с использованием традиционных методов обучения, таких как объяснение, вопросно-ответная работа и закрепление материала. В экспериментальной группе занятия были организованы на основе метода Case Study с применением проблемных ситуаций, группового обсуждения, аналитического мышления и связи изучаемого материала с реальными жизненными примерами. Для оценки исходного уровня знаний учащихся, степени усвоения темы и умения применять теоретические знания на практике были проведены входные и итоговые диагностические тесты. Полученные результаты показали, что учащиеся, обучавшиеся по методу Case Study, продемонстрировали более высокие показатели усвоения знаний по сравнению с учащимися контрольной группы. В частности, данный метод оказался эффективным для развития критического мышления, логического анализа, самостоятельного рассуждения и навыков решения проблемных ситуаций.

Ключевые слова:
физическое образование, традиционный метод, метод Case Study, закон Джоуля–Ленца, интерактивное обучение, критическое мышление, проблемные ситуации, концептуальные знания, эффективность обучения, экспериментальное исследование.

Abstract.
This article analyzes the effectiveness of physics teaching through a comparison of traditional and Case Study methods. The research was conducted among 8th-grade students, and the topic of the Joule–Lenz law was selected as the basis for experimental comparison. In the control group, the topic was taught using traditional teaching methods such as explanation, question-answer activities, and reinforcement exercises. In the experimental group, the lesson was organized through the Case Study approach based on problem situations, group discussion, analytical thinking, and real-life applications. Diagnostic pre-tests and post-tests were used to evaluate students' initial knowledge, level of understanding, and ability to apply theoretical concepts in practice. The results showed that the students taught through the Case Study method achieved higher learning outcomes than those in the traditional group. In particular, this method proved effective in developing critical thinking, logical analysis, independent reasoning, and problem-solving skills.

Keywords:
Physics education, traditional method, Case Study method, Joule–Lenz law, interactive learning, critical thinking, problem-solving, conceptual knowledge, teaching effectiveness, experimental research.

Introduction. In the context of a rapidly evolving educational environment, the demands placed on the general secondary education system are steadily increasing. It is widely recognized that physics education plays a crucial role in shaping students' scientific worldview.

In particular, the rapid advancement of science and technology requires students to develop a deep understanding of the fundamental principles of physics[1]. Therefore, introducing physics from the early stages of schooling is an essential component of modern education. Despite its importance, several challenges remain within the contemporary physics education system. These include low student interest in physics, difficulties in relating physical processes to real-life situations, the continued reliance on traditional teaching methods, the insufficient use of innovative pedagogical tools, the lack of adequate material and technical resources in schools and higher education institutions, and the use of teaching methodologies that do not fully meet current educational requirements[2-4]. To address these issues, it is necessary to strengthen theoretical knowledge, connect theoretical concepts with practical applications, increase the use of practical tasks and exercises, apply problem-based learning to develop logical thinking skills, and incorporate innovative pedagogical methods into classroom instruction.

The role of physics in the school curriculum is significant not only because it helps students understand natural phenomena, but also because it contributes to the development of their scientific worldview. In particular, physical concepts and laws form the foundation of students' conceptual understanding. Through the study of these laws, students learn to connect theory with practice by conducting experiments and analyzing physical processes [5-7]. This process enables them to reinforce theoretical knowledge through practical application.The scientific novelty of this study lies in the development of a methodological model based on the Case Study approach for teaching the topic of the Joule–Lenz law in the 8th-grade physics course, as well as in the substantiation of its effectiveness through a quasi-experimental study.

Within the framework of this research, a comparative analysis of the effectiveness of traditional and Case Study teaching methods was conducted. In addition, students' conceptual knowledge, their ability to analyze problem situations, and their capacity to apply knowledge in practice were experimentally evaluated. The effectiveness of the Case Study method in developing students' critical thinking and problem-solving skills was also scientifically substantiated. Based on the obtained findings, methodological recommendations for the use of interactive methods in physics lessons were developed.

