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THE FUNDAMENTALITY OF THE LAWS OF INNOVATION PROCESSES IN THE EDUCATIONAL ECO ENVIRONMENT: THE ASPECT OF TEACHING PHYSICS ON THE BASIS OF STEM

Abstract. *In the article, as a result of the research, the main directions of innovations in the educational activity of higher education institutions in the context of the development of innovations, in particular STEM education, are identified and analyzed. It has been established that the development of innovativeness affects the modernization of higher education, in particular technical in the context of STEM education. It has been found that the development and implementation of STEM education as a component of innovativeness affects the modernization of physics teaching methods in technical higher education institutions, and physics in particular. This modernization requires taking into account the general trends in the development of psychological and pedagogical aspects of higher education in the context of globalization and European integration processes. The main regularities and conditions of functioning of innovative educational processes in technical institutions of higher education are considered. The concepts of interdisciplinarity and levels of integration of scientific knowledge are analyzed and highlighted: intradisciplinary, interdisciplinary, supradisciplinary, transdisciplinary. The result of the innovation process is the transformation of new types and ways of human life into socio-cultural norms and models that ensure their institutional design, integration and consolidation in the culture of society. New knowledge that arises as direct experience within the framework of research work is removed from the sphere of the cognitive process and transformed into an innovative process in new systems of technological activity. STEM innovations are one of the main socio-cultural prerequisites for the development of social practice, its enrichment with new cognitive, technological forms of human experience, which are subject to reproduction in the process of their mastery by students of higher education of the new generation. It was determined that the achievement of the professional goal for the subject of training is ensured by integrated scientific knowledge of physics and professional disciplines, which is a prerequisite for mastering methods of solving industrial problems, where the difference between educational and professional activities from practical and cognitive activities is considered, taking into account the concept of STEM education.*

Keywords: *STEM education, physics teaching methodology, transdisciplinarity, fundamentality, innovation.*

Problem statement in general and its connection with important scientific or practical tasks. Modern studies of innovativeness (STEM, implementation of robotic technical kits, IoT, Big Data, etc.) are characterized by a tendency not only to the subject, but also to the methodological analysis of the essence and content of innovations in education, in particular, the teaching of physics on the basis of STEM education.

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The necessity for employing a universal scientific approach in examining innovative processes arises from the fact that any innovation or scientific discovery prompts a thorough analysis of the established content of key cross-generating concepts in physics. This leads to a shift in approaches and methods for interpreting existing theoretical concepts, as well as the development of new ones. Additionally, it entails a reassessment of the established knowledge and experiences related to innovations. The importance of the methodological foundation in the study and organization of innovative processes in institutions of higher education (hereinafter referred to as higher education institutions) is emphasized in the studies of S. Honcharenko [1].

At the same time, analysis of the content of scientific research [2; 3] shows that quite often the problems of educational innovations are considered rather narrowly, limiting themselves to attempts to find their solutions only from the standpoint of some one disciplinary theory of the innovation process. We hold the view that the intricate and multifaceted characteristics of innovative educational processes require a thorough examination through various general scientific approaches.

The specificity of innovation is that it is a transdisciplinary field of knowledge in which methodological concepts, theoretical and empirical methods of various sciences are combined to study the problems of educational innovations and innovative activities with the aim of increasing their practical effectiveness (see *Fig. 1*).

The foundation of the interdisciplinary research of innovation phenomena was laid at the beginning of the 20th century by the work of theoretical scientists G. Tard, I. Schumpeter, and M. Kondratiev. Their main ideas became the basis of modern innovative theories [4] in which the driver of social progress is recognized as not one, but a complex of social, technological, economic and other factors of the development of society for the effective formation of the ECO environment (see *Fig. 2*).

Thus, in the context of innovative changes, cognitive practices show an attraction to transdisciplinary synthesis, because these changes are associated with the ability to comprehensively approach the analysis of problems and allow studying what cannot be seen, perceived within the limits of one scientific discipline with its specific object, subject and research methods [5; 6].

