TRANSDISCIPLINARY ASPECT OF TEACHING BIOLOGICAL PHYSICS BASED ON STEM EDUCATION TECHNOLOGIES

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An urgent task of modern didactics of biological physics as a science is to find ways and means that should be effective for practical use during the study of theoretical research using innovative STEM-technologies.

The strategic concept of the integration of the theory and practice of innovative education defines a triad of components: fundamental research, applied scientific developments, practical implementation of innovations. However, the gap between methodological, theoretical and methodical knowledge often reaches threatening proportions [3, p. 96]. Therefore, modern innovation is characterized by a tendency to integrate the goals, content, functions of neology, axiology and praxeology, which determines the integrity of the processes of creation, perception, evaluation, mastering, implementation and analysis of the effectiveness of using the new in pedagogical practice. The innovation methodology emphasizes the unity of the three components of the innovation process: creation, development and implementation of innovations. This three-component process is the object of study in pedagogical innovation [2].

Methodological provisions of pedagogical integration appear as a function and method of learning the theory and practice of innovative processes. As methodological knowledge, pedagogical integration can ensure the continuity of traditional and new, theoretical knowledge and practical experience. As a tool for transforming practice, pedagogical integration is capable of eliminating duplication, that is, optimizing the pedagogical process, leading to the creation of new theoretical and practical objects: concepts, theories, pedagogical systems, training courses, types of activities, models, technologies, didactic tools [1, p. 97].

Applied integrative research is aimed at finding ways to apply theoretical concepts in the development of technologies for the implementation of innovations in the activities of medical higher education institutions. Practical aspects of integration cover all substructures of innovative activity: goals, principles, content, methods, means and forms. «Integrative-pedagogical concepts, condensing a rich set of integrative means, are used as technological-methodological and technological tools for implementing integrative-pedagogical activities. They can give rise to integrative-pedagogical technologies on their basis» [3, p.48].

Summarizing the results of the analysis of scientific research and educational practice makes it possible to highlight the most significant directions of integration of innovative educational processes at three main levels. At the methodological level, the following is carried out: solving complex problems of integrating innovative processes in modern education; the use of cognitive tools of the integrative approach as tools for the analysis of innovative pedagogical phenomena; optimization of traditions and innovations in the conditions of modernization of education; building an integrative educational paradigm; synthesis of methodological, theoretical, methodological and technological knowledge.

At the theoretical level, we consider the following to be relevant: ensuring close integration links between the main components of pedagogical innovation: neology, axiology and praxeology;

creation of invariant integrative models of innovative educational processes; synthesis of the principles and conditions of effectiveness of all stages of the life cycle of innovation; integration of innovative systems related to various types of pedagogical process (for example, a combination of problem-based and modular learning).

The main factors of the development of interdisciplinarity in science and education are immanent complexity (complexity) of nature and society; the need to research problems and questions that cannot be carried out within the framework of individual disciplines; the need to solve social problems of a national and global nature; controversial development of new STEM learning technologies (digital, IT-technologies).

In modern cross-disciplinary research, there are three approaches: multidisciplinary, interdisciplinary and transdisciplinary. Multidisciplinarity means that from the point of view of a common problem, two disciplines A and B are considered simultaneously, but not integrated.

Under an interdisciplinary approach, the perspectives on a common problem of two disciplines A and B are integrated to obtain a more generalized understanding. In a broad sense, interdisciplinarity involves the mutual integration of organizational concepts, methodological procedures, terminology, data, and the organization of research and teaching.

At the current stage of the development of education, transdisciplinary research is found in many fields of science, so at the moment we cannot imagine «pure» physics or biology or chemistry, taking into account the modern requirements of STEM education. We consider this scientific problem for today's stage of the development of science as a complex one, covering various fields of knowledge in the process of its research. Therefore, the solution of such problems, the analysis of such phenomena and the lens are impossible within the framework of a narrow disciplinary framework. Research of reflexive interpretation of complex problems on the basis of philosophical methodological approaches, which do not contradict the disciplinary requirements of specific sciences, but complement their disciplinary content.

The spread among modern scientists of the understanding of problems related to the organization of interdisciplinary research is perceived as the discovery of the impossibility of solving problems with the same means by which we created them.

In connection with the above, M. Max-Nif in his works justifies that integrative cognitive synthesis cannot be achieved based on the accumulation and generalization of the products of the mental activity of different individuals. Such a synthesis, according to Max-Niff, must begin inside the individual brain. In his opinion, the so-called monodisciplinary teaching method is becoming less and less effective.

Considering today's education, only some disciplines, for example, biophysics and disciplines of professionally oriented training, can imagine the inclusion in the plan of using transdisciplinary approaches in modern universities.

Agreeing with the research of native scientists V.S. Stepina, and I. S. Dobronravova, we should note that in modern post-non-classical science, transdisciplinary studies are becoming relevant more often.

