

Broadening didactic resource of physics dictation

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Abstract

It is well known that even excellent scientific and methodological presentation of educational material cannot yield high results without constant monitoring of course assimilation. There are many forms of assessment; one of them is physics dictation. Systematic and regular implementation of dictations, especially of various types, significantly expands the possibilities of this form of work. In accordance with the lesson structure and its educational objectives, we employ several types of dictations (lasting 5 to 25 minutes).

Keywords

physics education, dictation methods, assessment techniques, active learning, problem-solving skills, thermodynamics, optics, dynamics, student engagement

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- final dictation on a topic;
- for operational control of learning material;
- for reinforcing knowledge during the lesson;
- for developing problem-solving skills;
- commentary dictation.

We record the text of the assignments on magnetic tape in advance using a tape recorder, reading each one twice and making pauses, the duration of which depends on the complexity and volume of the question (to prevent excitement in students and create a calm work rhythm, we recommend making pauses after the first tasks slightly longer than necessary to answer the question; when the task is completed and the pause is still ongoing, students gain confidence and tension is relieved).

In cases where the dictation needs to be accompanied by showing drawings, we reproduce them before the lesson on an additional board or prepare appropriate slide or transparency images and project them onto a screen. (If a slide projector is used, the dictation is recorded on a four-track tape recorder. In this case, pulses for the synchroniser are recorded on the free track, which automatically illuminates and changes the slides.)

We compile all types of dictations in one variant (except for dictations on developing problem-solving skills), include 16 questions in the final dictation and 8 in the others; we formulate them so that answers can be given in a brief form: as a graph, formula, simple drawing, etc.

This article is a translation of the original work by Illia O. Teplitskyi (1941–2018), published in Russian in the journal *Fizika v shkole (Physics in school)*, 1985, No. 1, pp. 22–28 [2].



Science
Education
Quarterly



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We select the content of the tasks in such a way that approximately half of them involve reproduction of covered material, while the rest stimulate mental activity with increasing difficulty.

In class before conducting the dictation, students prepare a table form for recording answers. For this, they divide a page in their notebook into 8 equal parts and number them in order. (For final dictations, two adjacent pages are used, as there are twice as many tasks.)

The teacher prepares exactly the same form, but with already formulated and written answers. After conducting the dictation, it is only necessary to compare the teacher's form with the student's form, which significantly reduces checking time. Moreover, errors do not need to be corrected, but only underlined on the student's form, as a form with correct answers is displayed in the classroom at the next lesson.

Final dictation (20-25 minutes)

We usually conduct this type of dictation after studying a topic, before the final test work.

In the physics classroom, we display the text of the upcoming dictation on the "Methodological corner" stand, and next to the questions we also provide answers. We do this so that when preparing for the dictation, students do not scatter their attention on secondary facts, but once again revise the most important and essential points according to correct examples.

To eliminate the possibility of mechanical memorisation, we make the order of tasks different in the text on the stand and in the tape recording, and warn students about this. This simple technique stimulates conscious revision of the material.

The first part of the dictation usually contains tasks on factual material (with elements of comparison, classification by common and opposite features, etc.), and the second part contains tasks on commented solutions of typical problems.

As an example, we provide a physics dictation conducted in the 9th grade after studying the topic "Thermal phenomena. The first law of thermodynamics".

Heat and work

Task 1. Indicate two ways of changing the state of a thermodynamic system.

Task 2.

- 2.1. Write the formula for the work done by gas during isobaric expansion.
- 2.2. What is the amount of heat required to heat a body?
- 2.3. How is the amount of heat required for melting a solid body at melting temperature calculated?
- 2.4. How is the amount of heat released during complete combustion of fuel determined?

Task 3. Write the equation of the first law of thermodynamics.

Task 4. What form will this equation take for the following processes:

- 4.1. isothermal compression;
- 4.2. isobaric expansion;
- 4.3. isochoric heating;
- 4.4. adiabatic compression?

Task 5. Gas isobarically increases its volume from V_1 to V_2 .

- 5.1. Depict the process in pressure-volume coordinates.
- 5.2. Show with dashed lines on the graph what the work done by the gas is equal to and write its value.

