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METHODOLOGICAL FEATURES OF PROFESSIONALLY ORIENTED EDUCATION OF PHYSICAL ENGINEERING DISCIPLINES BASED ON STEM TECHNOLOGIES: ASPECT OF ONTOLOGICAL APPROACH

Abstract. *The article considers the urgency of the problem of interrelation of teaching physics and professionally-oriented disciplines based on STEM-technologies in the conditions of ontological approach in the process of training students in engineering and technical education according to the educational-professional program of speciality 272 "Air Transport". Developed and proposed methods of teaching physics based on STEM-technologies, taking into account the definition of ontology aimed at forming STEM skills in subjects, due to the statement before educational institutions significantly improve the quality of students' knowledge, the role of learning in shaping student's thinking and cognitive abilities development of STEM education. It is determined that one of the innovative directions of modern education is the introduction of STEM education, which involves the integration of sciences aimed at the development of STEM technologies, innovative thinking and meeting the need for well-trained engineering and technical specialists. The methodical features of professionally-oriented teaching of physical engineering disciplines based on STEM technologies taking into account the ontological approach are substantiated. In the process of conducting a pedagogical experiment, theoretical and empirical research methods were used. In particular, the analysis of philosophical, psychological-pedagogical, educational-methodical literature, recommended textbooks and manuals on methods of teaching physics in the context of the development of STEM education was carried out. Observations, questionnaires, testing, surveys, interviews with scientists and students were conducted. These experimental results were comprehensively analyzed and processed, quantitative data using the methods of mathematical statistics. The results of a comparative experiment to identify the effectiveness of the proposed method of teaching physics in the context of STEM education showed that the level of physical knowledge, skills and abilities of students in control groups is lower than the corresponding level in experimental groups.*

Keywords: *physics, features of methods of teaching physics, STEM education, ontological approach, pedagogical experiment, professionally-oriented and engineering disciplines.*

Problem statement in general and its connection with important scientific or practical tasks. The modern educational process in physical engineering disciplines based on STEM-technologies in educational institutions is based on applied aspects and fundamentals of teaching physical and mathematical sciences and should take into account the optimal combination of innovative approaches, including ontological. Therefore, regardless of the method of cognition, which is the basis of the learning process of physical engineering disciplines, it is necessary to outline methodological professionally oriented features of teaching students in an ontological approach, taking into account the concept of STEM education [1; 2].

The relevance of our study is determined by the need to reorient traditional teaching methods and the introduction of STEM-technologies in the teaching of physical engineering, which is due to the following contradictions:

- outlined material of working curricula (http://www.glau.kr.ua/index.php/ua/17-ukrainian/2466–2021) and syllabuses (http://www.glau.kr.ua/images/docs/Silabusi/Silabus_fizika_ukr1.pdf;http://www.glau.kr.ua/images/docs/Silabusi/Silabus_fizika_eng1.pdf) in the discipline "Physics", as well as the multiplicity of introduced teaching methods, STEM-technologies, innovative approaches, including ontological, is the foundation for the study of engineering disciplines, but at the same time in terms of volume, and according to the teaching methods and types of educational activities should be presented in educational programs in the specialty 272 "Aviation Transport";
- in the educational process in physics there is a need for widespread introduction of STEM-technologies, but the proposed options are generalized and do not fully meet the educational and practical objectives of the general course of physics (focus on applied and professionally oriented aspects of fundamental disciplines);
- physics laboratories in educational institutions, insufficiently provided or completely absent STEM-technologies (STEM-tools, devices for 3D printing, robotic kits, information and communication technologies, elements of real and augmented reality, etc.), including their kits for ensuring the applicability of physics education to engineering disciplines (radio electronics, electrical engineering, avionics, etc.), where there is an urgent need for staging different in complexity and quality of educational experiments, students perform physical workshop, which involves the intensification of their independent activities and requires modern methodological and logistics based on STEM-technologies, taking into account the ontological approach.

Thus, taking into account the above contradictions, it is important to further study the problem of teaching physics and engineering disciplines on the basis of the developed teaching methods with the introduction of STEM technologies in the ontological approach.