Let's agree that transdisciplinary research is a historically new phenomenon; at the current stage, scientists build an understanding of this concept based on a continuum, which theoretically covers the entire set of knowledge at all stages, starting with monodisciplinary, multidisciplinary, plurodisciplinary, interdisciplinary and ending with transdisciplinary research.

However, taking into account the opinion of Max-Neef, we must take into account that after the creation of the union of transdisciplinary researchers in 1994, the idea of a new concept of «open

science» was formed, which requires the interconnection of natural, humanitarian, fundamental and applied sciences, which is the field of research STEM education.

In the 19th century interdisciplinary connections arose and general scientific concepts were formed, and in the 20th century, this trend gained momentum. In addition, the analysis of knowledge itself shows that it is not always possible to clearly distinguish research within the boundaries of the discipline and going beyond these boundaries. In the process of learning within one science, researchers often go beyond the accepted boundaries of a certain discipline, and when arranging the already recognized results, they give them a «disciplinary appearance».

Many problems that exist today in the plane of transdisciplinarity are related to the fact that we need to use different definitions.

The goal of transdisciplinarity is the study of the modern world based on unity and the solution of mega- and complex problems, relying on the conceptual foundations of various disciplines and interested parties of a non-academic profile (stakeholders), taking as a basis one priority theory.

In contrast to the integration of disciplines, there is a synthesis of various knowledge with a potential possibility of transition to a new quality, the birth of a new scientific direction or scientific discipline.

Consider the comparative characteristics of multidisciplinarity, interdisciplinarity, and transdisciplinarity given in Table 1.

Table 1

Comparison of multidisciplinarity, interdisciplinarity and transdisciplinarity [4]

Multidisciplinarity	**Interdisciplinarity**	**Трансдисциплінарність**
Comparison	Interaction	Transition to a new quality
Sequence	Integration	Offensiveness
Coordination	Focusing/ Combination	Transformation

The basis of interdisciplinary research is the acquisition of new, qualitatively higher knowledge compared to the previous one. Epistemological dimensions of interdisciplinarity become crucial in the process of establishing new approaches in education and scientific research.

In the system of transdisciplinarity, four main trends should be singled out, which should be used in the methodology of teaching medical physics based on STEM education:

– use of epistemological searches for system integration of knowledge, the roots of which go back to Ancient Greece, medieval Christianity, principles of universal causality of the Enlightenment era, Hegelian philosophy, unified physical theory, etc.;

– taking into account the synthetic paradigm of postmodern content;

– application of the critical direction of interdisciplinary research, considering transdisciplinarity not only as a transition to a new quality but also overcoming existing disciplinary boundaries (transgression);

– introduction of the concept of post-normal science and the «Second method» of obtaining knowledge, based on the principles of logic, cybernetics, general theory of systems, structuralism, organizational theory.

The second method of obtaining knowledge is characterized by complexity, nonlinearity, heterogeneity, etc. Such knowledge involves public discussions with the participation of stakeholders in order to obtain «reliable scientific knowledge» and «socially sound knowledge».

Interdisciplinarity in natural sciences of the 21st century demonstrates the following trends: 1) a critical attitude to disciplines and individual spheres; 2) blurring the boundaries between natural sciences and humanities; 3) transition from singularity, indivisibility of knowledge to generalizing, unifying strategies within different contexts; 4) the development of transdisciplinarity in the field of natural sciences, where a natural scientist works in real time with partners outside the academic institution.

In terms of methodology, all three main approaches of cross-disciplinarity are united under the common denominator of the main principles of philosophical science:

–the basis of interdisciplinary interaction is the scientific picture of the world, which forms a holistic image of the universe and the interaction of its inorganic, organic and social components;

– the above allows establishing the similarity of the subject areas of various sciences and justifying the translation of knowledge from one science to another, exchanging paradigmatic attitudes;

– interdisciplinary exchange, integration contribute to obtaining new fundamental results that are included in the general scientific picture of the world;

– theories are the main content of science a mature science ideally deals with one identified theory that explains all the phenomena in its field;

–science can produce different theories in different subfields, but the integral scientific goal is to unite such theories within a common system of scientific coordinates;

– using logic, explanation and confirmation, formulate universal general principles for all scientific fields.

Therefore, taking into account the significant scientific research, scientific-organizational and scientific-pedagogical potential, transdisciplinary and integrated approaches provide the content, organizational-technological, institutional-communicative, and personal-developmental functions of the integration of innovative educational processes. As a logical and methodological toolkit, integration is used to solve synthetic problems in the conceptualization, optimization, unification, and universalization of innovative educational processes in the teaching of biological physics based on STEM technologies.

The use of a transdisciplinary approach in the teaching of biological physics contributes to the creation of a complex scientific picture of the innovation process, deepens and enriches scientific ideas about its components, acts as a heuristic and methodological tool for researching theoretical and practical problems of innovative transformations in education, which will ensure high-quality training of highly qualified specialists in the medical field teaching.

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