

PROBLEMS OF TRAINING PHYSICS TEACHER TO DEVELOP STUDENTS' CREATIVE ABILITIES

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Abstract: Preparing a physics teacher to facilitate students' creative activities is quite challenging. This is especially true when working with individuals who have already received the relevant education and have established views on learning and child development. Furthermore, the author believes that the influence of the consumer stereotype, which some have developed, on teachers and students cannot be ruled out, thereby precluding the need for creativity.

Drawing on personal experience in inventive activities, as well as serving as a jury member at the All-Ukrainian Tournament of Young Inventors and Innovators, the author attempts to uncover some of the challenges of working with such teachers. Her own teaching experience lends credibility to her arguments. She also draws on research by psychologists and educators who work on developing students' creative abilities.

Keywords: creativity, development of abilities, teacher training, professional pedagogy, physics

Introduction. Creative activity is usually understood as a human activity during which something new is created. It makes no difference whether the product is material or intangible. Clearly, only an individual with developed creative abilities is capable of creating something new.

The issue of developing the creative abilities of the younger generation is important from several perspectives. As we noted above, human creative activity can create original products, such as technical devices, chemical substances, new plant varieties, architectural structures, literary works, works of art, etc. That is, anything that improves our lives.

At the same time, we do not always notice another important feature of the creative process. A person with the capacity to create something new can successfully realize their potential only through such (creative) activity. In psychology, this is explained by the need to release the energy that accumulates for this purpose—a process described as "stepping outside oneself" or "liberation." Rogers, N, who practices expressive therapy, points out that without realizing their creative potential, people lose some of their vital energy and become blocked and frustrated. She goes on to write: "My hypothesis is that our hi-tech culture and industrial civilization have separated us from our innate creativity, thus cutting us off from a vital sense of personal satisfaction" [10].

To someone who has not closely engaged with this issue, working with creatively gifted students might seem quite simple and not require any special teacher training. But this is not true at all. Upon starting work at a school, a teacher immediately encounters numerous challenges. It turns out that imparting the specific knowledge outlined in the physics curriculum to students constitutes merely the mandatory "pedagogical minimum" for which future teachers are prepared at university. Experience shows, however, that this is insufficient. In addition to imparting knowledge to students, he also needs to take care of developing their talents for certain types of activities, in particular creativity. And this is much more complicated.

The purpose of this article is to attempt to at least partially show the problems that arise in physics teachers when working with creatively gifted students. This will allow for the subsequent implementation of appropriate training in the system of additional (postgraduate) education.

Methodology. Our research draws upon the analysis of both foreign and domestic sources, as well as observations of the creative processes of participants and jury members at the All-Ukrainian Tournaments for Young Inventors and Innovators (TYuiR).

In addition, we drew upon our own experience in invention-related activities, as well as experience gained in training teachers to work with creatively gifted students at the K. D. Ushinsky Chernihiv Regional Institute of Postgraduate Pedagogical Education. We also took into account observations of the teachers' performance while they carried out educational projects during professional development courses specifically designed for this purpose.

During our research, we used video recording, which allowed us to conduct a more in-depth analysis of the process of preparing teachers to work with creatively gifted students in advanced training courses, identify emerging problems, and adjust our future activities.

We also interviewed teachers, which also provided the opportunity to obtain data on the effectiveness of their preparation for this type of work with students. At the same time, we naturally took into account the results of their work with such students.

Results and discussion. As we begin to discuss these issues and assess the current state of research into them, let us recall that human creative activity gives rise to everything new—both material and ideal. Due to the fact that creative activity can only be carried out by a person who possesses the corresponding (creative) abilities, the problem of their development has long been the focus of attention of researchers in the fields of psychology, philosophy, pedagogy and other sciences.

When it comes to creativity, which is used to create new technical devices and technologies, physics and the process of learning it offer significant potential for developing creative abilities. Consequently, physics teachers should be the ones to address this issue. This emphasis is reflected in physics curricula as well as in numerous manuals and articles on teaching methodology used in pedagogical universities. It is obvious that as a result of training we should obtain a teacher who would have certain knowledge in the field of psychology of creativity, would be able to diagnose students' creative abilities and would have mastered the methods of working with such students. In other words, a physics teacher must possess the competencies required to implement the engineering component of STEM [5].

