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THEORETICAL AND METHODOLOGICAL FUNDAMENTALIZATION OF SCIENCE EDUCATION IN THE CONDITIONS OF INTEGRATION OF PHYSICS AND PROFESSIONALLY ORIENTED DISCIPLINES ON THE BASIS OF STEM-EDUCATION

Abstract. *The emphasis of science education is to increase students science literacy through investigative measures that include planning, measuring, observing, analyzing data, developing and evaluating procedures, and studying evidence based on the introduction of modern learning technologies (STEM-technologies). The article considers the concept of science as a pioneer of "science education", substantiates the theoretical and methodological fundamentalization of science education on the basis of STEM-education of a technical institution of higher education. It is determined that the main function of the system of science education is to provide society with sciencealy literate citizens. The information and resources (usually financial) reinforce this system. In the article we have formed a model of science on the development of STEM-educational trends of innovative development of education in Ukraine. We have formed the features of science education on the basis of STEM-technologies that will contribute to the introduction of modern methods of teaching physics and professionally oriented disciplines. The integration processes in education in recent years have become increasingly important, as they are aimed at implementing new educational ideals — the formation of a holistic system of knowledge and skills of the individual, the development of their creative abilities and potential. The idea of integrated teaching of physics and professionally oriented disciplines is relevant, because its successful methodological implementation involves achieving the goal of quality science education, ie competitive education, able to ensure each person to achieve a life goal, creative self-affirmation in various social spheres. Learning science will allow students to lead a full and responsible life, encouraging them to learn independently, solve new situations, think critically, think creatively, make informed decisions and solve problems. Students should also develop an understanding of the relationship between science, technology, society and the environment (STSE), and strengthen the ability to integrate and apply knowledge and skills in physics and vocational disciplines in technical freelance education. They must be able to address changes and challenges in a constantly evolving society and contribute to the science and technological world.*

Keywords: *science education, STEM-education, fundamentalization, physics, professionally oriented disciplines.*

Problem statement in general and its connection with important scientific or practical tasks. The implementation of the requirements of modern life has set before the technical institutions of higher education (HEI) a fundamentally new general pedagogical task to purposefully prepare student's through professional development to fully enter the complex modern life. The task of higher education is to provide society with fundamentally trained competent professionals who are able to creatively apply in practice the latest advances in modern science and technology, use innovative technologies, flexibly responding to the demands of a market economy. The existing threat of losing the high professional qualification of graduates of technical HEI's, reducing the level of their education necessitates a priority solution to the problem of higher education on the basis of STEM-education, abandonment of traditional stereotypes of education in these educational institutions. To work in the fields of science, culture, medicine, education, where engineers-graduates of technical free economic zones find their field of activity, today we need competent, cultural and professionally trained specialists (mastering epistemological knowledge, distance learning skills, artificial intelligence, real and augmented reality, etc.) [1; 2; 3], who are really able to help revive science activity in Ukraine with their work. From the above follow the priority aspects of the study of this problem, namely the disclosure of the essence of the fundamentalization of science education as a principle of modernization based on STEM-educational approaches inherent in the professional development of technical specialist's.

All this puts hardly the most priority research of such a pedagogical problem: fundamentalization as a principle of modern education in the professional development of future engineers. Currently, researchers in the field of general, vocational education are radically reconsidering the paradigm that has traditionally developed in the system of higher vocational education of specialists in all sectors of the economy of Ukraine, including engineers, which can not be really solved outside the context of institutional, social and psychological-pedagogical problems that the lives of technical freelance graduates face very harshly. They are often not ready to solve such complex and extraordinary tasks, so the qualification of engineers requires significant improvement, especially in the framework of fundamental knowledge on the basis of STEM education with the separation of its components.

An analysis of recent research and publications that have begun to address this issue. The definition of "science" is revealed in human activities aimed at obtaining new knowledge (using theories, hypotheses, laws, etc.) in terms of innovative development of the state.

The terms science and scientist were first introduced by Whewell William (1794–1866) in The Philosophy of the Inductive Sciences in 1847. "… It is extremely important for us to choose a name to describe someone who is engaged in science in general. I tend to call him a Scientist" [4].

Given Kant's opinion — science reflects a set of knowledge related to the principles, judgments, predictions and problems of reality and its individual areas or aspects.

Science education is the teaching and mastering of aspects of science by pupils, students, scientists. The field of science education includes work in the content of science, the science process using the science method and didactic aspects of pedagogy. U. S. science education standards provide expectations for the development of understanding for students throughout their course of study K-12 and beyond. Traditional subjects included in the standards are physical, household, terrestrial, space and humanities [5; 6; 7; 8].