Materials and methods. In the modern school education system, interactive teaching methods are increasingly used in physics lessons to promote students' deeper understanding of the subject. Among these methods, the Case Study method is considered one of the important pedagogical approaches, as it enables students to analyze real-life situations, connect theoretical knowledge with practice, and develop independent thinking skills. In this study, the Case Study method was applied as an interactive instructional approach in teaching physics. This method is based on the analysis of problem situations related to real or realistic contexts and encourages students to identify, discuss, and solve subject-based problems. In contrast to traditional teaching, where students mainly receive ready-made information, the Case Study approach actively involves them in the learning process and supports the development of analytical and critical thinking.

According to Yin (2018), case-based analysis is especially useful when the focus is placed on understanding a phenomenon in context and interpreting relationships between causes and outcomes. In educational practice, this approach allows students to examine a given situation in detail, propose explanations, and justify their conclusions based on scientific reasoning. One of the major advantages of the Case Study method is its flexibility. It encourages students to consider different aspects of a problem, evaluate alternative solutions, and apply theoretical concepts to practical situations. Such an approach is particularly important in physics education, where many topics require not only memorization of formulas but also conceptual understanding and real-life application. The relevance of this study lies in the fact that traditional school lessons often focus mainly on the explanation of theoretical concepts, while the Case Study method creates opportunities to connect the topic with real-life practice. This increases students' interest in the subject, strengthens their conceptual understanding, and improves their ability to apply knowledge in solving practical and problem-based tasks[8-10].

Moreover, the use of interactive methods in physics lessons helps students not only memorize formulas, but also interpret physical laws through observation, discussion, and analysis of practical examples. As a result, students' motivation, logical thinking, and learning activity are significantly enhanced[11].

Lesson Topic: The Amount of Heat Released When an Electric Current Passes Through a Conductor: The Joule–Lenz Law

Type of Lesson: Introduction of new knowledge through a problem-based analytical approach (Case Study)

Lesson Objectives:

to explain the thermal effect of electric current;

to present and interpret the mathematical expression of the Joule–Lenz law;

to develop students' ability to apply acquired knowledge to real-life situations.

Teaching Methods: Case Study, brainstorming, presentation, discussion, KWL chart, and "How?" diagram.

1	Organizational part	2 minutes
2	Revision of the previous topic	10 minutes
3	Explanation of the new topic	20 minutes
4	Consolidation of the new topic	10 minutes
5	Conclusion and assessment	2 minutes
6	Homework	1 minutes

Course of the Lesson

I. Organizational Stage.

At the beginning of the lesson, the teacher greets the students, checks attendance, and assesses their readiness for the class. The teacher then introduces the lesson objectives and motivates students to participate actively in the learning process [12].

II. Revision of the Previous Topic.

The previous topic is reviewed through discussion-based questions. Students are asked the following: How is electric power expressed? In what units is electric current measured? What do you know about the power of electrical devices? How is electricity consumption in households calculated? Why is electrical energy consumption measured in kWh? To reinforce prior knowledge, the teacher uses an electronic board and presents a short problem-based visual or video task for discussion.

The teacher then introduces a real-life problem situation: an old electrical wiring system in a house is connected to a powerful electric heater, and after some time the wires become hot and pose a fire risk. Students are asked to explain why the wires heat up and identify the physical law responsible for this phenomenon.

Students are divided into groups of three or four. Each group receives a case text based on the Joule–Lenz law and discusses the following questions: What is the physical cause of the problem? How much heat is released? Which factors affect the amount of heat produced?

Based on these questions, students analyze the electric circuit and conclude that the resistance is greater in the heating spiral and lower in the connecting wires. Since the amount of heat released is directly proportional to the square of the current and to the resistance, the spiral becomes hotter. In this way, students independently identify the physical meaning of the Joule–Lenz law through reasoning and discussion.

During the discussion stage, each group presents and justifies its conclusions, after which the teacher summarizes the main ideas. The teacher also demonstrates practical applications of the law, explaining that devices such as electric kettles, irons, heaters, and electric stoves operate on this principle. As a result, students develop a better understanding of electrical safety, energy efficiency, and the working principles of household electrical appliances.

