Educator Insights: A Journal of Teaching Theory and Practice
Volume 01, Issue 12, December 2025
brightmindpublishing.com
ISSN (E): 3061-6964


# DEVELOPING PUPILS' DIVERGENT THINKING THROUGH COGNITIVE TASKS

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**Abstract**

This article explores the didactic potential of using cognitive tasks to develop students' divergent thinking through solving physics problems by multiple methods. Divergent thinking is understood as the ability to generate several alternative solutions, ideas, or approaches to a given problem, which is a key component of creativity and scientific reasoning. The study is based on the analysis of typical physics problems solved using traditional (convergent) and alternative (divergent) solution strategies. Two representative physics problems were selected and solved using several methods, including analytical, graphical, kinematic, and average-value approaches. Each solution method was analyzed in terms of the type of thinking it predominantly develops.

The research results demonstrate that traditional formula-based solutions mainly foster convergent thinking, focusing on logical consistency and accuracy, whereas alternative and visual methods stimulate divergent thinking by encouraging flexibility, creativity, and the exploration of multiple solution paths. The findings indicate that combining convergent and divergent approaches within physics problem-solving activities enhances students' analytical skills, creative abilities, metacognitive awareness, and cognitive flexibility. The article concludes that multi-solution tasks serve as an effective pedagogical tool for balancing analytical rigor and creative exploration, contributing to the formation of scientifically literate and innovative learners.

**Keywords**: Divergent thinking, convergent thinking, cognitive tasks, physics problem solving, creativity, multiple-solution tasks, scientific thinking.

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brightmindpublishing.com
ISSN (E): 3061-6964


## Introduction

**Аннотация**

В статье рассматриваются дидактические возможности развития дивергентного мышления учащихся посредством когнитивных заданий на основе решения физических задач несколькими способами. Дивергентное мышление трактуется как способность выдвигать альтернативные идеи и находить несколько возможных путей решения одной и той же проблемы, что является важнейшим компонентом творческого и научного мышления. Исследование основано на анализе типовых физических задач, решаемых как традиционными (конвергентными), так и альтернативными (дивергентными) методами. В качестве примеров были выбраны две физические задачи, каждая из которых решена несколькими способами, включая аналитический, графический и кинематический подходы.

Результаты исследования показывают, что стандартные алгоритмические методы преимущественно развивают конвергентное мышление, ориентированное на точность и логическую последовательность, тогда как альтернативные и наглядные методы стимулируют дивергентное мышление, формируя гибкость, креативность и способность к поиску нестандартных решений. Установлено, что сочетание конвергентного и дивергентного подходов в процессе решения физических задач способствует развитию аналитических, творческих и метакогнитивных умений учащихся. Сделан вывод о высокой педагогической эффективности многошаговых и многовариантных задач в формировании научного мышления и творческого потенциала обучающихся.

**Ключевые слова:** дивергентное мышление, конвергентное мышление, когнитивные задания, решение физических задач, креативность, многовариантные задачи, научное мышление.

## Introduction

In modern education, the formation of divergent (creative) thinking skills of students plays an important role. Divergent thinking represents a process aimed at searching for several possible solutions to a problem and proposing various creative ideas [3]. Divergent (creative) thinking is free thinking, which means considering many approaches to solving a problem. Psychologist J. Guilford first

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brightmindpublishing.com
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introduced these terms into science in 1956.

In traditional schools, mainly convergent thinking skills are developed - that is, finding one correct solution based on the given information. This type of thinking helps students find a quick and accurate answer and solve a problem using formulas. Divergent thinking, on the other hand, develops creativity in students and the ability to see several solutions to a problem. Studies show that divergent thinking increases students' open-mindedness, the ability to interpret the problem in a new way, and to find unconventional solutions. In scientific creativity, it is precisely through this divergent thinking that new ideas are created. At the same time, convergent, critical thinking is necessary for the final solution of a scientific problem, for testing and organizing the selected ideas [2]. Therefore, the process of true scientific thinking consists of a balanced combination of these two types of thinking: first, various hypotheses are put forward regarding the solution of the problem (the creative-divergent stage), and then the most correct solution is selected and justified from them (the analytical-convergent stage). The process of solving problems in physics is an effective tool for developing students' thinking. Although physical problems usually have a clear solution, various methods can be used to solve them. By solving a problem in several ways, it is possible to form both types of thinking in students: while the standard solution to the problem requires the student to think logically, sequentially (convergent), searching for alternative methods increases the student's ability to think unconventionally, to find new connections (divergent). We will show the solution of the following two typical physics problems in several ways and analyze what type of thinking each approach develops.

## Methodology

In this section of the scientific study, two physics problems were selected as examples, each of which was solved in several ways, and each step of the solution was analyzed sequentially. The selected problems were: (1) a kinematic problem about the distance traveled by a freely falling body in the last two seconds, and (2) a problem about the static equilibrium of a hanging electric lamp and the tension forces. For each problem, traditional and alternative methods of solution were considered step by step.

If a ball falling with no initial velocity traveled a distance of 40 m in the last two seconds, how long did it fall?