An analysis of recent research and publications that have begun to address this issue. General provisions of didactics of methods of teaching physics are revealed in the works of P. Atamanchuka, O. Buhaiova, S. Velychka, V. Vovkotruba, S. Goncharenka, E. Korshaka, O. Liashenka, M. Marytyniuka, M. Sadovoho, I. Salnyk, O. Serhieieva, N. Podopryhory, V. Sharko, M. Shuta.

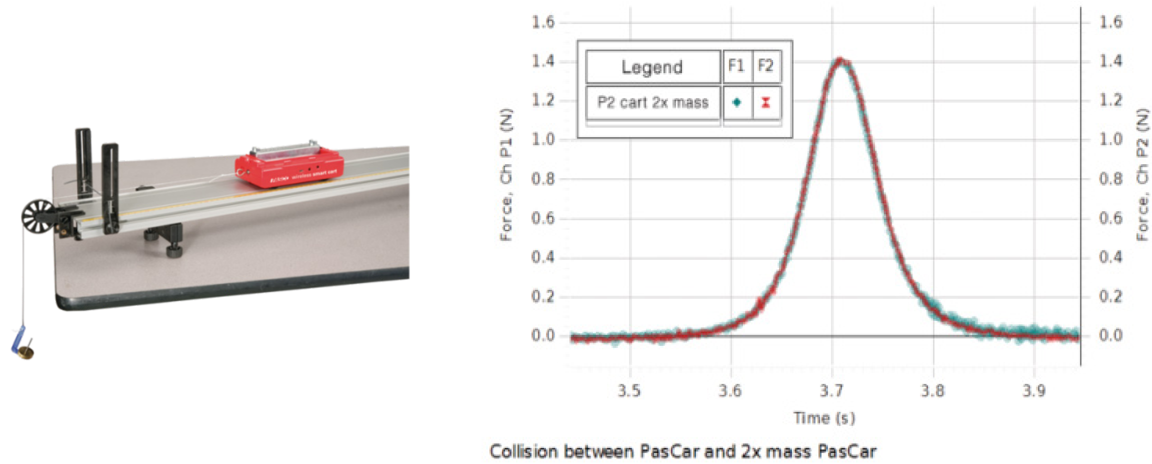
Theoretical and methodological problems of studying physics in the Free Economic Zone were reflected in the doctoral dissertations of Yu. Bendes, G. Bushka, S. Velychko, V. Serhihenko, A. Sylvester, M. Sadovyi, N. Podopryhora, V. Sharko and in the candidate dissertations of I. Bohdanov, L. Vovk, D. Somenko, O. Slobodyannyk and others.

Scientific research on the relevance of the introduction of the ontological approach and the definition of ontology is outlined in the works of leading scientists O. Strнzhaka [3; 4], V. Demyanenko, I. Savchenko, O. Ovdii, Ye. Shapoval and others.

Thus, analyzing the scientific works of the above scientists, we support the *purpose of the article* which identifies the selection of methodological features of professionally oriented teaching of physical engineering disciplines based on STEM technologies in the ontological approach.

According to the stated purpose of our research, the following research methods were used:

- *theoretical:* analysis of research on methods of teaching physics, STEM-technologies, ontological approach, as well as educational programs in the speciality 272 "Air Transport", working curricula in the discipline "Physics", textbooks, manuals and publications, reflecting the problem of research, to identify modern physical scientific positions and achievements, trends in the development of methods of teaching physics based on STEM-technologies;
- *empirical*: diagnostic methods (questionnaires, surveys, etc.) to determine the level of interest and activity of subjects in the process of teaching physics based on STEM-technologies;
- *experimental methods*: pedagogical experiment and experimental verification of research results on methods of teaching physics based on technologies of STEM-education, taking into account the ontological approach;
- *statistical methods*: mathematical processing of results of pedagogical experiment for revealing



a) *b)*

Fig. 1. Images of the installation for the study of Newton's laws:
a) the scheme of the installation; *b)* graph of force versus time [11]

of efficiency of the offered technique of training of physics on the basis of STEM technologies in the conditions of the ontological approach.