III. Presentation of the New Topic.

After announcing the new topic, the teacher explains how to complete the KWL chart and encourages students to organize their prior knowledge, learning interests, and newly acquired understanding of the topic[13].

“KWL” chart

What I Know	What I Want to Know	What I Have Learned

Main Part:

When an electric current passes through a conductor, free electrons collide with the metal lattice. As a result of these collisions, part of the electrical energy is converted into thermal energy. This phenomenon is described by the Joule-Lenz law [14].

According to Halliday, this process is based on the law of conservation of energy, meaning that electrical energy is not lost but transformed into another form of energy – heat. This phenomenon plays an important role in the operation of electrical devices. Furthermore, as the resistance of a conductor increases, the amount of heat released also increases, which shows that it directly depends on the properties of the material.

If the work done by the electric current in a xonductor is entirely used for heating, then the work done by the current is equal to the amount of heat released in the conductor:

$$Q = A \quad \text{or} \quad Q = I\,U\,t \qquad (1)$$

From Ohm’s law, where U = IR, it follows that the amount of heat released in the conductor is given by:

$$Q = I^2 R\, t \qquad (2)$$

$$Q = \frac{U^2}{R}\, t \qquad (3)$$

In this formula, **Q** is the amount of heat (J), **I** is the electric current (A), **R** is the resistance of the conductor (Ω), **U** is the voltage (V), and **t** is the time (s).

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- The amount of heat released in a conductor when an electric current passes through it is equal to the product of the square of the current, the resistance of the conductor, and time during which the current flows.

This conclusion was reached independently based on experiments conducted by the English scientist James Prescott Joule and the Russian scientist Emiliy Lenz. Therefore, it called the Joule-Lenz law.

The amount of heat released when an electric current passes through a conductor is measured in joules.

$$1kJ = 1000\ J = 10^3\ J \qquad 1\ MJ = 1000000\ J = 10^6\ J$$

Another form of the law can also be expressed in terms of electric power. Electric power is mainly determined using two formulas:

$$P = I^2 R \qquad (4)$$

$$P = \frac{U^2}{R} \qquad (5)$$

Using formulas (4) and (5), the amount of heat energy released over a certain period of time can be calculated by the following formula:

$$Q = P\, t \qquad (6)$$

Here is **Q** is the amount of heat (J), **I** is the current (A), **R** is the resistance of the conductor (Ω), **U** is voltage (V), **t** is time (s), and **P** is electric power (W).

This expression forms the physical basis for the operation of electric heaters, irons, kettles, and other household devices. All these devices are designed for an alternating voltage of 220 V; therefore, power and heat energy are calculated as being proportional to U^2. Electrical devices designed for higher voltage use relatively thicker conducting wires, while devices intended for lower voltage use thinner wires. On the other hand, the calculations also depend on how these devices are connected. If the devices are connected in series, calculations are proportional to I^2, where as in parallel connections, they are proportional to U^2. This is determined by comparing the expressions under constant conditions.

The Joule-Lenz law is applied not only in household appliances but also in industrial electric furnaces, irrigation pumps, and welding equipment. At the same time, the overheating of electrical wires and the risk of fire are explained by this law. Specially, electric current is carried by electrons, and as these electrons collide with atoms in the conducter heats up.

IV. Consolidation of the New Topic. The teacher addresses students with questions, and students respond to them:

1. How is the Joule-Lenz law expressed in formula form?
2. Why does a conductor heat up when an electric current passes through it?
3. Why does the thinner part of an electric stove spiral heat up more intensely?
4. Where can we observe the Joule-Lenz law in practice?

Based on the new topic, students independently complete the “How” diagram.