The concept of science education was revealed by Yuriy Gotsulyak, Maxim Galchenko [9], Svitlana Babiychuk [10], Liliia Hrynevych, Nataliia Morse, Mariia Boyko [11]. The works of such scientists Stanislav Dovhyi, Maxim Galchenko and others were devoted to the study of this concept in the educational process of educational institution's, the philosophical direction in this aspect was outlined by Victor Andrushchenko and Dmitryi Dzvinchuk [12], Victor Vashkevych [13], Victor Ognevyuk and Olha Kuzmenko [14] and others.

The aim of the article is to highlight the theoretical and methodological fundamentalization of science education in terms of the integration of physics and professionally oriented disciplines on the basis of STEM-education.

According to the article, we have identified the following tasks:

1. To reveal the concept of science, which is fundamental for the formation of science education.
2. Consider the genetic development of the concept of science, based on physical and materialist categories.
3. To form a model of science on the development of STEM-educational trends of innovative development of education in Ukraine.
4. To consider the concept of fundamentalization and substantiate the theoretical and methodological principles of science education in the context of STEM-education in technical HEI.
5. To consider an example of integration of physics and professionally oriented disciplines with allocation of a component of scienceity, which is important for formation of practical skills

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of subjects of training in engineering and technical branches of training.

Theoretical and empirical methods were used in the research process: analysis and synthesis to clarify the definition of science and science education, the genesis of science development; substantiation of the concept of fundamentalization and formation of theoretical and methodological fundamentalization of science education in the process of teaching physics and professionally oriented disciplines on the basis of STEM-education; processing of statistical data on science education in Ukraine and the world.

Research education should focus on competencies with an emphasis on learning through science and the transition from STEM to STEAM, the connection of the science component (physics) with professionally oriented disciplines of the technical of HEI.

Taking into account the Law of Ukraine «On Education», the Law of Ukraine "On Higher Education"; Law of Ukraine "On Science and Science-Technical Activity" and the National Qualifications Framework [15], which reflects the importance of science education as a means of acquiring key STEM competencies to facilitate the transition from "education to employment", it is necessary to take into account: 1) the study of science and the separation of the science component in the process of teaching natural sciences and professionally oriented disciplines in technical free economic science; 2) interdisciplinary links and synergies between science, creativity, engineering, mathematics and innovation; 3) increasing the emphasis on mastering digital skills of the 21st century (STEM-competencies), which are necessary for the subjects of education in the educational process of technical free economic zones. The standard framework for science education was originally outlined in the K-12 program for the implementation of STEM education in the United States and is referenced https://www.deped.gov.ph/wp-content/uploads/2019/01/Science-CG_with-tagged-sci-equipment_revised.pdf.

The historical development of the concept of science is shown in table 1, which is an important factor for the development of science education in the 21st century in terms of innovative development of Ukraine, aimed at training highly qualified specialist's in science.

Thus, given the analysis of the genesis of science, we conclude that for science education in the 21st century the following features are inherent:

- differentiation of science — a dialectical process characteristic of the whole process of science development and due to knowledge, practical and theoretical needs of society. Differentiation is objective in nature and is repeated every 5–10 years;
- *integration of science* — is clearly traced in the process of transition of modern science from subject to problem orientation during the solution of complex theoretical and practical issues on the basis of STEM-education technologies. Integration reflects the relationship and interdependence of science knowledge, increased penetration of some sciences into others;
- *accelerated development of natural sciences* — the basis of science in general, which is considered in basic and applied research, as well as the development of production progress;
- *mathematization of sciences* — promotes the development of logical thinking, the use of SPS (software and pedagogical software, elements of engineering), increases the requirements for the usefulness of the tasks, increases the level of generalizations, the effectiveness of explanatory and predictive functions of science;
- *the relationship of science, technology and business* — at the present stage, science is a productive force of society, which is manifested in profound changes in the relationship between science and industry;
- *digitalization of science education* — education that functions due to digital technologies implemented through the use of the Internet;
- *development of the Internet of Things* — physical objects or devices that have built-in sensors and sensors, as well as software that allows physical things to interact with computer systems and networks, in incl. Internet.

The content of science and her processes are considered in the curriculum from K 12 [5; 16]. The development of the curriculum due to problem situations stimulates the development of interest of subjects in the study of natural sciences and professionally oriented disciplines.

The curriculum of the K-12 research program is research-oriented, emphasizing the use of evidence to construct explanations. Concepts and skills from the life sciences, physics, chemistry

Table 1

The genesis of the development of science as the originator of the definition of "science education"