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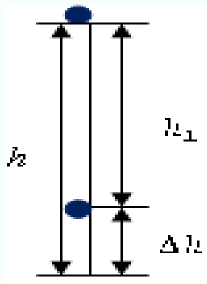
**Given:** **Need to find:**

$\Delta t = 2$ s, $\Delta h = 40$ m $t = ?$

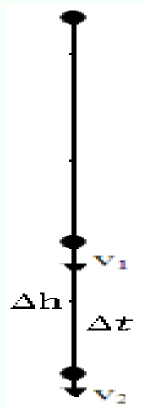


**Method I.** Let the body fall from a height h at time t without initial velocity (Figure 1). $h = \frac{gt^2}{2}$ (1) The distance traveled by the body in time $t - \Delta t$: $h_1 = \frac{g(t-\Delta t)^2}{2}$ (2) Then $h = h_1 + \Delta h$ (3).

Substituting (1) and (2) into (3): $\frac{gt^2}{2} = \frac{g(t-\Delta t)^2}{2} + \Delta h$

From this we find t: $t = \frac{\Delta t}{2} + \frac{\Delta h}{g\Delta t} = \frac{2}{2} + \frac{40}{10 \cdot 2} = 3$ s. Answer: 3 s

**Figure 1.**



**Method II.** Let $\upsilon_1 = g(t - \Delta t)$ be the initial velocity at a distance of Δh (Figure 2): $\Delta h = \upsilon_1 \Delta t + \frac{g\Delta t^2}{2}$ $\Delta h = g(t - \Delta t)\Delta t + \frac{g\Delta t^2}{2}$ Finding t from this equation, we find that $t = \frac{\Delta t}{2} + \frac{\Delta h}{g\Delta t}$. Performing the calculations, we find that t = 3s.

**Method III.** $\Delta h = \frac{v_2^2 - v_1^2}{2g}$ (1) The initial velocity (v1) and final velocity (v2) of the object at a distance Δh are equal to: $v_1 = g(t - \Delta t)$ (2) $v_2 = gt$ (3)

**Figure 2.**

Putting (2) and (3) into (1). $\Delta h = \frac{(gt)^2 - (g(t-\Delta t))^2}{2g}$, we find that t=3s.

**Method IV.** When a body falls freely from a height $h$, it covers a distance $\Delta h$ in time $\Delta t$. The average velocity in uneven motion is $\bar{v} = \frac{\Delta h}{\Delta t}$ or $\bar{v} = \frac{v_1 + v_2}{2}$, from which it follows: $\frac{\Delta h}{\Delta t} = \frac{v_1 + v_2}{2}$; When a body falls freely from a height $\Delta h$ in time $\Delta t$, its velocity is equal $\upsilon_2 = \upsilon_1 + g\,\Delta t$.

$$\begin{cases} v_1 + v_2 = \frac{2 \cdot \Delta h}{\Delta t} \\ v_2 - v_1 = g \cdot \Delta t \end{cases}$$

Solving this system of equations, we find the time of fall of the body, taking into account that $v_2 = \frac{\Delta h}{\Delta t} + \frac{g \cdot \Delta t}{2}$; $t = 3s$.

Educator Insights: A Journal of Teaching Theory and Practice
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brightmindpublishing.com
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**Method V.** We solve the problem graphically. The distance traveled in time *(t-Δt)* is equal to the area of the trapezoid according to the velocity-time graph (Figure 3).

$\Delta h = \frac{v_1+v_2}{2} \cdot \Delta t$ (1) The velocity of the object at time $(t - \Delta t)$ is

$v_1 = g \cdot (t - \Delta t)$ (2)

The velocity of the object when it has traveled a distance h in time t $v_2 = gt$ (3) We put (2) and (3) together:

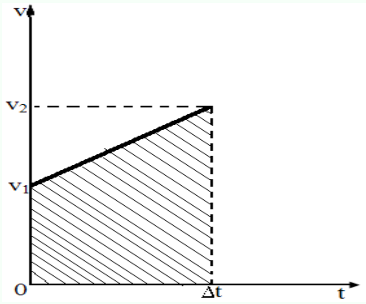


**Figure 3.**

$\Delta h = \frac{g\cdot(t-\Delta t)+gt}{2} \cdot \Delta t$; From this expression we find t: $t = \frac{\Delta t}{2} + \frac{\Delta h}{g\Delta t} = \frac{2}{2} + \frac{40}{10\cdot 2} = 3s$

**Research Results**

The different methods used to solve the above problem require specific thinking activities and develop different skills. Five different methods were used to solve the problem. The first method - solving with a classical formula - relied mainly on convergent thinking: the student used a standard equation and found a single answer with certainty. This approach develops logical sequence and accuracy of mathematical calculations (clear thinking). Similarly, methods 2 and 3 were traditional analysis of the problem using formulas - that is, an analytical-convergent approach. They strengthen the students' skills in applying physical formulas in their place, constructing and solving algebraic equations. However, methods 4 and 5 required a different approach to the problem, alternative solutions. For example, the average velocity method (method 4) required the student to understand the logical connection behind the formula—that is, to see the relationship between two physical quantities (initial and final velocities) in order to find Δh. This method requires analytical thinking as well as some creativity, as the student is using a non-standard formula (the average velocity formula). The graphical method, on the other hand, involves visual modeling of the problem, moving away from traditional formulas—that is, it requires elements of divergent thinking. The student visualized a velocity-time graph, understanding that the area under the graph gives the distance; in the process, he or she abstracted the problem geometrically and used a different method than usual. Thus, considering several methods in the process of solving the free fall problem requires the student to first come up with different ideas (solution methods)—an example of divergent thinking. It required the student to consistently implement each of the solutions and check that the final answers are