It should be immediately noted that general education institutions do not yet have textbooks that contain materials for developing students' creative abilities. In their article "Physics textbooks: Do they promote or inhibit students' creative thinking?", researchers Klieger, A. and Sherman, G. analyzed an Israeli textbook on Newtonian mechanics and concluded that its content does not promote the development of creative thinking. Therefore, the authors conclude that it is necessary to change teaching materials and provide appropriate training for teachers. For instance, instead of a traditional problem such as "Calculate the acceleration of the body...", students could be asked to find as many ways as possible to determine it. One could also suggest changing the experimental conditions to obtain a different character of movement. In other words, the problem should allow for multiple answers rather than just one specific solution. The structure and content of such problems influence the nature of the student's activity and the scope for demonstrating creativity [7].

In the article "Learning physics by making models," Schecker, H. proposes that students model physical phenomena. According to the author, the importance of this approach lies in the fact that each student can propose their own model, which will differ from those created by others. They can then test the models in action and compare them [11].

P. Labudde proposes fostering creativity through play and construction-based activities. He views play not merely as entertainment, but as a methodological approach to teaching physics. Games involving the construction of technical devices are of particular interest; for instance, the book presents a challenge to build a small boat out of Styrofoam that can both move water and be propelled by it. Students are presented with specific constraints and a goal they must achieve using methods of their own choosing [8].

Niedderer, H., Schecker, H., and Bethge, T. propose using computer-based modeling tools to foster students' creative abilities during physics instruction. Their work focuses, in particular, on the STELLA software environment. It is important that the computer does not act as a means of demonstrating ready-made physics, but as a tool for constructing and researching models. In other

words, the student creates a model, runs it, obtains a result, compares it with reality, and—if necessary—modifies (refines) it. Essentially, the authors are creating a digital environment to cultivate creative abilities [9].

Specialists in the theory and methodology of physics education are familiar with the doctoral dissertation by Davidenko, A. A. titled "Theoretical and Methodological Foundations for Developing Students' Creative Abilities in the Process of Physics Instruction." It proposes a model of creativity that individuals can enact at varying levels of complexity. During the research, students were engaged in inventive activities [2]. Davidenko, A. A. also authored a monograph titled "Methodology for Developing Students' Creative Abilities in the Process of Physics Instruction" [1]. In addition, Davidenko, A. A. published scientific and scientific-methodological articles, which outlined issues of methodology for working with students who have the potential for scientific and technical creativity [4, 5].

The teaching aid he authored, *Scientific and Technical Creativity of Students* [3], is intended for both teachers and students. It contains a large number of creative problems, with hints provided for the solution of some of them.

The second manual was co-authored with Viorel Bocancea and published in the Republic of Moldova in Romanian[6].

Davidenko, A. A. research findings have been widely implemented in teaching practice. In particular, in 1998, he initiated the annual All-Ukrainian Tournament of Young Inventors and Innovators (TYIIR). It should be noted that already in 2002, UNESCO recognized TYUIR as a mass event for students that surpassed all existing analogues in the world at that time. A few years later, he also initiated the All-Ukrainian Competition for Young Researchers and Inventors, "Edisons of the 21st Century." In 2023, this large-scale extracurricular event was transformed into the International STEM Competition "Edisons of the 21st Century," with members of the organizing committee and jury representing several European countries, including the Republic of Moldova, Romania, and Ukraine.

Below are the conditions of inventive problems that were given to the participants of the above-mentioned mass extracurricular activities to solve.

Problem 1. "Energy of descent from the mountain" Every person knows that when moving uphill, he gets more tired than when moving horizontally. Moving uphill requires the expenditure of one's own energy. However, when the road slopes steeply downward, a person must again expend energy to restrain their movement (by "braking").

Create a technical device that would allow a person to walk downhill without braking, while simultaneously making it possible to generate electrical or at least mechanical energy.

Problem 2: "Refrigerator." During a prolonged power outage (6–8 hours), the refrigerator "defrosts," and the food stored inside becomes unfit for consumption.

Suggest how we can extend the shelf life of food in such a refrigerator without using additional power sources.

As we can see, solving these problems does not always require knowledge beyond the scope of the standard school physics curriculum. In addition, most of the problems traditionally used in the physics teaching process require students to have a sufficient level of knowledge in mathematics. consequently, not all students are able to solve them. In contrast, solving inventive problems relies on creativity, making them more engaging for some students. Furthermore, the process of solving such problems does not always demand an advanced command of mathematics.