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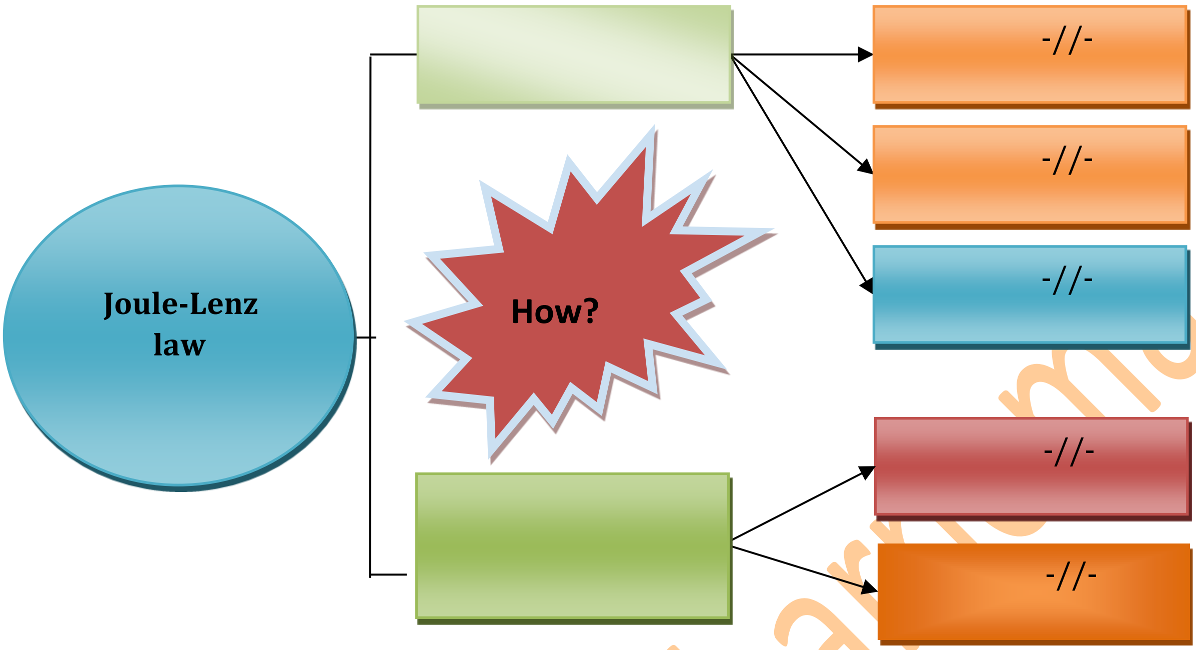

V. Conclusion of the Lesson and Assessment.

At the end of the lesson, the main ideas are summarized and students are assessed according to their performance. The assessment is based on the correct application of formulas, accurate unit conversions, the ability to explain cause-and-effect relationships, and active participation in group work.

VI. Homework Assignment.

Students are asked to determine the power of various household electrical appliances and calculate the amount of heat energy they release in one hour.

RESULTS AND RESEARCH PROCESS

The study was conducted using a quasi-experimental design. The participants were 8th-grade students from classes "A" and "B" of the 1st General Secondary School in Marhamat District, Andijan Region. The classes were selected from existing parallel groups. In the study, class 8-"A" served as the control group and was taught using traditional teaching methods, whereas class 8-"B" served as the experimental group and participated in interactive lessons based on the Case Study method. Before the experiment, students' initial knowledge levels were assessed through a diagnostic test. The obtained results indicated that the overall knowledge levels of the two groups were sufficiently comparable for further analysis. At the end of the study, a final test was administered and the results were compared.

The number of students involved in the experimental study is presented in Table 1.

Table 1. Number of students involved in the experimental study

№	Educational institution	Control group	Number of students	Experimental group	Number of students
1	1st General Secondary School	8-"A"	21	8-"B"	22

Before the study, the learning achievement levels of students in the control group were determined based on the results of the diagnostic test. The results are presented in Table 2.

Table 2. Learning achievement levels of students in the control group before the study

№	Class	Number of students	Knowledge levels			
			0-55%	56-70%	71-85%	86-100%
			Grade 2	Grade 3	Grade 4	Grade 5
1	8 "A"	21	5	5	7	4

Before the study, the learning achievement levels of students in the experimental group were determined based on the results of the diagnostic test. The results are presented in Table 3.