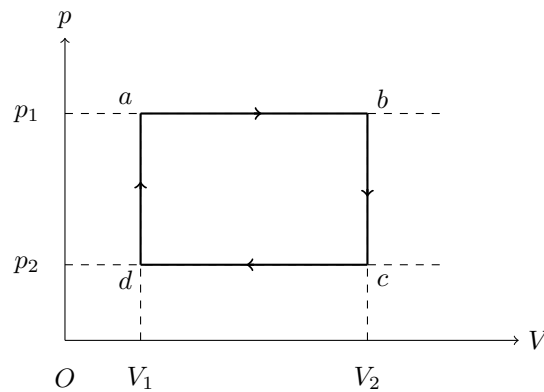


Figure 1:

Task 6. A heat engine operates in a cycle shown in figure 1.

- 6.1. What is the work A' done by the gas during expansion?
- 6.2. What work A must be done to compress the gas?
- 6.3. What is the useful work A_u of the heat engine?

Task 7.

- 7.1. Write the formula for the efficiency of a heat engine.
- 7.2. Write the formula proposed by S. Carnot for calculating the efficiency of an ideal heat engine.

Task 8. List the types of heat engines.

Task 9. Write a shortened condition of the problem: “During isobaric heating of 800 moles of gas by 500 K, 9.4 MJ of heat was supplied to the gas. Determine the work done by the gas and the increase in its internal energy.”

Now solve this problem by completing the following tasks.

Task 10. Write the equation of the first law of thermodynamics and the Mendeleev-Clapeyron equation.

Task 11.

- 11.1. Write the formula for the work of gas during its isobaric expansion.
- 11.2. Write the Mendeleev-Clapeyron equation so that the product of gas pressure and change in its volume is on the left side.
- 11.3. Compare the last two expressions and derive the necessary formula for work from them.

Task 12.

- 12.1. Calculate the work of the gas.
- 12.2. Using the first law of thermodynamics, calculate the change in internal energy.

Task 13. Write a shortened condition of the problem: “In an ideal heat engine, for each kilojoule of energy received from the heater, 300 J of work is performed. Determine the efficiency of the machine and the temperature of the heater if the temperature of the cooler is 280 K.”

Solve this problem by completing the following tasks.

Task 14.

- 14.1. Choose the formula for determining the efficiency of the machine.
- 14.2. Calculate the efficiency value.

Task 15.

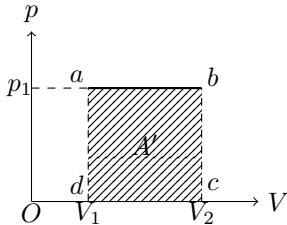
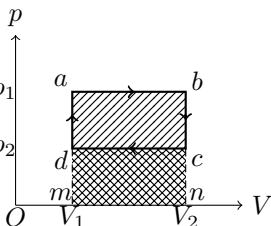
- 15.1. To determine the temperature of the heater, write the efficiency formula for an ideal heat engine.

15.2. After performing transformations, find the expression for the heater temperature from it.

Task 16. Calculate the temperature of the heater.

Table 1 provides answers to the questions of the final dictation.

Table 1

1. a) Heat transfer, b) Work done	9. $p = \text{const},$ $\nu = 800 \text{ mol},$ $\Delta T = 500 \text{ K},$ $Q = 9.4 \cdot 10^6 \text{ J},$ $A' = ? \Delta U = ?$
2. 1. $A = p\Delta V;$ 2. $Q = cm\Delta t;$ 3. $Q = \lambda m;$ 4. $Q = qm$	10. $Q = \Delta U + A',$ $pV = \nu RT$
3. a) $\Delta U = A + Q;$ b) $Q = \Delta U + A'$	11. 1. $A' = p\Delta V,$ 2. $p\Delta V = \nu R\Delta T,$ } $\Rightarrow 3. A' = \nu R\Delta T$
4. 1. $T = \text{const} \Rightarrow U = \text{const} \Rightarrow \Delta U = 0, Q = A' = -A$ 2. $p = \text{const} \Rightarrow Q = \Delta U + p\Delta V,$ 3. $V = \text{const} \Rightarrow \Delta V = 0 \Rightarrow A = 0, \Delta U = Q;$ 4. $Q = 0, \Delta U = A = -A'$	12. 1. $A' = 800 \cdot 8.31 \cdot 500 = 3.3 \cdot 10^6 \text{ J},$ 2. $\Delta U = 9.4 \text{ MJ} - 3.3 \text{ MJ} = 6.1 \text{ MJ}$
5.  2. $A = S_{abcd}$	13. $Q_1 = 1 \cdot 10^3 \text{ J},$ $A' = 0.3 \cdot 10^3 \text{ J},$ $T_2 = 280 \text{ K}$ $\eta = ? T_1 = ?$
6.  1. $A' = S_{mabn};$ 2. $A = S_{mdcn}$ 3. $A_u = S_{abcd}$	14. 1. $\eta = \frac{A'}{ Q_1 };$ 2. $\eta = \frac{0.3 \cdot 10^3}{1 \cdot 10^3} = 0.3$
7. 1. $\eta = \frac{A'}{ Q_1 } = \frac{ Q_1 - Q_2 }{ Q_1 };$ 2. $\eta_{max} = \frac{T_1 - T_2}{T_1}$	15. 1. $\eta = \frac{T_1 - T_2}{T_1};$ 2. $\eta T_1 = T_1 - T_2, T_1 = \frac{T_2}{1 - \eta}$
8. Internal combustion engine, steam and gas turbine, jet engine	16. $T_1 = \frac{280}{1 - 0.3} = 400 \text{ (K)}$