At the same time, only a few publications address the issue of teacher training [4]. Occasionally, a thought arises that can be phrased as a question: "Does anyone really believe that a teacher is inherently capable of fostering students' creative abilities without appropriate training?"

But, as our teaching practice and preliminary scientific research show, this is not at all the case. There are numerous challenges, and their nature and scope are constantly evolving. Consequently, teachers require thorough preparation to work with students who show aptitude for creative activity. And given that such training is not carried out at the appropriate level in universities, it needs to be carried out in the system of postgraduate teacher education.

The author does not claim to provide an exhaustive analysis of the issues or to offer solutions, but believes that the material presented in the article will be of interest to specialists involved in the professional training of physics teachers within the system of postgraduate pedagogical education—specifically, in the system of teacher professional development.

We begin our discussion of this issue with a brief analysis of society's attitude toward it, as well as how it is perceived by students and teachers. Without first clarifying the current situation, it would be difficult to identify the specific problems involved or determine how to resolve them. These problems are determined by the dynamics of the development of society itself, science and production. All this forms an attitude among teachers and students towards creating an original product through their own creative activity.

At certain times, members of our society took direct part in the development of science and production. They developed new means of production, communication systems, power plants, factories, and more. The achievements of these innovators received extensive media coverage and were featured in textbooks and popular science magazines. Students were involved in technical creativity, for which purpose technical clubs operated in schools and extracurricular institutions, for example, at young technicians' stations, and young technicians' clubs were created at large factories. Exhibitions of technical creativity and competitions in technical sports, such as "Fox Hunting," were held everywhere, and communications were established between radio amateurs from different countries using self-made radio stations, etc. Naturally, this was a time when technical creativity was both relevant and widely accessible to many students.

The crisis affecting society and the industrial sector led to the closure of certain institutions that hosted technical creativity clubs. Schools also underwent changes. They manifested themselves not only in a decrease in the level of their material support, but also in approaches to assessing the academic achievements of students. Teachers began to focus more on preparing students for standardized tests, neglecting the development of their abilities—particularly their creative potential.

A teacher's motivation to foster students' creative abilities is also influenced by the fact that, over the course of several decades, a psychological stereotype of the "consumer" has been taking shape in modern society.

This, in particular, had a negative impact on the development of inventive creativity. The abundance of new household appliances, combined with the ability and eagerness of educational administrators to purchase new equipment for schools, often leads physics teachers and their students to believe that their own creative efforts are no longer needed. While decades ago physics teachers and students enthusiastically built various devices for themselves and the physics classroom, today they see no point in such activities. In the article "The Nature of Creativity," Sternberg, R. J. points out that creativity is often evident in young children but may be harder to detect in older children and adults, as their creative potential is suppressed by a society that encourages intellectual conformity [12].

It is also important to consider here that a child who has inherited creative talents always, without any coercion, strives to develop and realize them in the course of activities that are relevant to him. I remember how, even when I was a preschooler, I saw in a physics classroom (my father was a teacher at the time and often took me to work with him) the rise of water in a thin glass tube (capillary). That same day, I proposed creating a perpetual motion machine of this type. I illustrated its design in a drawing (Fig. 1). When I shared the idea with my father, he did not criticize it or try to convince me that it was unfeasible. ... Later, I became an inventor and in 2002 I was awarded the Gold Medal of the World Intellectual Property Organization (Geneva) in the category "Best Young Inventor".