Table 3. Learning achievement levels of students in the experimental group before the study

№	Class	Number of students	Knowledge levels			
			0-55%	56-70%	71-85%	86-100%
			Grade 2	Grade 3	Grade 4	Grade 5
1	8 "B"	22	6	8	4	4

The table results show that at the beginning of the study, knowledge levels of students in both groups were almost the same, with no significant differences observed. This allow for a reliable comparison of the results after the experiment. The level of mastery was calculated as follows:

$$\eta = \frac{M}{N} \cdot 100\% \qquad (7)$$

Where: η - level of mastery (%), N – total number of students, M – sum of students who received grades 4 and 5.

Calculations:

8- "A" class (Control group)

Grade 4: 7 students

Grade 5: 4 students

Total students: 21

Initial result:

M = 7+4 = 11

$\eta_1 = \frac{11}{21} * 100 = 52.4\%$

Final result:

M = 8+5 = 13

$\eta_2 = \frac{13}{21} = * 100 = 61.9\ \%$

Control group improvoment: 61.9 - 52.4 = 9.5 %

8- "B" class (Experimental group)

Grade 4: 4 students

Grade 5: 4ta students

Total students: 22

Initial result:

M = 4+4 = 8

$\eta_1 = \frac{8}{22} * 100 = 36.4\ \%$

Final result:

M = 7+5 = 12

$\eta_2 = \frac{12}{22} = * 100 = 54.5\ \%$

Experimental group improvement: 54.5 -36.4 = 18.1 %

Difference in improvement between groups:

$\Delta\eta_{total}$ = 18.1 % - 9.5 % = 8.6 %

According to the analysis, the proportion of students achieving high grades (4 and 5) in the experimental class increased from 36.4% to 54.5%, representing an improvement of 18.1 percentage points. In the control class, this indicator increased from 52.4% to 61.9%, representing an improvement of 9.5 percentage points. Thus, the experimental class demonstrated an 8.6 percentage-point greater improvement than the control class. To improve the methodological system for developing students' competencies in physics, a quasi-experimental study was conducted at the 1st General Secondary School. During the study, tests were administered to evaluate the effectiveness of the educational content, the selected teaching methodology, and the instructional tools used in the learning process. The test consisted of 15 questions and had a total duration of 45 minutes, allowing approximately 3 minutes per question. Each question included four answer options (a, b, c, d), with only one correct answer. Each correct response was awarded 1 point, and the maximum possible score was 15 points. The obtained results were then analyzed.

Grading criteria based on the scores were as follows:

13–15 points – Grade "5" (excellent)

10–12 points – Grade "4" (good)

7–9 points – Grade "3" (satisfactory)

0–6 points – Grade "2" (unsatisfactory)

Based on the results of the experimental study, the findings are presented in Tables 4 and 5.

Table 4. Learning achievement levels of control class students at the end of the study

№	Class	Number of students	Knowledge levels			
			0-55%	56-70%	71-85%	86-100%
			Grade 2	Grade 3	Grade 4	Grade 5
1	8 "A"	21	4	4	8	5

Table 5. Learning achievement levels of experimental class students at the end of the study

№	Class	Number of students	Knowledge levels			
			0-55%	56-70%	71-85%	86-100%
			Grade 2	Grade 3	Grade 4	Grade 5
1	8 "B"	22	4	6	7	5

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According to the final results, the proportion of students achieving high grades (4 and 5) in the experimental class increased significantly. In particular, it was observed that students with average performance improved their knowledge levels. This confirms the effectiveness of the Case study method.