Dictation for reinforcing learning material

We conduct such dictations (usually lasting 5-12 minutes) after explaining new material to reinforce its assimilation by students and to quickly determine the quality of knowledge. Experience shows that this form of assessment allows the teacher to establish how well students have understood the essence of the topic explained in the given lesson, and allows for future adjustments to teaching methods.

We begin the lesson with an explanation, which is accompanied by demonstrations of experiments and visual aids. On the board, we write the headings of points and sub-points of the content being studied, draw necessary graphs, provide mathematical calculations, and logically justify the issues under consideration.

Students simultaneously transfer all notes from the board into their notebooks as the teacher explains. Thus, a summary of the lesson is recorded on the board and in students' notebooks.

After the first explanation, we give a second one, in which we draw students' attention to the most essential aspects of the phenomena being studied, to methods of their graphical representation, peculiarities of symbolic recording of conclusions, etc. Then we offer students questions from the upcoming dictation and collectively discuss possible answer variants. (Students do not make any notes at this time.) Finally, when answers to all dictation questions have been clarified, we turn on the tape recorder, and the class begins to complete the tasks in writing.

We select the content of the dictation so that the first tasks require only reproduction of the main ideas and facts of the new material, while subsequent ones require application of this knowledge in new situations.

Practice shows that a double explanation followed by a detailed analysis of the material, and then independent work by students on the dictation text, which represents active reinforcement, creates real conditions for eliminating student overload when preparing homework, as the educational material is mainly assimilated in the lesson, and the teacher receives extensive and timely information about the level of course assimilation.

As an example, here is a dictation conducted in the 10th grade when studying the properties of lenses.

Lenses

Task 1. How is a thin lens depicted if

- its middle is thicker than the edges?
- its middle is thinner than the edges?

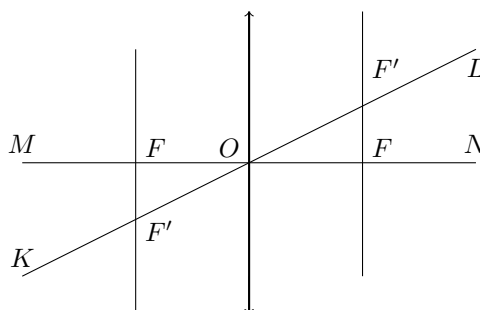


Figure 2:

Task 2. Carefully examine figure 2. Which points and lines denote: the centre of the lens? the principal foci of the lens? the principal optical axis? the focal planes? the secondary optical axis? the secondary foci?

Task 3. Show how the following rays travel after refraction in a thin converging lens:
 a) falling on it parallel to the principal optical axis; b) passing through the principal focus; c) passing through the centre of the lens.

Task 4. Show the path of a ray arbitrarily falling on the lens.

Task 5. Redraw figure 3. Construct the image of point S .

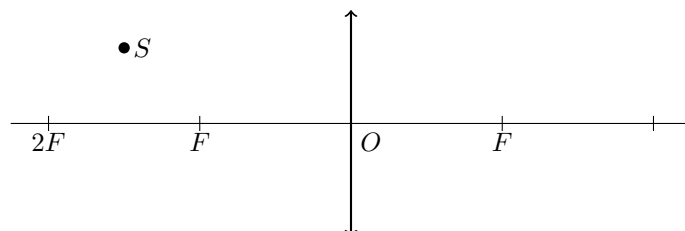


Figure 3:

Task 6. Figure 4 shows the path of a ray passing through a thin lens. Redraw figure 4. By construction, determine the focal plane and the principal focus of the lens.