№	The name of the stage	Inherent features
1	Ancient science	Natural philosophy, which is characterized by a method of dialectics and materialism, was studied
2	Sciences of the ancient world (Babylon, Egypt, India, China)	Spontaneous-empirical process of cognition, which combined cognitive and practical aspects. Knowledge had a practical orientation, methodological developments for a specific activity
3	Science level of knowledge (Ancient Greece)	Creation of the first theoretical systems in geometry (Euclid), mechanics (Archimedes), astronomy (Ptolemy)
4	A new form of science, scholasticism is spreading in Europe	Scholasticism is characterized by a combination of theological and dogmatic preconditions with a rationalist method of teaching and interest in formal-logical problems
5	In the science and philosophical system of Aristotle there was a division of science: into physics and metaphysics	Metaphysics — the philosophy of existence, reflections on the ultimate and supersensible principles and principles of existence. Subsequently, there was a process of differentiation of science and the selection of independent subjects and methods of individual disciplines: logic and psychology, zoology and botany, mineralogy and geography, aesthetics, ethics and politics
6	From the second half of the XV century in the Renaissance begins a period of significant development ofscience as a science	Much attention is paid to experimental research. At this time there is a further differentiation of science; fundamental educational disciplines — mathematics, chemistry, and physics — were taught in educational institutions
7	The first science revolution	During this period, along with observations, experimentation was widely used (the creation of analytic geometry by Rene Descartes, logarithms by John Napier, differential and integral calculus by Isaac Newton and Gottfried Leibniz, as independent sciences, chemistry, botany, physiology, and geology emerged). At the end of the 17th century. Isaac Newton discovered the law of universal gravitation. Discovery of the steam engine by James Watt, electric current and the phenomenon of electromagnetic induction by Alessandro Volt, Vasil Petrov, Humphrey Dewey, Andre-Marie Ampere, Michael Faraday. Dmytro Mendeleev's discovery of the periodic law of chemical elements, which proved the existence of an internal connection between substances. Of great importance were the discoveries of non-Euclidean geometry (Nikolayi Lobachevskyi) and the laws of the electromagnetic field (James Clerk Maxwell), electromagnetic waves and the pressure of light
8	The second science revolution	Open electron, laid the foundations of quantum mechanics (Max Planck, 1900). Thus, the second science revolution (late 19th — early 2st century) Led to the emergence of a new, non-classical science, which includes the discovery of the electron, radio, transformation of chemical elements, the creation of relativity and quantum theory, penetration into the microworld and knowledge of high speeds
9	The third science revolution	The emergence of post-neoclassical science. Just as the first science revolution grew into the industrial revolution that gave birth to industrial civilization, the third science revolution became the technological revolution that shapes post-industrial civilization, which corresponds to post-industrial, informational, postmodern society. Science is developing in three directions: microworld, megaworld, macroworld

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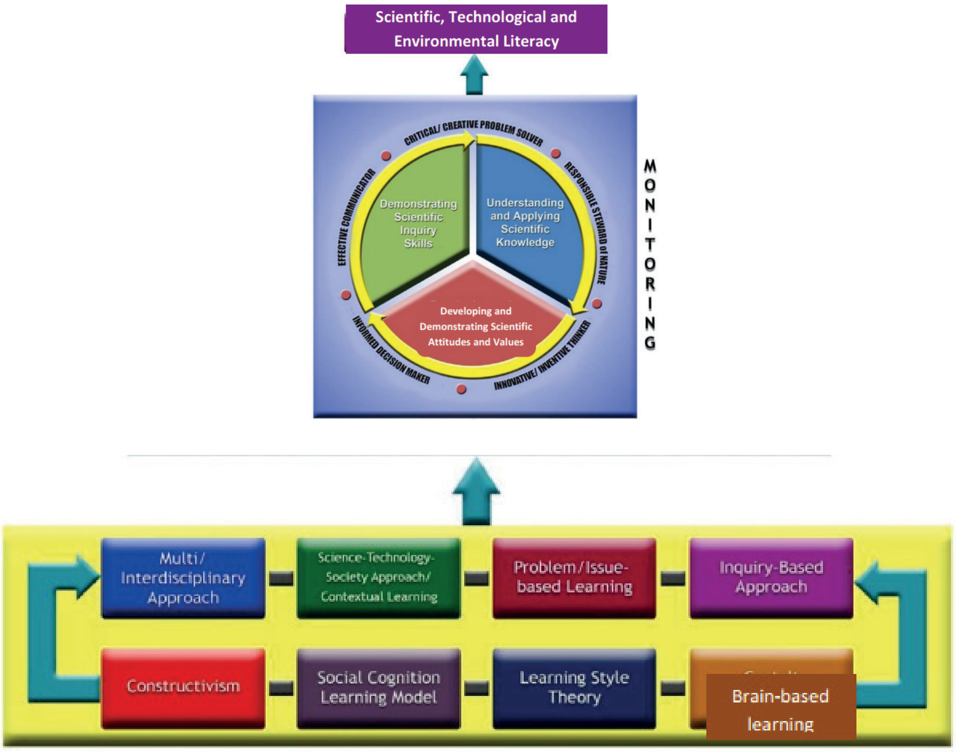

Fig. 1. Framework for science education in the K-12 program, USA [5]

and earth sciences are presented with increasing complexity from one level of class to another in a spiral progression, thus paving the way for a deeper understanding of basic concepts. Integration between science topics and other disciplines will lead to a meaningful science concept. The conceptual framework of science education from the K-12 program is shown in Fig. 1.