Thus, the development of soft skills in modern science (teaching physics, IT technologies, cyber security, introduction of unmanned aerial vehicles, etc.) based on the implementation of STEM occurs mainly due to discoveries made at the intersection of the fields of various scientific disciplines (separation of STEM components) [7; 8], since the traditional field of subject knowledge has practically exhausted its resources.

The methodological arsenal of modern education (didactics, methods, taking into account the psychological characteristics of the subjects of education) is mainly aimed at local modification of the educational process and does not solve the problems of systemic innovative changes in education. In this regard, innovative content requires

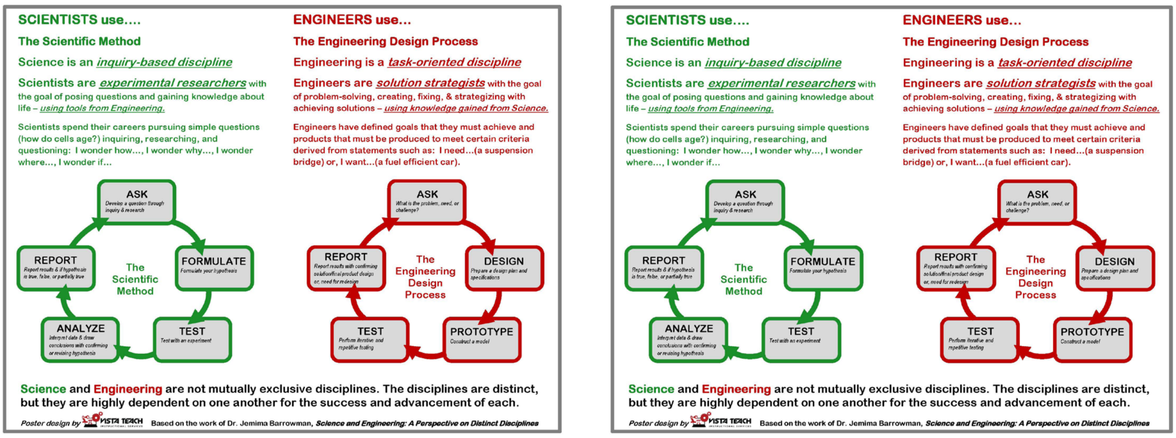

Fig. 1. Interdisciplinarity between the science and engineering component of STEM education

methods of both theoretical understanding and practical analysis of problems that cannot be solved only by means of pedagogical methodology. It is the transdisciplinary approach in the context of STEM education that positions changes in the education system with the process of interpenetration of new things from all scientific and practical fields, which brings research to the meta-theoretical level of building and conceptualizing models of innovative educational processes in the ECO environment.

An analysis of recent research and publications that have begun to address this issue. Taking into account the development of the information society, there are changes (the use of IT technologies, e-learning and blended learning, STEM education technologies) that are constantly accelerating, so it is necessary that the learner in the process of learning physics using STEM learning tools not only master fundamental knowledge, but also formed a need for self-development and self-improvement with the help of thinking and its operations.

Let's highlight the features of interdisciplinary innovation in the ECO environment, which we use in our research in the process of developing a methodology for teaching physics based on STEM education (see *Table 1*).

Interdisciplinarity as a principle of organizing scientific knowledge opens up wide opportunities in solving complex problems of pedagogical innovation, which is an important aspect in teaching physics in the context of STEM.

Along with the term "interdisciplinarity", the terms "transdisciplinarity", "multidisciplinarity" are also used. "Interdisciplinarity" is defined as the transfer of research methods and models from one scientific field to another; "transdisciplinary" characterizes such studies that go "through" different disciplines and reach a meta-level that is independent of one or another specific discipline. "Multidisciplinarity", in turn, is a characteristic of research in which the subject is studied simultaneously by several scientific disciplines. Therefore, it is more appropriate to talk about transdisciplinary strategies and interdisciplinary research, since transdisciplinarity means the starting points of search work and the direction of research, while interdisciplinarity shows the main content of research.