Task 7. Figure 5 shows the principal optical axis of a thin lens, a light source S and its image S' . Redraw figure 5. By construction, find the foci of the lens.

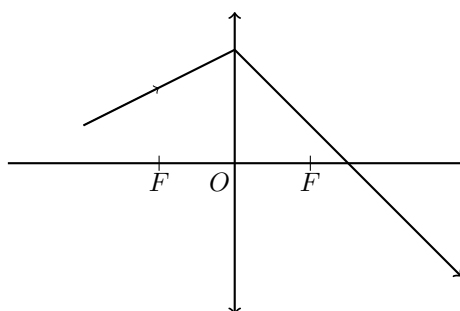


Figure 4:



Figure 5:

Task 8. Write the following formulas:

8.1. Thin lens formula.

8.2. Linear magnification given by the lens.

Table 2 provides answers to the dictation questions.

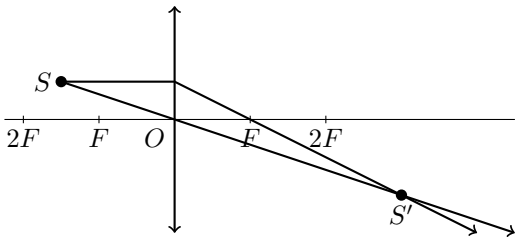
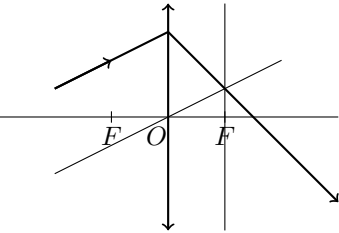
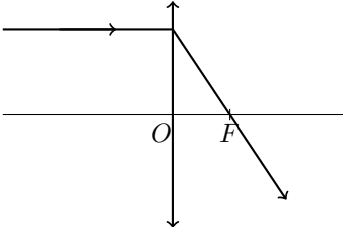
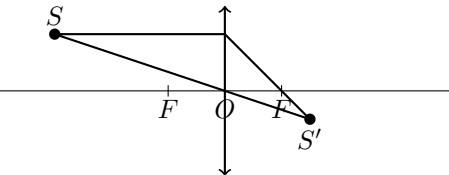
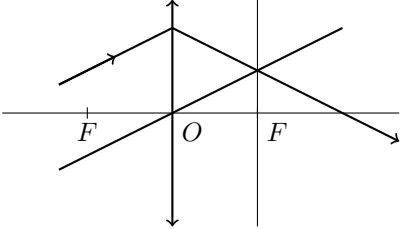
Dictation for developing problem-solving skills and abilities

At the beginning of the lesson where the dictation is planned, we solve a typical problem of medium difficulty with the whole class. We choose a problem whose solution is easily algorithmizable, i.e., allows for creating a clear sequence of actions and reasoning. Then we comment on the solution again, noting the order of operations.

After this, we offer students a dictation with two variants of similar problems. In the first tasks of this dictation, students should analyse the condition, make a drawing and write the necessary equations, then choose a method for solving the equations in general form, calculate and analyse the obtained answer.

Developing problem-solving skills and abilities during the dictation is advantageous compared to the usual method (when one student solves the problem at the board, and the rest in their notebooks), as in this case, all students are interested in the work because everyone's results will be evaluated.

Table 2

1. a)  b) 	5. 
2. $O; F; MN; FF'$ and $F'F; KL; F'$	6. 
3. 	7. 
4. 	8. 1. $\frac{1}{F} = \frac{1}{d} + \frac{1}{f}$; 2. $\Gamma = \frac{H}{h} = \frac{ f }{ d }$

An example of such a dictation is one conducted in the 8th grade on the topic “Application of dynamics laws”.

Application of dynamics laws

Variant I

Problem: A car with a mass of 14 tonnes, starting from rest, covers the first 50 m in 10 s. Find the tractive force if the coefficient of friction between the wheels and the Earth’s surface is 0.05.

Variant II

Problem: A trolleybus with a mass of 10 tonnes, starting from rest, gained a speed of 10 m/s over a distance of 50 m. Determine the coefficient of friction between its wheels and the Earth’s surface if the tractive force of the engine is 14 kN.