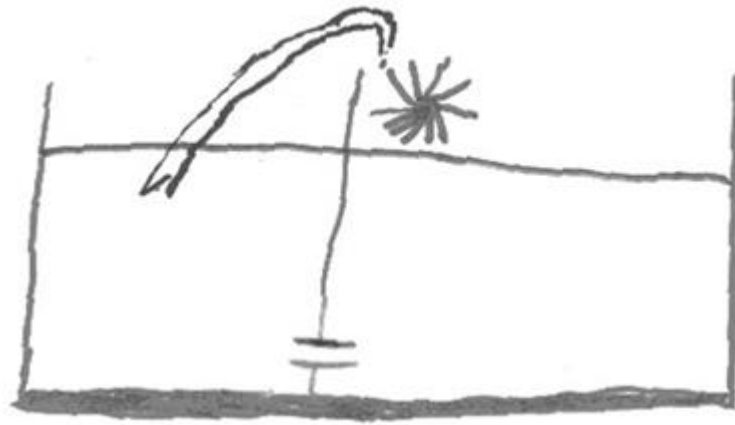


Fig. 1. Capillary "perpetual motion machine"
Child's drawing by the author

This example confirms the need for careful and special attention to children who, having certain creative abilities, are making their first attempts to express them in practical activities. This remains significant for the creative individual throughout their life. It is enough for us to recall cases of rejection of new things by society, which must be taken into account when working with such students.

It should also be noted that a significant number of teachers and students do not believe it is still possible to create anything new. This results in a lack of effort to perceive the extraordinary within the ordinary or to pay attention to existing contradictions—the resolution of which constitutes the very essence of creativity. At the same time, it is important for the teacher to know that he should not expect students to come up with important inventions that will revolutionize everyday life or production. *We are working on developing a person's creative abilities, not on creating something new in the material world.* At the same time, we do not always take into account that students' creative activities can be oriented not only towards improving new or creating new technical devices, but also towards creating new educational tasks, creating original multimedia didactic tools, etc.

Throughout the text, we have repeatedly used the terms "innate potential" and "talent." These are qualities a child inherits from their parents. Without delving into genetics, we will focus only on aspects relevant to this article. While such potential can be inherited, it is not guaranteed. The challenge lies in the ability to identify it. If a person has not inherited the innate predispositions for a particular type of activity, how can one speak of developing them? This is especially true regarding **special** predispositions—those which, through development, enable a person to engage in creative pursuits such as composing music, painting, writing poetry, or creating new technical devices (inventing). Consequently, this issue must be considered paramount.

It should be noted that a teacher's lack of understanding regarding the aforementioned issues has a negative impact on the development of creative abilities in the younger generation.

An analysis of relevant pedagogical experience—specifically that of physics teachers Victor Ciuvaga (Soroca, Moldova), Yuriy Krasnovid, Natalia Litvyakova (Chernihiv region, Ukraine), and their colleagues—convinces us that these issues can be successfully addressed. Our research leads to the conclusion that preparing physics teachers to work with creatively gifted students can be effectively carried out within the system of postgraduate pedagogical education.

Our future research will focus on preparing physics teachers to work with creatively gifted students.

Conclusions. Those representatives of the younger generation who have inherited a talent for creative activity require special attention from society and, in particular, from schools. We must do everything we can to promote the transformation of these inclinations into corresponding abilities, because thanks to them, a person gains the potential to participate in the creation of new technical devices and technologies, works of art, solutions to environmental problems, etc. Moreover, as a

result of the development and realization of the corresponding abilities, as well as thanks to their productive use, a person remains in a state of stable equilibrium with the surrounding world.

In pedagogical science, in particular in physics teaching methods, research has been conducted, the results of which make it possible to organize work with students aimed at developing their creative abilities. However, the issue of training teachers capable of conducting such activities has not been adequately investigated.

During the training of future physics teachers at the university, they are primarily focused on transmitting knowledge to students. Their preparation for working with creatively gifted students is kept to a minimum.

Motivation to work with creatively gifted students is also undermined by the fact that the results achieved do not appear as mandatory items in reports on the teacher's professional activities.

A significant obstacle in working with creatively gifted students is the "consumer" stereotype that has taken root among teachers.

A significant factor regarding teachers' preparation for working with creatively gifted students is their lack of relevant psychological knowledge. This manifests itself in a failure to consistently distinguish between the concepts of intelligence and creativity; consequently, students' activities are directed not toward creating something new, but rather toward seeking pre-existing solutions in accessible sources (such as textbooks, articles, databases, etc.). Such teachers do not encourage the development of students' creative imagination, fantasy, and the like.

To work successfully with creatively gifted students, one must learn to diagnose their inclinations for creative activity. We have developed relevant approaches that we will share in future publications.

Preparing physics teachers to work with creatively gifted students can be successfully carried out within the system of postgraduate pedagogical education.

A teacher should not expect quick results when working with young inventors. It should be remembered that our goal is not to create inventions, but to develop the corresponding abilities in the student.

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