Interdisciplinarity implies dialogue, interaction, mutual enrichment, and not opposition

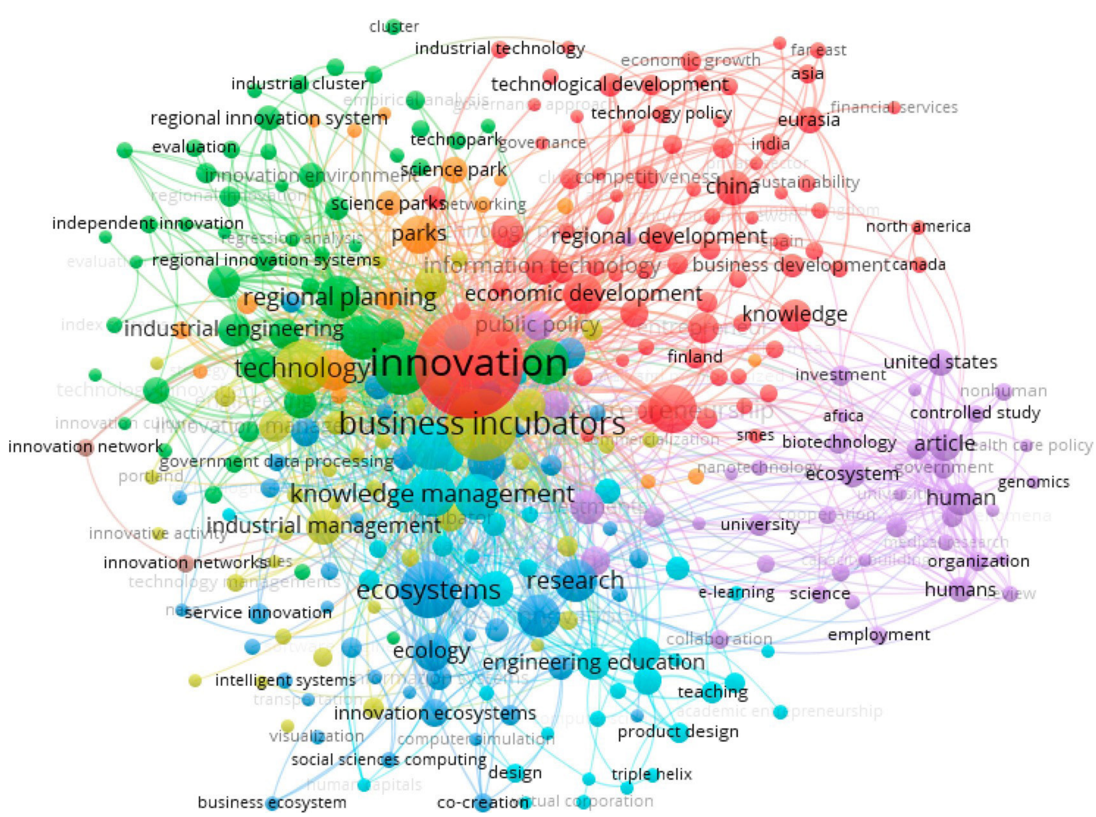

Fig. 2. Map of innovative development in the modern ECO environment [4]

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to different methodologies in innovation research. As the main principle of conducting an interdisciplinary discourse, let us draw attention to the need to go beyond the internal disciplinary paradigm, with the aim of weakening its inherent limitations, expanding the methods of describing reality possessed by individual researchers, and shifting perception in the metaposition in relation to the paradigmatic approaches of individual participants of the interdisciplinary discourse.

The exploration of innovative educational processes is driven by an interdisciplinary approach, encompassing methodological, theoretical, and technological-practical dimensions. The methodological level's importance is rooted in the integration of laws and principles, as well as the complementary nature of diverse approaches and methods in the scientific understanding of the essence, origins, formation, and validation of new elements in education.

In the theoretical realm of interdisciplinary research, matters related to the integration of concepts, models, principles, methods, and ontological ideas from various scientific domains into pedagogical innovation are addressed. This includes considerations of the appropriateness and legality of their application.

The interdisciplinary perspective of research on praxeological problems of pedagogical innovation allows for the synthesis of theoretical constructs from various scientific fields for the development of design technologies, expertise, implementation and monitoring of innovations in higher education. From an interdisciplinary standpoint, praxeological tasks are intricately tied to practical requirements, encompassing all facets of innovative endeavors, including goals, principles, content, methods, means, forms, and more.