We solve the problems in an inertial reference frame associated with the Earth; air resistance is not taken into account.

Task 1. Write a shortened condition of the problem.

Task 2.

- 2.1. Indicate which bodies interact with the given body.
- 2.2. Write the values of the forces with which these bodies act on the given one.

Task 3. Make a drawing depicting the given body, coordinate axes, acting forces, and acceleration vector.

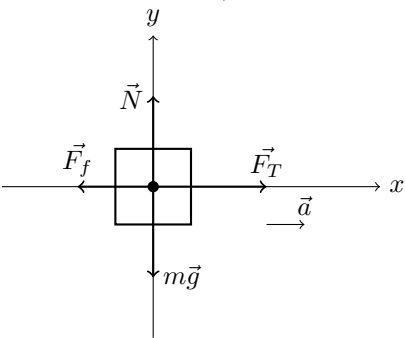
Task 4. Write the equation of Newton's second law in vector form for the motion of the given body.

Task 5.

- 5.1. Rewrite this equation in projections on the coordinate axes. (Note that the resulting system of two equations is incomplete, as there are more unknowns than equations.)
- 5.2. Using the values given in the condition, write the kinematic equation for acceleration.
- 5.3. Write the formula relating the friction force and the modulus of the normal reaction of the support.
- 5.4. Number the four obtained equations.

Task 6.

Table 3

Variant I	Variant II	Variant I	Variant II
1. $m = 1.4 \cdot 10^4 \text{ kg},$ $v_0 = 0,$ $s = 50 \text{ m},$ $t = 10 \text{ s},$ $\mu = 0.05.$ $F_T - ?$	1. $m = 1 \cdot 10^4 \text{ kg},$ $v_0 = 0,$ $v = 10 \text{ m/s},$ $s = 50 \text{ m},$ $F_T = 1.4 \cdot 10^4 \text{ N}$ $\mu - ?$	5. 1. $F_T - F_f = ma, (1)$ $N - mg = 0; (2)$ 2. $a = \frac{2s}{t^2}; (3)$ 3. $F_f = \mu N (4)$	5. 1. $F_T - F_f = ma, (1)$ $N - mg = 0; (2)$ 2. $a = \frac{v^2}{2s}; (3)$ 3. $F_f = \mu N (4)$
2. 1. $\begin{cases} \text{Earth} - \vec{m}g, \\ \text{support} - \vec{N}, \\ \text{engine} - \vec{F}_T, \\ \text{Earth's} \\ \text{surface} - \vec{F}_f \end{cases}$ 2.	2.	6. 1. $F_f = \mu mg; (5)$ 2. $F_T - \mu mg = m \frac{2s}{t^2}$	6. 1. $F_f = \mu mg; (5)$ 2. $F_T - \mu mg = m \frac{v^2}{2s}$
3. 	3.	7. 1. $F_T = \mu mg + m \frac{2s}{t^2},$ $F_T = m \left(\mu g + \frac{2s}{t^2} \right);$ 2. $\text{kg} \left(\frac{\text{m}}{\text{s}^2} + \frac{\text{m}}{\text{s}^2} \right) =$ $= \frac{\text{kg} \cdot \text{m}}{\text{s}^2} = \text{N}$	7. 1. $\mu mg = F_T - m \frac{v^2}{2s},$ $\mu = \frac{F_T - m \frac{v^2}{2s}}{mg}$ 2. $\frac{\text{N} - \frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}}{\text{kg} \cdot \frac{\text{m}}{\text{s}^2}} = 1$
4. $m\vec{g} + \vec{N} + \vec{F}_T + \vec{F}_f = m\vec{a}$	4.	8. $F_T = 1.4 \cdot 10^4 (5 \cdot 10^{-2} \times$ $\times 10 + \frac{2 \cdot 50}{100}) =$ $= 2.1 \cdot 10^4 \text{ (N)} = 21 \text{ (kN)},$ $F_T = 21 \text{ kN}$	8. $\mu = \frac{1.4 \cdot 10^4 \cdot \frac{1 \cdot 10^2 \cdot 10^2}{2 \cdot 50}}{1 \cdot 10^4 \cdot 10} =$ $= 0.04$ $\mu = 0.04$

- 6.1. Analyse equations (2) and (4). Express the friction force from them.
- 6.2. Designate this expression as number (5). Substitute expressions (3) and (5) into equation (1).

Task 7.