The formation of science education in Europe is a solid impetus for the development of educational activities in educational institutions of various profiles. As a result of the analysis of science works of scientists [17;18;19] we have identified factors for the formation of science education in Ukraine:

- uneven basic science literacy in Europe and Ukraine, which is necessary to ensure understanding and use of science knowledge in natural sciences and professionally oriented disciplines in technical free economic zones;
- significant differences in science education in formal, informal forms for the development of regions that affect society's participation in the innovative development of the state;
- reducing the interest of subjects in science, technology, engineering and mathematics, which are important for the training of competitive professionals, researchers in the context of the development of STEM-education;
- taking into account the quality of training that will arise between the demand and supply of training of technical professionals;
- insufficient understanding of the concept of STEM-competence, which is necessary for teachers to increase personal and shared use of achievement, innovation and economic sustainability;
- insufficient investment in strategic cooperation and development of ecosystems that would facilitate the effective adoption of the latest research using STEM-technologies.

Let's consider the model of science created by us *(Fig. 2)* concerning introduction of components of innovative development in technical HEI.

Scientist Wilhelm Humboldt in the fundamentalization of education considered the need to include in the educational process of fundamental knowledge, which are open to natural sciences and professionally oriented disciplines. Domestic mechanical engineer Stepan Tymoshenko substantiated the base of physical and technical knowledge of technical disciplines.

Fundamentalization of science education considers improving the quality of education and the level of awareness of society, by modifying the content of disciplines and methodology of educational process based on STEM-education technologies, as well as focusing on innovation (blended learning, virtual, augmented reality, adaptive technologies, etc.).

To substantiate the science education of technical free economic education, we support the opinion of Alexander Subetto, which considers the fundamental training of students in a mobile market of intellectual labor. Based on this, we highlight the factors of fundamental development, which we attribute to science education on the basis of STEM-education in technical HEI: 1) the transition from a disciplinary information approach to interdisciplinary knowledge, to master the methodology of the subject, to the intellectual foundations of future professional activity; 2) inclusion of high intellectual and new information educational technologies; obtaining fundamental qualitative results.

Considering the fundamentalization of science education, it is important to support the state, the adoption of the concept of development of science education, improving the licensing system and accreditation of higher education institutions; development and implementation of new educational technologies, introduction of virtual reality system and Internet learning, etc.

Attention should be paid to the criteria for determining the level of fundamentalization of education, as science must find non-traditional solutions, because in the transition to the methodological paradigm of education to check the quality of training with a set of knowledge factors is fundamentally incorrect. Scientist Alina Sbrueva considers that the integrated personality has certain characteristics that we use in our study: intellectual skills (diagnosing phenomena and processes, their analysis; innovation, self-education; communication, decision making, team adaptation, teamwork, positive constructive behavior), professional knowledge and skills of a fundamental nature (the basis for professional mobility) and entrepreneurial skills (personal initiative, creative attitude to work, the ability to understand the prospects of its development, anticipation of risks in making new decisions, understanding the laws of business) [20].

Fundamentality of education, according to Alexander Sukhanov, is the basis for the development of science competence, focused on understanding the deep, essential bases and connections between various phenomena and processes of the world, because it is the fundamentalization of science education is the basis for increasing intellectual potential, humanization and socialization [21].

The task of basic education — to provide optimal conditions for the education of flexible and multifaceted science thinking, different ways of perceiving reality, to create an inner need for self-development and self-education throughout life. According to other sources, the main task of basic education is the formation of a science way of thinking. Every competent specialist must have