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the same, that is, to use convergent thinking. As a result, the student's thinking flexibility develops - that is, he can alternate between different approaches to solving the same problem. This is an important skill for scientific thinking: if one way to solve a problem does not work, then another is formed, the ability to check different options is formed [5].

In general, the practice of solving a problem using several methods provides a harmonious development of convergent and divergent thinking in students. While traditional solutions strengthen basic knowledge and skills (using formulas, mathematical calculations, making logical conclusions), unconventional solutions stimulate creative and critical thinking (seeing different alternatives, comparing, searching for alternative paths). During the process of solving problems, students also develop the following skills:

Analytical skills: Logical justification of each stage of the solution, appropriate application of formulas, verification of the results obtained. This is mainly inextricably linked with convergent thinking and serves to achieve a clear and correct solution.

Creative skills: By approaching a problem in several ways, students practice thinking in new ways. Finding alternative solutions to a problem is a product of divergent thinking - it forms a tendency in the student to propose new ideas and methods.

Graphical and spatial thinking: In some solution methods (for example, graphic integration or vector triangulation), the student is required to interpret mathematical expressions geometrically. This develops visual logic and modeling skills within the framework of general scientific thinking.

Flexibility and reflection: Having seen several options for solving a problem, the student acquires the ability to compare them and analyze which one is the most convenient or fastest. As a result, the student's thinking does not "get stuck" in one direction, but is open to trying different strategies. Such open-mindedness and the ability to re-analyze the results (reflection) are also very important qualities for scientific research activities [5].

## Discussion

From the above analysis, it can be seen that solving a problem in several ways is an effective didactic method that serves to comprehensively develop students' thinking. In traditional approaches, the student learns one "correct" way to solve

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a problem and gets used to it - this develops convergent thinking, but a fixed pattern can form in the choice of solution methods. The comparative use of several methods shows the student that there are several ways to solve a problem, and thus stimulates his ability to creatively search. Didactic research shows that the use of multiple solution tasks (i.e., Multiple Solution Tasks) deepens students' knowledge and increases creativity. In particular, by solving the same problem in different ways, students develop aspects such as flexible thinking (the ability to switch strategies) and deeper understanding. Different approaches to a problem broaden their horizons and help them see the connections between different branches of science, such as mathematics and physics. For example, in physics, some problems can be solved using the laws of classical dynamics, while the same problem can be solved using the energy or momentum method - each approach is based on a separate topic within the science, but they give the same result. Solving a problem from such different theoretical perspectives allows the student to see the structure of physics more holistically, to understand its content rather than memorizing formulas and laws. Solving a problem using several methods teaches students to alternate between analytical and creative thinking. This method is, in fact, the basis of scientific creativity: to first think divergently when solving a problem, considering different ideas, and then choosing the most optimal solution with a convergent approach [4]. In the process of solving a problem, students sometimes think in the mode of "discovery" (search for solutions, divergent stage), and sometimes in the mode of "clarification" (checking and selecting the found methods, convergent stage). Such an approach develops their creative and critical thinking in balance. It is worth noting that teaching only convergent (critical) thinking can lead to the student being accustomed to uniqueness and having difficulty in unusual situations; encouraging only divergent (creative) thinking can lead to an increase in chaotic and impractical ideas. The best result is achieved when using both methods together - the alternating use of analytical and creative approaches allows you to find innovative solutions to the problem and implement them in life [2]. Another didactic advantage is that solving a problem in different ways also forms self-assessment and metacognitive skills in students. They learn to compare solution methods and ask themselves questions such as "Which method is the most convenient or fastest?", "Where did I make a mistake?", "How could I approach it differently?" This turns the student into an active participant and independent

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brightmindpublishing.com
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thinker in the educational process. The student compares his solution with the solution methods of other students or in the textbook, analyzes its shortcomings and successes - as a result, his critical thinking develops. Knowing that there is more than one way to solve a problem gives the student confidence: if he cannot find a solution with the first approach, he will not despair, but will try another method. Such a mentality cultivates a student's perseverance and interest in approaching complex issues.

## Conclusion

In conclusion, it can be said that solving physics problems in several ways is not only a method that provides a didactic advantage in solving complex problems, but also a powerful exercise that stimulates students' creative and analytical thinking. Such an approach enriches the learning process, ensures that students acquire deeper knowledge and skills in the subject. As a result, students learn not only to solve physics problems, but also to analyze any problem comprehensively and creatively, not one-sidedly. This is one of the important steps in educating young people who are capable of solving life problems, who are inquisitive and creative thinkers.

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