P. Atamanchuk [9] outlines the problem of the expediency of an interdisciplinary approach in the educational process in interdisciplinary integration, which is reflected in the processes of combining educational disciplines to solve epistemological, methodological, technological and practical needs. Integration is interpreted by scientists as ensuring the integrity of the educational process.

Table 1

Interdisciplinary innovation in physics education — STEM context

№	Innovation	Characteristic
1	Intradisciplinarity or monodisciplinarity	Considered within the framework of one discipline (for example, physics)
2	Interdisciplinarity	Practices the use of two or more disciplines (for example, physics, avionics, theoretical mechanics)
3	Supradisciplinarity	Characterized by a high degree of generalization (use of a systems approach, the theory of functions and sets, models, etc.), that is, defined (a high degree of integration: all cycles of technical disciplines and physics)
4	Transdisciplinarity	Studying the modern world on the basis of unity and solving mega- and complex problems, relying on the conceptual foundations of various disciplines and interested parties of a non-academic profile (stakeholders)
5	Multidisciplinarity (plurodisciplinarity, polydisciplinarity)	Does not involve further integration or changes in the methodological base of a separate discipline
6	Cross-disciplinarity	Studying a subject using methods borrowed from disciplines not directly related to this subject
7	Paradisciplinarity	Unification of disciplines through dialogue and exchange, opposition of their methods, theories, tools, in order to expand relationships between separate areas of scientific knowledge
8	Metadisciplinarity	Integration of scientific and non-scientific knowledge
9	Superdisciplinarity	Involves going beyond disciplinary limitations and brings scientific research or the educational process into the field of interdisciplinarity

The concept of interdisciplinary relations, as a distinct didactic principle, posits that the content of educational disciplines ought to mirror the dialectical relationships inherent in nature, as understood by contemporary sciences. Interdisciplinary linkages serve as counterparts to inter-scientific connections, with their methodological foundation grounded in the integration and differentiation processes of scientific knowledge. Psychologically, inter-subject connections are underpinned by the establishment of inter-system associations, enabling the reflection of diverse objects and phenomena in the real world, encompassing unity, opposition, complexity, and contradictions.

Scientist V. Sydorenko singles out four levels of integration of scientific knowledge, which demarcate the directions of scientific research to solve complex interdisciplinary problems [10]: interdisciplinary (within separate sciences); interdisciplinary (within two or three branches of science); interdisciplinary (high degree of integration); transdisciplinary (integration of scientific concepts, theories of methods and methods in philosophical concepts).

We see a solution to the problem of overcoming the contradiction between the need to ensure a high level of integration of scientific knowledge in physics and the accelerating process of differentiation of educational disciplines of the cycle of professional training at the intra- and interdisciplinary (interdisciplinary) levels, which will cover such specialized fields of science as physics, which is the foundation for studying disciplines of a professional profile in institutions of higher education of a technical profile.

As noted by N. Podopryhora [11, p. 82] integration processes in modern didactics of physics occur mainly at applied, methodical and didactic levels and are interdisciplinary in nature. The implementation of integrative approaches is a significant factor in increasing the effectiveness of training, which can ensure the high-quality training of a physics specialist and provides for the maximum use at each stage of training of what has been achieved at the previous stages. This, in turn, requires the implementation of not only interdisciplinary connections, but also the sequence of studying individual academic disciplines, topics, and the correlation of the content of individual sections.

In our research, we share the opinion of L. Shestakova regarding the features of interdisciplinary interaction in the educational process of a higher education institution, which will contribute to the improvement of physics teaching methods based on STEM education technologies. She notes [11]:

- the structure of modern scientific knowledge is formed in four branches: 1) natural science knowledge (knowledge about the surrounding world and the natural environment of human life); 2) techno-knowledge (knowledge about artificial intelligence and the artificial environment of human life); 3) social knowledge (knowledge about society); 4) humanitarian knowledge (knowledge about people);
- in the structure of modern scientific knowledge, there is a constant and dynamic interaction between all four branches of modern knowledge;
- in the present phase of educational advancement, humanitarian knowledge permeates all domains of scientific understanding. This is evident in the distinctive characteristics of diverse scientific schools and researchers, the thinking styles and methods employed by various scholars, the incorporation of heuristic and intuitive approaches across different realms of scientific knowledge, and the utilization of methods such as association.