Table 6. Comparative analysis of the level of Methodological System Improvement in developing students' competencies in Physics

Classes	Number of students	Knowledge levels			
		2 point	3 point	4 point	5 point
Control class	21	5 / **4**	5 / **4**	7 / **8**	4 / **5**
Experimental class	22	6 / **4**	8 / **6**	4 / **7**	4 / **5**

Figure 1

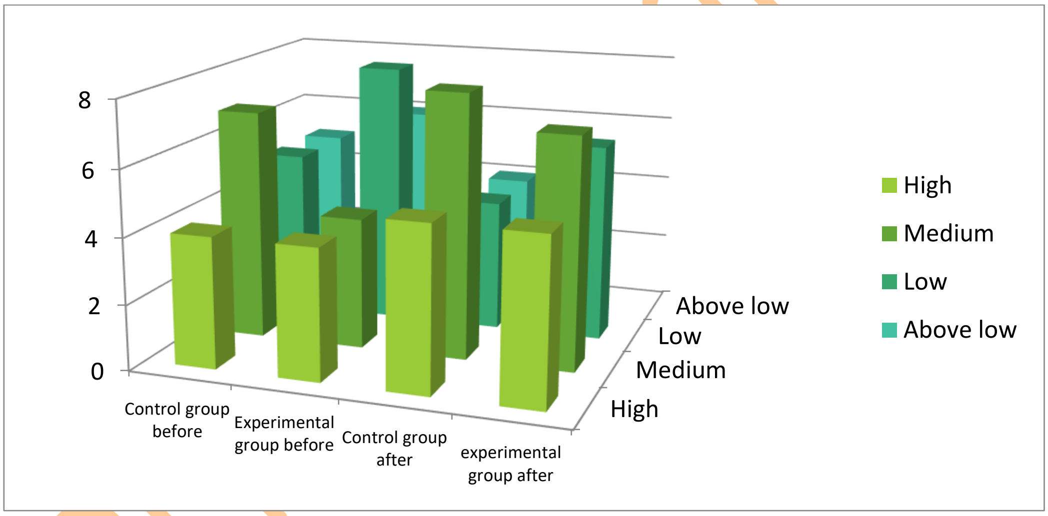

Figure 1. Comparative diagram of the level of Methodological System Improvement in developing students' competencies in physics

According to the obtained results, the findings of the conducted pedagogical research confirmed that the selected model for teaching physics based on a innovative approach, the educational content, the chosen teaching methodology, as well as the lessons developed on this basis and the organizational forms and tools used in their implementation, are appropriate and effective. The research results indicate that students in the experimental group demonstrated significantly higher levels of theoretical knowledge, practical skills, and competencies compared to students in the control group. According to the experimental results, it was determined that students' overall achievement increased by an average of 8.6%. This achievement was calculated based on the difference between the initial and final results.

Conclusion

The findings of this study made it possible to determine the effectiveness of interactive approaches in physics teaching through a comparative analysis of traditional and Case Study methods. The experimental work, conducted with 8th-grade students on the topic of the Joule–Lenz law, showed that lessons organized through the Case Study method contributed more effectively to students' understanding of the topic, their ability to apply knowledge in practical situations, and their skills in analyzing problem-based tasks. These results confirm that the use of real-life situations and discussion-based learning creates favorable conditions for deeper conceptual understanding in physics education.

A comparison of the results obtained in the control and experimental groups demonstrated a clear positive shift in the experimental class. In particular, the proportion of students achieving high grades increased from 36.4% to 54.5% in the experimental group, representing an improvement of 18.1 percentage points, while in the control group the increase was from 52.4% to 61.9%, or 9.5 percentage points. Thus, the growth observed in the experimental group was 8.6 percentage points higher than that of the control group. This indicates that the Case Study method can serve as an effective pedagogical tool for improving students' academic achievement and engagement in physics lessons.

In conclusion, the use of the Case Study method in physics teaching is effective not only for strengthening theoretical knowledge, but also for developing students' critical thinking, logical analysis, independent reasoning, and problem-solving abilities. The study confirms that interactive teaching methods should be more widely integrated into secondary school physics education, especially when teaching concepts that require both theoretical understanding and practical interpretation. The obtained results may serve as a methodological basis for improving the quality of physics instruction and increasing students' interest and competence in the subject.

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