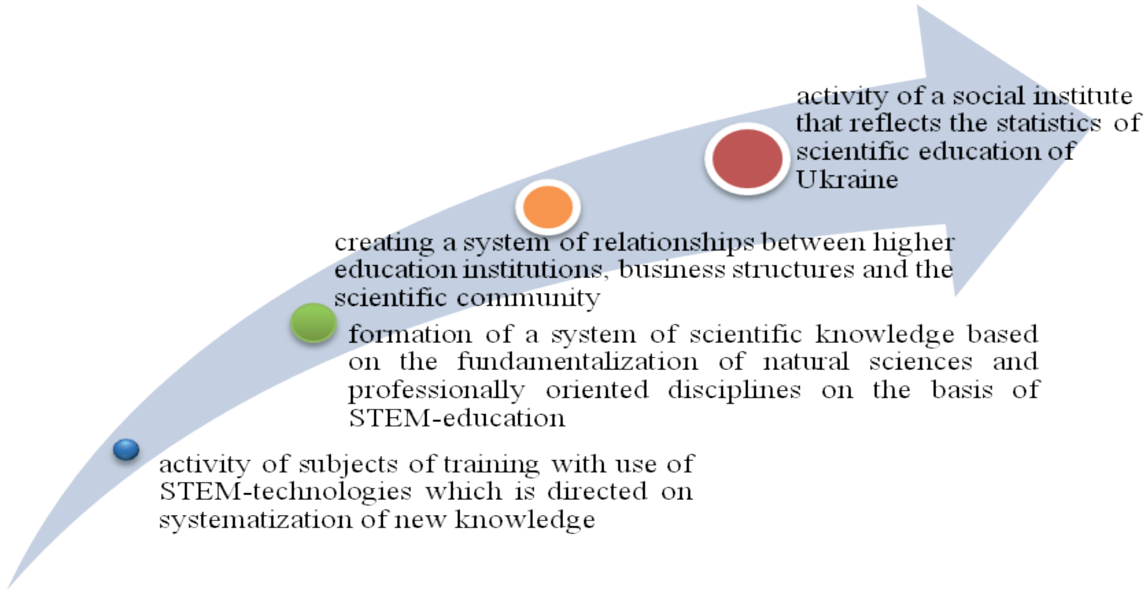

Fig. 2. Model of science on trends in innovation

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an idea of the basic laws of thinking and its forms, must be able to reason logically, motivate their actions, be able to justify their decisions. As a tool for engaging in modern intellectual culture, basic education contributes to the achievement of a qualitatively new level of culture of rational thinking, which is fruitful not only for solving problems of the local field of knowledge, but also the whole field of cognitive activity. Necessary and sufficient activities, according to Victor Kagan, are transformative, cognitive, value-oriented, which are not reduced to each other, although interacting, closely intertwined, as well as subsystems that provide mastery of the relevant components of education: theoretical, practical and project training, science (theoretical and empirical) training and education. Educational systems are fundamental if they cannot be replaced [22].

Consider the statistics on science trends in Ukraine, namely the number of researchers in the implementation of research on the largest indicators by region in the country *(Fig. 3)*. From these statistics, we can conclude that young scientists occupy a leading position between the ages of 25 and 40 years.

The number of employees involved in the implementation of R&D, by level of education by sector of activity is shown in Fig. 4.

In 2017, the share of R&D performers (researchers, technicians and support staff) in the total employed population was 0.58%, including researchers — 0.37%. According to Eurostat, in 2015 the highest share was in Finland (3.21% and 2.35%), Austria (3.10% and 1.92%) and Sweden (2.97% and 2.33%); the lowest — in Romania (0.53% and 0.33%), Cyprus (0.83% and 0.61%), Poland (1.0% and 075%) and Bulgaria (1.0% and 0.65%).

The share of doctors of sciences and doctors of philosophy (candidates of sciences) among GDR performers was 27.7%, among researchers — 43.8%.

More than half of the total number of doctors of sciences and PhD who carried out research and development worked in organizations of the public sector of the economy, 36.1% — in higher education, 5.4% — in the business sector.

In 2017, 44.7% of researchers were women, of whom 7.1% — doctors of sciences and 33.7% had a PhD. The share of female researchers in the field of social sciences (65.7%), medical (65.3%) and humanities (60.0%) was higher than the average, and lower in the field of technical sciences (33.6%).

Naturally, given the breadth of knowledge that should be given to the graduate, it is advisable to rely on the most important fundamental concepts and patterns of science or science discipline, supplementing them with a number of applied tasks.

From the above we substantiate the theoretical and methodological fundamentalization of science education:

- changing the relationship between the pragmatic and theoretical and methodological components of the content of science education in technical free economic education in the development of STEM-education;
- change of the content and methodology of the educational process on the basis of STEM-technologies in technical HEI, which provides emphasis on fundamental concepts, laws, phenomena, statements of natural sciences (physics) and pro-

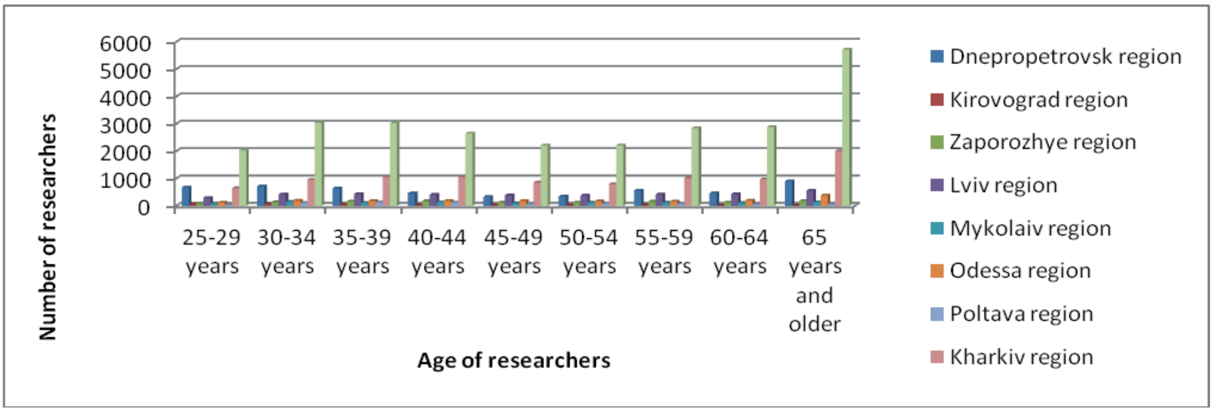

Fig. 3. Diagram of statistical data of scientists involved in the implementation of research by age and regions of Ukraine