A set of theoretical propositions elucidating the essence of integration in contemporary pedagogy is encompassed by the overarching concept of the "integrative approach". Through integration, formerly independent elements are combined and synthesized into a comprehensive system, establishing functional relationships, facilitating mutual transition and addition, and managing the convergence of theories related to education and upbringing. This integration extends to the unification of systems governing education organization and content. Primary methods of integration include unification, universalization, categorical synthesis, extrapolation, generalization, modeling, and systematization [12, p. 95–96].

The strategic framework for integrating theory and practice in innovative education defines a triad of components: fundamental research, applied scientific developments, and the practical implementation of innovations. However, the disparity between methodological, theoretical, and methodical knowledge often becomes alarmingly wide. Consequently, contemporary innovation exhibits a tendency to integrate the goals, content, and functions of neology, axiology, and praxeology, thereby ensuring the coherence of processes involved in creating, perceiving, evaluating, mastering, implementing, and analyzing the effectiveness of incorporating the new in pedagogical practice.

The methodology of innovation underscores the unity of the three components of the innovation process: creation, development, and implementation of innovations. This tripartite process serves as the focal point of study in pedagogical innovation. Methodological provisions of pedagogical integration emerge as a means and method for learning the theory and practice of innovative processes. As a form of methodological knowledge, pedagogical integration facilitates the continuity between traditional and new theoretical knowledge and practical experience. As a tool for transforming practice, pedagogical integration can eliminate duplication, optimizing the pedagogical process and giving rise to the creation of novel theoretical and practical entities, including concepts, theories, pedagogical systems, training courses, types of activities, models, technologies, and didactic tools [12, p. 97].

Applied integrative research in the teaching of physics is aimed at finding ways to apply theoretical concepts in the development of technologies for the implementation of STEM innovations in higher education. Practical aspects of integration cover all substructures of innovative activity in teaching physics in the context of STEM education: goals, principles, content, methods, means and forms. Integrative-pedagogical concepts, condensing a rich set of integrative means, are used as a technological-methodological and actually technological toolkit for the implementation of integrative-pedagogical activity. On their basis, they can give birth to integrative and pedagogical technologies.

In the modern concept of innovation, three types of innovation are distinguished: 1) product innovation; 2) process innovation; 3) strategy innovation.

From the point of view of integrative characteristics, innovation is a systemic entity that unites: a) an integrative whole, which is a synthesis procedural and effective components; b) integration is a process; c) integration — a result that reflects the moment of fixation of receipt during the implementation of the integration process of a certain integral product. In such an integrative vision, the innovative process in the teaching of physics based on STEM education technologies must be considered as a system in which two sides are combined: conceptual-subject (what new is created) and procedural-technological (how the new is implemented and embodied in the required result). Therefore, STEM innovation represents a system, process and technology that together provide the necessary integrative result in the process of learning physics.

The traditional pedagogical system develops and acquires signs of innovation as a result of interaction with systems of a higher level of development (social, economic, political, pedagogical) and integration in its structure and functions of their more progressive goals, content, and forms of activity.

Integration processes within the pedagogical system involve both qualitative and quantitative transformations of its elements, leading to alterations in the relationships between them. The integrative system exhibits the functions of nonlinearity and linearity, wherein changes in one element do not occur proportionally but follow a more intricate law. For instance, when integrating educational content, it is imperative to anticipate various consequences stemming from the introduction of specific innovative structures. Therefore, constructing integrative content necessitates adherence to the principle of continuity. Linearity presupposes the existence of direct and indirect connections among the elements of the integrative system being developed, enabling compensation for deficiencies arising from its non-linear characteristics.

Summarizing the outcomes of scientific research and educational practice enables the identification of the most significant directions for integrating innovative educational processes at three primary levels. At the methodological level, tasks involve addressing complex issues related to the integration of innovative processes in modern education, utilizing cognitive tools of the integrative approach for analyzing innovative pedagogical phenomena, optimizing traditions and innovations amidst the modernization of education, constructing an integrative educational paradigm, and synthesizing methodological, theoretical, methodological, and technological knowledge.

