

Methodological Foundations For Preparing Students In Physics For Olympiads Through Problem Solving

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Received: 08 December 2025; **Accepted:** 27 December 2025; **Published:** 31 January 2026

Abstract: This article analyzes strategies used by scientists to solve physics problems. The study compares the problem-solving strategy based on analogy with the explicit strategy in solving physics problems. It is shown that solving Olympiad problems contributes to the development of students' creative, intellectual, and scientific potential. A sample Olympiad problem is solved as an illustration.

Keywords: Olympiad, analogy, explicit strategy, heuristic approach, problem, student.

Introduction: In modern physics education, developing students' competencies in effectively solving problems is considered one of the key methodological directions. Physics problems, particularly Olympiad and non-standard tasks, require students to conduct deep analysis, draw logical conclusions, and apply multiple physical laws and concepts simultaneously. According to research findings, problem-solving activities not only reinforce theoretical knowledge but also enhance students' independent thinking and problem-solving skills [1].

Moreover, brainstorming and heuristic approaches stimulate students' creative thinking and enable them to connect theoretical knowledge with real-world situations [2]. Systematic strategies developed by IBMR and Fred Reif are particularly important for solving complex physics problems at the high school and university levels [3]. This article analyzes analogy-based and explicit problem-solving strategies for school physics and illustrates their application using a sample Olympiad problem.

LITERATURE REVIEW

One effective strategy in general education schools is the use of analogy-based thinking. Students can be taught to draw analogies between a previously solved problem and a new problem in a clear and structured manner, even if the problems differ in appearance. This

approach develops students' ability to transfer knowledge from one situation to another based on deep similarities, which is a key skill for specialists. For example, identifying the main similarities between a previously solved problem and a test problem and using them to solve the test problem [4].

Research by N. Podolefsky and colleagues indicates that analogies can be effectively used for teaching advanced students, and when teaching physics through analogies, teachers should pay attention to various ways of interpreting representations and aim to create meaningful connections between them [5]. The importance of analogies is especially significant in solving Olympiad problems because students can apply knowledge gained from previous problems to new situations.

Another strategy highly effective for school students is the explicit problem-solving approach, which involves solving problems in a clearly planned, step-by-step manner. In this approach, the main data and unknown quantities in the problem are identified, corresponding physical laws are selected, calculations are performed systematically, and the results are analyzed from a physical perspective. As a result, students develop logical thinking, deep analysis, and practical application skills, thereby improving their understanding of physics. This strategy not only helps solve the current

problem but also facilitates faster acquisition of new knowledge in the future. Research by M. Chi and K. VanLehn shows that students who consciously learn strategies can later apply them independently to new, complex, and unfamiliar problems. Consequently,

students solve new problems with less assistance and gain a deeper understanding more quickly. This phenomenon is referred to as “**accelerated future learning**” [6]. Table 1 presents the skills developed through this strategy.

Table 1. Skills Developed Through the Explicit Strategy

Structural Analysis of the Problem
Identifying Key Elements
Selecting the Appropriate Physical Laws and Relationships
Planning the Solution

METHODS

Based on the analysis above, we compare the analogy

method and the explicit strategy, taking into account their strengths and weaknesses.

Table 2. Comparison of the Analogy and Explicit Strategies

Criteria / Strategies	Analogy	Explicit Strategy
Suitability for General Secondary Education	Highly Suitable	Suitable
Suitability for Complex and Olympiad Problems	Moderately	Effective, but less supportive of creative thinking
Strengths	Reinforces understanding	Strengthens logical analysis and practical knowledge; suitable for beginner students
Weaknesses	Works only for similar problems	Inconvenient for solving non-standard problems; time-consuming
Main aim	Solve the problems by drawing on similarities with previously solved problems	Solve the problem clearly, step by step, and in an orderly manner.

It can be concluded from the comparison that both strategies complement each other and are very suitable for school students.

Physics Olympiad problems gradually increase in complexity and require students not only to have theoretical knowledge but also to apply physical phenomena creatively and think logically. Unlike ordinary textbook problems, Olympiad problems simultaneously cover several physical processes and laws. Therefore, solving them requires not only knowledge within a single topic but also the ability to

integrate concepts from different areas. Such problems encourage students to think deeply, work independently, make decisions on their own, and develop a creative approach. In the process of solving problems, students not only review their theoretical knowledge but also acquire skills in applying it to practical situations.

Furthermore, solving Olympiad problems requires a high level of mathematical preparation, including a solid understanding of derivatives, differentials, integrals, and geometric concepts. For these reasons,

Olympiad problems play an important role in developing students' intellectual and scientific potential [7]. Based on all these conclusions, a sample solution to an Olympiad problem related to the 9th-grade curriculum is presented below.

RESULTS AND DISCUSSION

Sample solution to an Olympiad problem. **Problem 1:** A diatomic ideal gas with an amount of substance $\nu=1$ mol occupies a volume $V=10V = 10V=10$ L at a pressure $P=250P = 250P=250$ kPa. First, the gas is heated isochorically to $T=400T = 400T=400$ K, then it is expanded isothermally until it reaches the initial pressure. After that, the gas is compressed isobarically back to its initial state. Determine the work done (FIK) during the cycle.

