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METHODS OF USING PEDAGOGICAL TECHNOLOGIES IN TEACHING TOPICS RELATED TO THE FIELD OF OPTICS

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Annotation; This article explores the application of modern pedagogical technologies in teaching optics-related topics within the physics curriculum. It emphasizes the importance of interactive and visual teaching methods—such as the "Hook Method," "Fishbone Diagram," and "Venn Diagram"—to improve students' understanding of complex concepts like photometry, wave optics, and geometric optics. The integration of computer-based multimedia tools and innovative instructional strategies enhances student engagement, fosters critical and creative thinking, and improves learning outcomes. The article also discusses the pedagogical and psychological benefits of using such approaches, including sustained interest, independent learning, and the development of analytical skills. Additionally, the reduction of chromatic and monochromatic aberrations is highlighted as essential for understanding optical systems, thus bridging theory with practice.

Keywords: Optics, pedagogical technologies, physics education, photometry, wave optics, geometric optics, interactive learning, multimedia tools, Hook Method, Fishbone Diagram, Venn Diagram, chromatic aberration, student engagement, innovative teaching, visual learning.

Today, technological development is one of the most important components capable of monitoring social processes. Improving pedagogical teaching technologies is essential for shaping the cultural level of society and its economic strength. Teaching technology ensures the functioning of education, facilitates the application of knowledge in the work process, shapes the teacher’s awareness, encourages dynamic activity, and influences one’s path in life. Various approaches to defining pedagogical technologies show that teaching technologies indeed occupy a place between science, production, and the educational-pedagogical process. They form an independent field within the system of professional didactic training, closely linked with the theory and practice of didactics. This field encompasses the functions of designing and constructing the process of managing educational activities. The structure of teaching technology includes both theoretical and practical knowledge about specific methods of managing the educational process, as well as effective teaching and management strategies. The sequence of the educational process is determined in accordance with the conditions under which it takes place.

Teaching technology, teaching theory, and teaching techniques are pedagogical domains concerning the management of educational activity, implemented according to a certain level of generalization. Defining teaching technology involves the normative management of the educational process to ensure the effectiveness of educational and developmental outcomes within professional activity. Scientific literature identifies three aspects of pedagogical technology: scientific, descriptive, and practical. The scientific aspect involves scientifically

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substantiating the goals, content, and methods of teaching and designing the pedagogical process. The descriptive aspect refers to developing an algorithmic process based on the interaction of planned goals, content, methods, and tools aimed at achieving the intended learning outcomes. The practical aspect concerns the implementation of the pedagogical technology process. In relation to educational practice, three levels of pedagogical technology are identified: general pedagogical, subject-specific methodological, and local (modular). General pedagogical technology reflects the entire educational process. Subject-specific methodological technology includes the methods and tools used to carry out the teaching and educational process within a specific subject. Local (modular) technology refers to applying technology to specific sections of the educational process, aimed at solving particular didactic and educational tasks. In pedagogy, alongside teaching technologies, educational technologies also play a significant role. In a similar manner, it is possible to categorize phenomena related to geometrical optics and wave optics into families, which helps reinforce the understanding of these concepts. Another useful example is the application of the “Hook Method” in the photometry section of optics, which allows learners to thoroughly grasp the system of interrelations between physical quantities and their units of measurement. To implement this method effectively, it is necessary to list the physical quantities encountered in photometry along with their measurement units and illustrate them using two “Fishbone diagrams.” The use of pedagogical technologies in the teaching process creates opportunities to achieve several goals and tasks effectively:

Encouraging students not to remain indifferent during lessons, but to engage in independent thinking, creativity, and inquiry;

Ensuring sustained interest in acquiring knowledge throughout the learning process;

Enhancing their curiosity and interest in knowledge by encouraging creative approaches to each task independently;

Organizing constant collaborative activity between the teacher and the student. These creative outcomes promote creative co-activity between the teacher and the learner, increase motivation and interest, and help form a healthy environment of constructive competition. Traditional teaching methodology, while requiring the teacher to possess a high level of knowledge and pedagogical skills, has not given sufficient attention to encouraging healthy competition among students in the learning process. As a result, it cannot provide enough efficiency in today’s modern, scientifically and creatively rich environment, which is supported by electronic sources of knowledge. Another example is the application of the “Hook Method” in the photometry section of optics, which is an effective approach for mastering the system of interrelations between physical quantities and their units of measurement. To implement this, it is necessary to list the physical quantities found in photometry along with their measurement units and organize them using two “Fishbone diagram” models.