On the theoretical level, emphasis is placed on establishing close integration links between the main components of pedagogical innovation and creating invariant integrative models of innovative educational processes. This includes the synthesis of principles and conditions for the effectiveness of all stages in the life cycle of innovation and the integration of innovative systems pertaining to various types of pedagogical processes, such as combining problem-based and modular physics teaching with the utilization of STEM technologies.

On the practical level, the primary objectives of researching the integration of innovative processes encompass ensuring continuity between scientific and experimental research and the practical implementation of their findings. This involves coordinating a cluster of diverse innovations simultaneously implemented in higher education institutions, managing innovative educational processes at various levels (state, regional, within individual educational institutions), designing integrated educational content along with corresponding forms and methods of development, establishing integrated forms of innovative activity such as innovation centers, laboratories, and schools of innovation, and developing integrative programs for training teachers for innovative activities within the context of STEM education.

The key factors driving the development of interdisciplinarity in science and education include the inherent complexity of nature and society, the necessity to address problems and questions beyond the scope of individual disciplines, the need to tackle social issues of national and global significance, and the contentious evolution of new STEM learning technologies (digital, IT technologies, etc.).

Transdisciplinary research spans various branches of science. In the current stage of educational development, envisioning "pure physics", biology, or chemistry is no longer feasible given the contemporary demands of STEM education. Addressing this challenge in today's scientific development is complex, requiring the examination of diverse fields of knowledge. Consequently, solving such problems and analyzing such phenomena is impossible within the confines of a narrow disciplinary framework. Exploring the reflexive interpretation of complex problems based on philosophical methodological approaches does not negate their disciplinary essence.

Considering today's education, in modern universities, inclusion in the plan of using transdisciplinary approaches can be imagined, perhaps, only some disciplines, for example, a general course in physics and disciplines of a professional nature, for example, flight dynamics, avionics, resistance of materials, etc.

Agreeing with the research of foreign scientists [13; 14], we note that in modern post-nonclassical science, transdisciplinary research in the context of the development of STEM education is becoming relevant more often.

Let us acknowledge that transdisciplinary research represents a historically novel phenomenon. In the contemporary stage, scientists are shaping their understanding of this concept within a continuum that theoretically spans the complete spectrum of knowledge at various stages. This begins with monodisciplinary, multidisciplinary, plurodisciplinary, and interdisciplinary approaches, as discussed earlier (refer to *Fig. 3*), and culminates in transdisciplinary studies.

In the 19th century interdisciplinary connections arose and general scientific concepts were formed, and in the 20th century. This trend gained momentum. In addition, researchers do not always achieve a clear distinction when considering one discipline, such as physics, in their research. Therefore, scientists go beyond the boundaries of this discipline and give it disciplinary character, taking into account the concept of STEM education.

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

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 in the context of STEM education.

The basis of interdisciplinary research is to obtain new, qualitatively higher knowledge compared to the previous one. Epistemological dimensions of interdisciplinarity become crucial in the process of establishing new approaches in teaching and scientific research in physics based on the implementation of STEM education technologies. Interdisciplinarity, which is considered in the teaching methodology of physics based on STEM education technologies, has three value dimensions: breadth, integration and transformation. Latitude reveals quantitative and qualitative indicators. On the one hand, it is about a set of interacting disciplines (for example, physics, higher mathematics, radioelectronics, theoretical mechanics), on the other hand — about common theoretical and methodological approaches, the object of research, the creativity of the scientific group, the division of labor between its members, compliance of the obtained results to quality standards, etc.

Success is achieved under conditions of coordination, cooperation and exchange. Intellectual interdisciplinary interaction contributes to the formation of self-referential, monolithic structures.

Integration (synthesis) in the first approximation implies a better vision and greater success in solving problems. It is a complex process of applying special concepts, mechanisms and expertise, which are not reduced to the components of individual disciplines (systemic principle) as a result of the introduction of STEM education technologies.