- 7.1. Perform algebraic transformations and determine the unknown quantity.
- 7.2. Carry out operations with the dimensions of physical quantities for the given case.

Task 8. Perform calculations and write the answer.

Table 3 contains answers to the dictation questions.

Commentary dictation

Physics dictation serves as a convenient form for organizing frontal experiments. In this case, we divide the dictation into two parts: the content of the first part consists of instructions for performing experiments (the duration of pauses between them is determined by the level of students' experimental preparation), and the second part consists of control questions, to which students give written answers.

Thus, the tape recording frees us from reading the text of tasks, resulting in conditions for productive individual work with students. In addition, this form of work stimulates focused and purposeful educational activity of students, and, in our opinion, has another advantage: there is no noise in the classroom, which often accompanies frontal experiments.

The most convenient and practically ready-made material for preparing these dictations can be found in the manual "Frontal experimental tasks in physics" (authors V. A. Burov, S. F. Kabanov, V. I. Sviridov. – Moscow: Prosveshchenie, 1981) [1].

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Illia O. Teplytskyi (1941-2018): Pioneering computer modeling in Ukrainian physics education



Ілля Олександрович Теплицький

Illia Oleksandrovych Teplytskyi (I. A. Teplitsky, 1941–2018) was a prominent Ukrainian educator and researcher who made significant contributions to the field of science education, particularly in physics and computer modeling. His work helped shape the development of teaching methodologies in Ukraine and beyond.

Born on June 23, 1941, in Kryvyi Rih, Ukraine, Teplytskyi graduated from Kryvyi Rih State Pedagogical Institute in 1964 with a degree in Physics and General Technical

Disciplines. This educational background laid the foundation for his lifelong dedication to physics education.

Teplytskyi's career in education spanned over five decades, during which he worked in various capacities, from a physics teacher in secondary schools to a senior lecturer at the university level. His early career saw him teaching physics in different schools across the Dnipropetrovsk region from 1962 to 1990. This extensive experience in secondary education provided him with valuable insights into the challenges and opportunities in teaching physics to young students.

In 1993, Teplytskyi transitioned to teaching informatics at the Central City Gymnasium in Kryvyi Rih, marking a shift in his focus towards the integration of computer technologies in education. This move coincided with the growing importance of computer science in the educational curriculum and reflected Teplytskyi's adaptability to changing educational needs.

From 2000 until his passing in 2018, Teplytskyi served as a Professor at the Department of Computer Science and Applied Mathematics at Kryvyi Rih State Pedagogical University. In this role, he was able to combine his expertise in physics education with his knowledge of computer technologies, leading to innovative approaches in science education.

Teplytskyi's most significant contribution to science education was his work on computer modeling in physics education. He recognized the potential of computer simulations to enhance students' understanding of complex physical phenomena. His research and publications in this area were groundbreaking, particularly in the Ukrainian educational context.

One of his key works, "Elements of computer modeling" (2005, 2009, 2018), became a fundamental text for introducing computer modeling into the physics curriculum. This work demonstrated how computer simulations could be used to visualize and explore physical processes, making abstract concepts more accessible to students.

Teplytskyi was also at the forefront of integrating new technologies into education. His work on using spreadsheets for neural network simulation, co-authored with colleagues including Serhiy Semerikov, showcased innovative ways to teach advanced concepts using readily available software tools. This approach made complex topics more accessible to a wider range of students.

Throughout his career, Teplytskyi was prolific in his research and publications. He authored and co-authored numerous articles, conference papers, and methodological guides. His work covered a wide range of topics, from the use of electronic tables in physics lessons to the development of creative abilities through computer modeling.

Teplytskyi's contributions extended beyond his own research and teaching. He was actively involved in organizing workshops and conferences on computer technologies in education, helping to disseminate new teaching methodologies and technologies among educators across Ukraine.

In recognition of his expertise, Teplytskyi often collaborated with other leading educators and researchers in Ukraine. His partnerships, particularly with Serhiy Semerikov, led to numerous joint publications that significantly influenced the direction of science education in the country.

Illia O. Teplytskyi's legacy in science education is characterized by his innovative approach to teaching physics, his early adoption and promotion of computer technologies in education, and his dedication to improving teaching methodologies. His work bridged the gap between traditional physics education and modern computational methods, paving the way for more engaging and effective science education in Ukraine. Through his teaching, research, and publications, Teplytskyi influenced generations of students and educators, contributing significantly to the advancement of science education in his country.