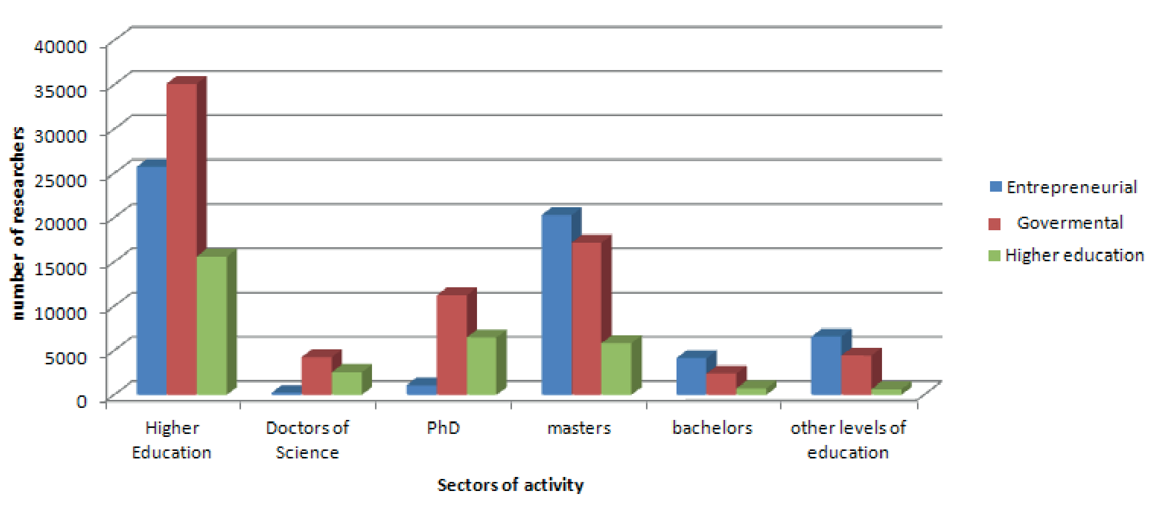

Fig. 4. Statistics of scientists involved in the implementation of research on the level of education

fessionally oriented disciplines of technical free economic zones;

- ensuring the priority of the information component in the knowledge system, where the most important role is played by fundamental knowledge about information processes in nature and society, etc.;
- fundamentalization of science education is considered as a system of conditions for designing the fundamental educational space on the basis of STEM-education, the main components of which are: value-semantic; informative; intellectual; culturological; activity; system space;
- fundamentalization of science education will be more effective if the fundamental knowledge discovered in science is mastered by the student in productive, research activities and serves as a basis for creative self-realization and self-development of the subject in the development of STEM education;
- fundamentalization of science education in the context of STEM-education is a methodologically important, invariant knowledge that contributes to the adaptation of subjects in modern socio-economic conditions;
- fundamentalization of science education should be considered as a didactic principle and a multidimensional process of improving the didactic system, the components of which are transformed taking into account the specifics of the principle of fundamentalization, as well as a system of conditions for designing fundamental educational space.

We highlight the science component of STEM-education on the example of the equation of motion of the aircraft in vector and scalar forms, which is studied by students in the process of teaching physics and professionally oriented disciplines at the Flight Academy of the National Aviation University.

An airplane in flight is a complex dynamic system of variable mass with a liquid filling, consisting of a set of solid deformed bodies (wing, fuselage, empennage, controls, power plant, landing gear, etc.), which are elastically or hingedly interconnected. The study of the dynamic properties of such a system is extremely difficult. The solution of practical problems of flight dynamics leads to the need to replace a real aircraft with simplified mechanical models, which make it possible to study the characteristics of aircraft movement with a relatively simple and sufficiently accurate degree of accuracy.

When calculating the possible flight trajectories of the aircraft and its flight performance, the aircraft is taken as a material point of constant mass. In this case, the motion of the center of mass of the aircraft is considered, and the real dimensions and shapes of the aircraft are taken into account only when determining the aerodynamic forces.

When solving problems of stability and controllability, an aircraft is considered to be a controlled rigid body of constant mass. The movement of the

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aircraft is considered under the influence of external forces and moments. External forces include gravity, aerodynamic forces, power plant thrust, control forces, forces arising from aircraft contact in airspace, inertial and Coriolis forces. These forces create corresponding moments about the aircraft's center of mass. When solving problems of aeroelasticity, an airplane is considered a deformable body.