Simultaneously, in their investigations, they noted the following aspects: the conceptual incompatibility of disciplines, the realization that integration is not necessarily the primary objective of interdisciplinary research when aiming for intellectual synthesis in a distinct domain, and the observation that the concept of integration overlooks the fact that knowledge originating from different conceptual paradigms may be incommensurable.

The third epistemological feature (value) of interdisciplinarity lies in its ability to transform old theories and dogmatized knowledge.

At the same time, transformative knowledge is, on the one hand, information about current knowledge and about opportunities for obtaining new ones. Transformational knowledge answers the question of how to achieve the set goals by legal, technical, economic, cultural and other means.

In consideration, disciplinary research distinguishes between instrumental and critical methodologies. Therefore, the instrumental methodology based on STEM technologies is aimed at solving the problems of a specific discipline or a number of related disciplines, for example, physics with theoretical mechanics, electrical engineering, radio electronics, aerodynamics, etc.

In the system of transdisciplinarity in the context of STEM education, we will highlight four main trends that need to be taken into account in the innovation of the ECO environment for teaching physics:

1) epistemological search for system integration of knowledge;

2) synthetic paradigm of postmodern content;

3) interdisciplinarity of research, considering transdisciplinarity not only as a transition to a new quality, but also as overcoming existing disciplinary boundaries (transgression);

4) the concept of post-normal science and adherence to the principles of logic, cybernetics, general systems theory, structuralism, organizational theory.

Interdisciplinarity in the natural sciences, in particular physics, taking into account the concept of the development of STEM education, in the 21st century demonstrates the following development trends: a critical attitude to disciplines as separate fields, taking into account the means of

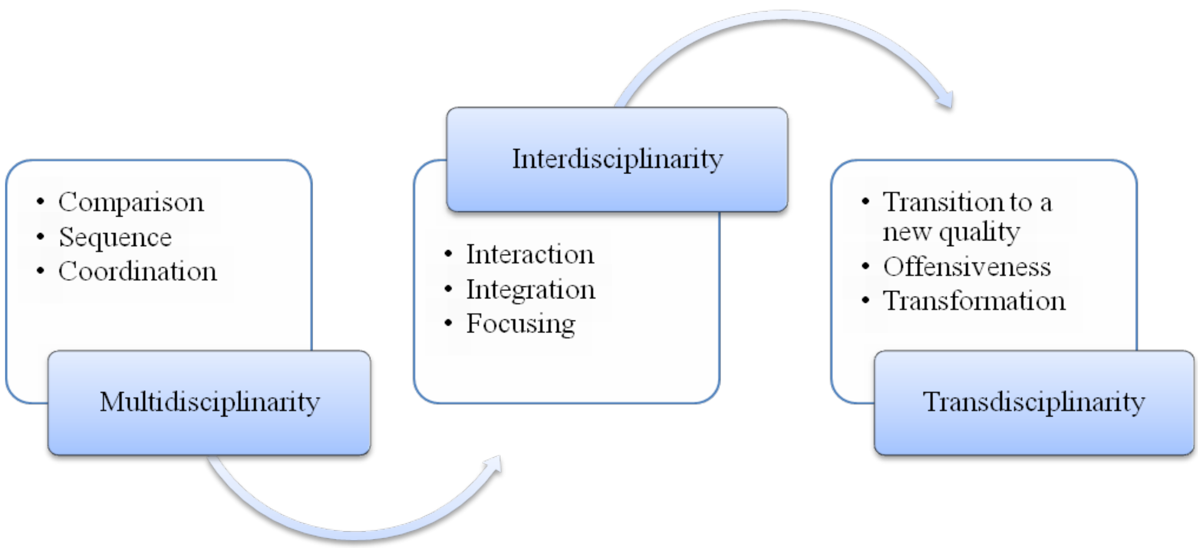

Fig. 3. Innovative approaches in teaching physics based on STEM

STEM education; blurring the boundaries between natural sciences and humanities; transition from singularity, indivisibility of knowledge to generalizing, unifying strategies within the framework of STEM education; the development of transdisciplinarity in the field of natural sciences in the process of using modern means of STEM education, where the natural scientist works in real time with partners outside the academic institution.