Given: $T=400T = 400T=400$ K, $P=250P = 250P=250$ kPa, $V=10V = 10V=10$ L

To find: $W=?$

Solution to Problem 1: The cycle consists of 1–2 isochoric, 2–3 isothermal, and 3–1 isobaric processes. The work done in any cycle can be determined using the following expression:

$$\eta = \frac{Q_1 - Q_2}{Q_1} \tag{1}$$

Here, Q_1 is the amount of heat absorbed by the gas from the heater during the cycle, and Q_2 is the amount of heat given off by the gas to the cooler during the cycle. The difference in heat, $Q_1 - Q_2$, equals the work done by the gas during the cycle. The working substance (gas) receives

$$\eta = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{\nu C_p (T_2 - T_1)}{\nu C_p (T_2 - T_1) + \nu RT \ln \frac{V_2}{V_1}} \tag{7}$$

If we replace the ratio of volumes in the derived expression with the ratio of temperatures in accordance with Gay-Lussac's law, it becomes possible to express the molar heat capacities C_v and C_p in terms of the molecule's degrees of freedom.

$$C_v = \frac{i}{2} R; \quad C_p = \frac{i+2}{2} R \tag{8}$$

Then, if we put these expressions into formula (7), we get the following

the heat $Q_{1,2}$ in two parts of the cycle: $Q_{1,2}$ during the isochoric process from 1 to 2, and $Q_{2,3}$ during the isothermal process from 2 to 3.

So

$$Q_1 = Q_{1,2} + Q_{2,3} \tag{2}$$

During the isochoric process, the amount of heat absorbed by the gas is given by the following:

$$Q_{1,2} = C_v \nu (T_2 - T_1) \tag{3}$$

Here, C_v is the molar heat capacity of a gas at constant volume, and ν is the amount of substance. Using the Mendeleev–Clapeyron equation, the initial temperature T_1 can be determined.

$$T_1 = \frac{P_1 V_1}{\nu R} \tag{4}$$

During the isothermal process, the amount of heat absorbed by the gas is given by the following:

$$Q_{2,3} = \nu RT_2 \ln \frac{V_2}{V_1} \tag{5}$$

Here, V_2 is the volume occupied by the gas at temperature T_2 and pressure P_1 ; during the 2–1 isobaric process, $Q_{2,3}$ represents the amount of heat.

$$Q_2 = Q_{3,1} = C_p \nu (T_2 - T_1) \tag{6}$$

“Here, C_p is the molar heat capacity of the gas in an isobaric process. The expressions derived for $Q_{1,2}$ and $Q_{2,3}$ are substituted into equation (1)

$$\eta = 1 - \frac{(i+2)(T_2 - T_1)}{i(T_2 - T_1) + 2T_2 \ln \left(\frac{T_2}{T_1} \right)} \tag{9}$$

By doing the calculations, we find the following answer: $\eta=0,041=4,1\%$

CONCLUSION

In conclusion, the analogy-based problem-solving strategy analyzed above facilitates the understanding of new and complex problems in physics by comparing them with previously studied, familiar situations. This

strategy is characterized by the development of students' conceptual thinking, creative thinking, and the ability to transfer knowledge from one situation to another. The explicit problem-solving strategy helps to solve physics problems in a systematic, logical, and understandable way. One of its most advantageous aspects is the formation of students' deep understanding, error control, and independent thinking skills.

REFERENCES

1. Docktor J. L., Mestre J. P. Synthesis of discipline-based education research in physics // Physical Review Special Topics-Physics Education Research. – 2014. – T. 10. – №. 2. – C. 020119.
2. Duit R. et al. On the role of analogies and metaphors in learning science //Science education. – 1991. – T. 75. – №. 6. – C. 649-672.
3. Reif F. Applying cognitive science to education: Thinking and learning in scientific and other complex domains. – MIT press, 2008.
4. Aragaw A. M., Alemu S. A., Seyoum D. G. Improving Secondary School Students' Physics Achievement through Scaffold Simulated Analogical Reasoning Strategy //Pedagogical Research. – 2022. – T. 7. – №. 4.
5. Podolefsky N. S., Finkelstein N. D. Use of analogy in learning physics: The role of representations //Physical Review Special Topics—Physics Education Research. – 2006. – T. 2. – №. 2. – C. 020101.
6. Chi M., Vanlehn K. Accelerated future learning via explicit instruction of a problem solving strategy //Frontiers in artificial intelligence and applications. – 2007. – T. 158. – C. 409-417
7. Isroilov S. S. Methodology Of Increasing Students' Interest In The Science Of Physics By Solving Olympic Problems In Specialized Schools //Galaxy International Interdisciplinary Research Journal. – 2022. – T. 10. – №. 12. – C. 530-533.