The motion of the aircraft as a material point relative to the inertial reference frame under the action of external forces is described by the vector equation

$$m\frac{d\vec{\upsilon}}{dt}=\vec{F}, \quad (1.1)$$

where *m* is the mass of the aircraft; $\vec{\upsilon}$ is the velocity vector of the aircraft center of mass; $\frac{d\vec{\upsilon}}{dt}$ — vector of acceleration of the center of mass; $\vec{F}$ is the total vector of all external forces acting F_i on the aircraft, $\vec{F}=\sum_i \vec{F}_i$.

An inertial reference frame is called in relation to which any material particle, in the absence of forces applied to it or under the action of mutually balanced forces applied to it, makes uniform rectilinear motion. If we neglect the daily rotation of the Earth, then when solving practical problems of flight operation of transport aircraft, the coordinate system associated with the Earth can be considered inertial.

The motion of an aircraft as a rigid body is determined by two vector equations:

$$m\frac{d\vec{\upsilon}}{dt}=\vec{F}\,;\ \frac{d\vec{K}}{dt}=\vec{M}\,, \quad (1.2)$$

where *K* is the total vector of the angular momentum of the aircraft relative to the center of mass; $\vec{K}=\sum_i(\vec{r}_i m_i \vec{\upsilon}_i)$. Here $\vec{r}$ is the radius vector determining the position of the elementary mass m_i relative to the center of mass of the aircraft; $\vec{\upsilon}$ — vector of linear velocity of elementary mass; $\vec{M}$ is the total vector of moments of external forces $\vec{M}_i$ acting on the aircraft relative to the center of mass.

The first equation of system (1.2) describes the forward motion of the center of mass of the aircraft along the trajectory under the action of external forces and is called the equation of forces. The second equation describes the rotational motion of the aircraft around the center of mass under the action of the moments of external forces and is called the equation of moments.

To study the motion of an aircraft, vector equations (1.1) and (1.2) are represented in scalar form, i. e. consider them in projections on the axis of the selected coordinate system. The choice of the coordinate system is made based on the nature of the problem being solved in such a way as to simplify the solution as much as possible.

For ease of study, the spatial movement of the aircraft is represented in the form of two independent movements: in the vertical plane and in the horizontal one. Each of the motions, in turn, is represented by a set of translational motion of the center of mass and rotational motion relative to the center of mass, which are also considered independent.

The movement of the aircraft in the plane of symmetry *OXYZ* is called the longitudinal movement of the aircraft. It includes: translational movement of the center of mass along the *OX* and *OY* axes and rotary movement about the *OZ* axis. The movement of the aircraft in the vertical plane is a partial case of the longitudinal movement of the aircraft. The system of equations of the aircraft motion in the vertical plane is as follows:

$$\begin{gathered} m\frac{d\upsilon}{dt}=F_{x_{\hat{E}}}\,;\ m\upsilon\omega_{z_R}=F_{y_{\hat{E}}}\,;\ I_z=\frac{d\omega_z}{dt}=M_Z\,; \\ \upsilon_{x_g}=\upsilon\cdot\cos\theta;\ \upsilon_{y_g}=\upsilon\cdot\sin\theta; \\ \frac{dx_g}{dt}=\upsilon_{x_g}\,;\ \frac{dy_g}{dt}=\upsilon_{y_g}\,; \\ \omega_{z_k}=\frac{d\theta}{dt};\ \omega_z=\frac{d\upsilon}{dt};\ \upsilon=\theta-\alpha\,, \end{gathered} \quad (1.3)$$

where I_Z is the moment of inertia of the aircraft about the O*Z* axis.

The first two equations are the dynamic equations of motion for the center of mass, the third is the dynamic equation of motion about the OZ axis, the rest are kinematic equations. The dynamic equations of motion of the center of mass and the corresponding kinematic equations make it possible to study the reference motion in rectilinear and curvilinear flight of an aircraft in a vertical plane. The reference movement can be steady ($\upsilon = const, \frac{d\upsilon}{dt} = 0$), unsteady ($\upsilon \neq const, \frac{d\upsilon}{dt} \neq 0$), with roll ($\gamma = 0$) and slding ($\beta \neq 0$) or without them, at a constant height ($\theta = 0$), with an ascent ($\theta > 0$) or descent ($\theta < 0$). The dynamic equation of motion relative to the center of mass together with the corresponding kinematic equations makes it possible to investigate rotational motion and obtain characteristics of longitudinal stability and controllability.

The movement of the aircraft in the plane *OXY*, perpendicular to the plane of symmetry of the aircraft, is called lateral. It includes the translational movement of the center of mass along the *OZ* axis and rotational movements about the *OX* and *OY* axes. Airplane movement in the horizontal plane is a partial case of lateral movement. The system of dynamic equations of aircraft motion in the horizontal plane has the form:

$$m\frac{d\upsilon}{dt} = F_{x_{\hat{E}}}\,; \quad -m\upsilon\frac{d\psi}{dt} = F_{z_{\hat{E}}}\,;$$

$$I_x\frac{d\omega_x}{dt} - I_{xy}\frac{d\omega_y}{dt} = M_x\,;$$

$$I_y\frac{d\omega_y}{dt} - I_{yx}\frac{d\omega_x}{dt} = M_y, \qquad (1.4)$$

where I_x and I_y are the axial moments of the aircraft; I_{xy} and I_{yx} — centrifugal moments of the aircraft relative to the axes of the associated coordinate system.