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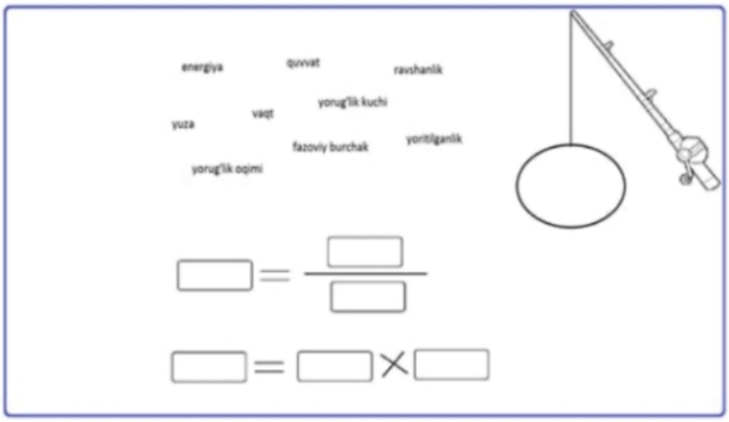

To reinforce physical laws and the units of measurement of physical quantities, the "Hook" and "Fishbone Ring" methods provide the opportunity to systematically apply, automate, and universalize the above-mentioned techniques in the future for consolidating other sections and topics as well. In astronomical practice, the condition of homocentricity is as follows: a plane wave Q incident on the objective (or mirror) is transformed into a spherical wave S, whose center coincides exactly with the image location of the point-like object being observed. In reality, however—except for certain specific cases—the image produced by the optical system is not stigmatic; the image of a point has a finite size. This is due to distortions known as aberrations in the optical system. Geometrically, this corresponds to the following: the plane wave altered by the objective or mirror no longer forms a perfect sphere. If we draw rays perpendicular to its surface, we find that they intersect in a spatial region where a volumetric image distorted by aberration is formed. In both practical and theoretical optics, reducing aberrations below a certain threshold is the goal. Since diffraction cannot be eliminated, this threshold is associated with the dimensions of the diffraction-limited image. Experimental results show that if the deviation of the wavefront from the ideal spherical wave S, centered at the system's focal point, does not exceed one-quarter of the wavelength (i.e., the $1/4\lambda$ Rayleigh criterion), the aberrations are not noticeable. First-order optical systems meet this condition.

Due to the dispersion of the lens material (i.e., the dependence of the refractive index on the wavelength), light of different colors is refracted differently by a given lens. As a result, instead of a single focal point, the lens produces separate foci for different wavelengths. The focal points Fb for violet rays and Fr for red rays are shown. Consequently, the image becomes colored. The shifting of colors depends on the position of the observation screen. This type of image distortion is known as chromatic aberration. Like spherical aberration, chromatic aberration is also characterized quantitatively by longitudinal chromatic aberration (Fb, Fr). To reduce chromatic aberration and minimize it as much as possible, combinations of specially selected lens materials are used. The simplest such lens system consists of a convex lens made of crown glass (a light type of glass) and a biconcave lens made of flint glass (a heavier type of glass), cemented together. If a diverging lens is added to this system, the focal length of the

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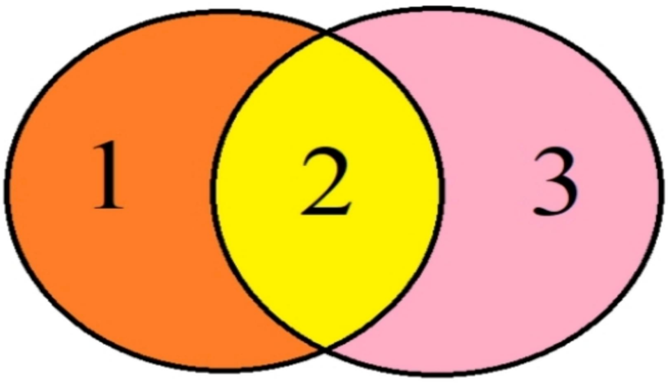
system increases. However, this increase in focal length also depends on the wavelength. Thus, although chromatic aberration can be minimized, it cannot be completely eliminated. The origin of chromatic aberration lies in the dependence of the refractive index nλ on the wavelength λ. Therefore, waves of different lengths are focused at different distances from the objective; each wavelength has its own focal point Fλ. In contrast, reflection of light is not wavelength-dependent, which gives mirrors an advantage over refractors.

The focal length Fl of a simple spherical lens, depending on the curvature radii r of its surfaces and the refractive index nl, is given by the following expression:

$$\frac{1}{F_\lambda}=(n_\lambda-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$$

The “Venn Diagram” method is used to compare two or more concepts and objects, visually represent the results in a diagram, and analyze them. This method helps students develop analytical thinking towards a topic and acquire the skills to grasp the general essence of a subject based on its individual components. It is implemented through schematic work in small groups. The writing board is divided into three equal (topic-appropriate) circles, and the following diagram is drawn accordingly.



In conclusion, the use of computer technologies and multimedia tools based on them in the educational process holds great significance from both pedagogical and psychological perspectives, leading to the following important outcomes:

It activates and accelerates the educational process, increasing its effectiveness; Presenting educational materials in various forms captures students' attention; A high level of visual representation stimulates students’ interest in the subject being studied; The materials help students retain the subject matter in memory for a longer time; Opportunities for independent learning increase, and students' self-learning skills develop;

The problem of time constraints is significantly reduced. Therefore, utilizing pedagogical technologies within the framework of modern educational tools yields good results in

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demonstrating physical phenomena. The application of modern pedagogical and information technologies is one of the most effective and convenient methods for expanding students' imagination, deepening their knowledge, and enhancing the quality of education. To obtain high-quality images, monochromatic and chromatic aberrations must be minimal. Typically, a certain compromise solution is selected, as it is generally impossible to eliminate all types of aberrations simultaneously. Often, it is sufficient to eliminate chromatic aberration for a chosen wavelength.

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