Conclusions and prospects for further explorations in this direction. From a methodological point of view, all three main approaches of transdisciplinarity used in the teaching of physics on the basis of STEM education are united under the common denominator of the main principles of philosophical science, namely:

- 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 based on the technologies of STEM education;
- the above allows establishing the similarity of the subject areas of various sciences and justifying the translation of knowledge from one science to another (for example, physics to avonics), exchanging paradigmatic attitudes taking into account the trends in the development of STEM education [15] and its main components;
- interdisciplinary exchange, integration contribute to obtaining new fundamental results in the teaching of physics, highlighting the elements of engineering, technology and science, which are included in the general scientific picture of the world;
- theories are the main content of science. Qualitative identification of the theory that explains all phenomena in its field of STEM innovation implementation;
- cience can produce different theories in different subfields, but an integral scientific goal in teaching physics in the context of STEM is to unite such theories within a common system of scientific coordinates;
- use logic, explanation and confirmation in teaching physics, taking into account the principles of STEM education, which formulate universal general principles for all scientific fields, which is relevant for the formation of an ECO environment.

Considering the considerable scientific-research, scientific organizational, and scientific-pedagogical potential, the transdisciplinary approach serves the content, organizational-technological, institutional-communicative, and personal-developmental functions for integrating innovative educational processes in physics education within higher education institutions. The logical and methodological tools of transdisciplinarity in teaching physics are applied to address synthetic problems related to the conceptualization, optimization, unification, and universalization of innovative STEM educational processes.

Therefore, the use of transdisciplinary and interdisciplinary approaches in teaching physics contributes to the creation of an effective methodology for teaching physics based on STEM-education technologies, which deepens and enriches the scientific ideas of subjects of education about its components, acts as an innovative methodological tool for theoretical and practical research problems regarding STEM transformations in education.

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ФУНДАМЕНТАЛЬНІСТЬ ЗАКОНІВ ІННОВАЦІЙНИХ ПРОЦЕСІВ В ОСВІТНЬОМУ ЕКОСЕРЕДОВИЩІ: АСПЕКТ НАВЧАННЯ ФІЗИКИ НА ЗАСАДАХ STEM

Анотація. *У статті в результаті дослідження виокремлено та проаналізовано основні напрями нововведень в освітній діяльності закладів вищої освіти в контексті розвитку інновацій, зокрема STEM-освіти. Визначено, що розвиток інноваційності впливає на модернізацію вищої освіти, зокрема технічної, в контексті STEM-освіти. З'ясовано, що розвиток та впровадження STEM-освіти як складової інноваційності впливає на модернізацію методики навчання фізики у технічних ЗВО. Ця модернізація потребує врахування загальних тенденцій розвитку психолого-педагогічних аспектів вищої освіти у контексті глобалізаційних та євроінтеграційних процесів. Розглянуто основні закономірності та умови функціонування інноваційних освітніх процесів у технічних закладах вищої освіти. Проаналізовано та виокремлено поняття міждисциплінарності та рівні інтеграції наукового знання: інтрадисциплінарний, інтердисциплінарний, супрадисциплінарний, трансдисциплінарний. Результатом інноваційного процесу є перетворення нових видів і способів людської життєдіяльності на соціально-культурні норми та зразки, які забезпечують їх інституційне оформлення, інтеграцію й закріплення в культурі суспільства. Нове знання, що виникає як безпосередній досвід у межах роботи дослідницького характеру, виводиться зі сфери пізнавального процесу й переоформлюється в інноваційний процес у нових системах технологічної діяльності. STEM-інновації виступають однією з основних соціокультурних передумов розвитку суспільної практики, збагачення її новими пізнавальними, технологічними формами людського досвіду, що підлягають відтворенню в процесі їх освоєння здобувачами вищої освіти нового покоління. Визначено, що досягнення професійної мети суб'єктом навчання забезпечується інтегрованими науковими знаннями фізики та професійних дисциплін, що є передумовою оволодіння способами вирішення виробничих проблем, де розглядається відмінність навчально-професійної діяльності від практичної та пізнавальної з урахуванням концепції STEM-освіти.*

Ключові слова: *STEM-освіта, методика навчання фізики, трансдисциплінарність, фундаментальність, інноватика.*

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