The science component of STEM-education, which is expressed in the teaching of physics (fundamental concepts, phenomena, processes) continues to be studied by subjects in professionally oriented disciplines (flight aerodynamics, avionics, electrical engineering, radio electronics, aeronautics, geophysics, etc.).

Thus, on the basis of theoretical and methodological fundamentalization of science education, we highlight the main provisions of the principle of fundamental knowledge:

1) the fundamentality of interdisciplinary knowledge should be reduced to the fundamentality of science knowledge;

2) the fundamentality of science knowledge in physics and professionally oriented disciplines should take into account science and rational knowledge and science intuition;

3) the fundamentality of knowledge is based on science and philosophical reflection of the teacher and take into account the conceptual system of the student;

4) the fundamentality of science knowledge is characterized by the laws by which the world functions and develops outside of man and the world within the subject of study;

5) fundamental knowledge is the core that contains the knowledge of reflections and the purpose of knowledge to obtain science knowledge;

6) the fundamentality of knowledge determines the universality, integrativity, problems, focus on the perception of the world as a whole; the holistic system of knowledge is the most important criterion of its fundamentality.

Conclusions and prospects for further explorations in this direction. Thus, substantiating the theoretical and methodological fundamentalization of science education on the basis of STEM-education technologies provides a transition to a new educational concept taking into account the trends of innovative development in Ukraine: we should keep in mind a qualitatively new goal of science education, new principles educational courses in each of the traditional natural sciences and professionally-oriented disciplines and their coordination to achieve a new quality of education of the subject on the basis of STEM-education in technical HEI.

We see the perspective of this study primarily in: substantiation of the theory of the curriculum for the training of future engineers; prognostic substantiation of the development of physical education in the conditions of globalization and integration processes.

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ТЕОРЕТИКО-МЕТОДОЛОГІЧНА ФУНДАМЕНТАЛІЗАЦІЯ НАУКОВОЇ ОСВІТИ В УМОВАХ ІНТЕГРОВАНОСТІ ФІЗИКИ ТА ПРОФЕСІЙНО ЗОРІЄНТОВАНИХ ДИСЦИПЛІН НА ЗАСАДАХ STEM-ОСВІТИ

Анотація. *Акцент у науковій освіті робиться на підвищенні наукової грамотності студентів за допомогою інноваційних заходів, які передбачають планування, вимірювання, спостереження, аналіз даних, розроблення й оцінку процедур та вивчення доказів на основі впровадження сучасних технологій навчання (STEM-технологій). У статті розглянуто поняття науки, обґрунтовано теоретико-методологічну фундаменталізацію наукової освіти на засадах STEM-освіти технічного закладу вищої освіти. Визначено, що основна функція системи наукової освіти полягає в забезпеченні суспільства науково грамотними громадянами. Інформація та ресурси (як правило, фінансові) підсилюють цю систему. У статті нами сформовано модель науки щодо розвитку STEM-освітніх тенденцій інноваційного поступу освіти в Україні. Нами сформульовані особливості наукової освіти на основі STEM-технологій, що сприятимуть впровадженню сучасної методики навчання фізики та професійно зорієнтованих дисциплін. Інтеграційні процеси в освіті останніми роками посідають щораз важливіше місце, оскільки вони спрямовані на реалізацію нових освітніх ідеалів — формування цілісної системи знань і вмінь особистості, розвиток її творчих здібностей та потенційних можливостей. Ідея інтегрованого навчання фізики та професійно зорієнтованих дисциплін актуальна, оскільки з її успішною методичною реалізацією передбачається досягнення мети якісної наукової освіти, тобто освіти конкурентної, спроможної забезпечити кожній людині самостійне досягнення тієї чи іншої життєвої цілі, творче самоствердження в різних соціальних сферах. Навчання науки дасть студентам змогу вести повноцінне й відповідальне життя, заохочуючи їх самостійно вчитися, вирішувати нові ситуації, критично міркувати, творчо мислити, приймати обґрунтовані рішення та розв'язувати проблеми. Студенти також мають розвинути розуміння взаємозв'язку між наукою, технологією, суспільством і навколишнім середовищем (STSE), а також зміцнити здатність інтегрувати й застосовувати знання та вміння з фізики і професійно зорієнтованих дисциплін у технічних ЗВО.*

Ключові слова: *наукова освіта, STEM-освіта, фундаменталізація, фізика, професійно зорієнтовані дисципліни.*

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