The main material of the study. One of the effective directions that allow solving these problems is the widespread introduction of STEM technologies in the educational process and their implementation in the educational process of the Flight Academy of the National Aviation University (FA NAU) and the National Center "Junior Academy of Sciences of Ukraine".

The need to implement modern equipment and STEM technologies in teaching physics and the development of their implementation stems from the fact that more than twenty years of supply of educational institutions with any teaching aids has stopped altogether because in Ukraine there is no industry for manufacturing educational equipment or it is expensive.

However, it should be noted that it is important and significant to address the development of creative activity of students is to involve them in the design and manufacture of homemade equipment, which allows you to effectively perform independent observations, studying and researching physical phenomena that are professionally oriented.

Along with this, the analysis of the current state of physics teaching methods and professionally-oriented learning based on STEM-technologies [5; 6; 7] indicates that there is a significant update and widespread introduction into the educational physical experiment elements of 3D modelling, robotics, reveals concepts related to mechatronics and technology.

In this regard, we have developed guidelines for the work of the physics workshop on the basis of STEM technologies [8; 9; 10], which is tested on the basis of FA NAU. Thus, the interdisciplinary integration of the discipline "Physics" with subjects of professional orientation in FA NAU in the context of the development of STEM-education is outlined in table 1 (fragment), according to specialization 272 "Aviation" and Educational Profesional Program (EPP) "Air Traffic Management", "Flight operation of aircraft", "Maintenance and repair of aircraft", etc.

Consider some research tasks performed by students of FA NAU.

1. *Verification of Newton's laws.*

Equipment: Smart Cart (red) ME-1240; Smart Cart (blue) ME-1241; PAScar Cart Mass (set of 2) ME-6757A; track ME-8972; set for masses ME-8979; elastic bumper ME-8998; pulley with clamp ME-9448B; 1.2 m aluminum dynamic track ME-9493; friction unit — IDS ME-9807.

Students were asked to use this equipment to detect or experimentally determine Newton's three laws (fig. 1). Newton's first law is that students study the motion of an object to see if it will change as a force acts.

Newton's second law is that students use the Smart Cart to identify the relationship between force, mass, and acceleration.

Newton's third law — using two Smart Cart force sensors, students prove that the forces

Table 1

№ q/n	The theme of the discipline "Physics"	The section on the subject of professional orientation, which is focused on this topic according to the EPP
		A fragment of topics for the first semester
1	Kinematics of a classical particle	**Air navigation (general navigation).** Topic 1. Basics of cartographic support. Path lines. Measure the distances between points on the map. Calculation of path angles and distances between route points. Topic 6. The speed of the aircraft. Airspeed and principles of its measurement. Calculation of the true airspeed of flight on a wide arrow KUS. Calculation of the required instrument airspeed. Road speed. The procedure for calculating the average speed in the area with a variable profile TASC. Topic 7. The influence of wind on the flight of the aircraft. Navigation speed triangle. Calculation of wind direction and speed. **Air navigation (radio navigation).** Topic 5. Navigation on departure and arrival routes. Calculation of the minimum vertical speed on takeoff. Minimum safe height in the MSA sector. Calculation of time and distance of a set of the height of the set echelon. Calculation of the required vertical speed in the set of heights. Calculation of time and distance of descent from the flight echelon. Calculation of the required vertical speed for descent from the flight echelon. **Engineering graphics.** Topic 2. Projections of a point, line and plane. Three coordinate points. Three coordinates of the radius vector of a point. **Aerodynamics of aircraft flight.** Topic 6. The main stages and modes of flight, flight specifications (FTC) of aircraft. Rectilinear horizontal flight. Set height and lower. Curvilinear flight of the plane. Takeoff and landing. Causes and ways to prevent and correct errors.
2	Dynamics of a classical particle	**Theoretical mechanics.** Topic 13. The dynamics of the material point. Dynamics as a section of theoretical physics. Basic concepts of the dynamics of a material point: force, as a constant and variable from time, coordinates and velocity of the body, the value of the inertia of the body, body mass. Laws of dynamics of a material point: the law of inertia (Newton's 1st law), the basic law of dynamics (Newton's 2nd law): in differential form (in scalar and vector notation), Newton's 3rd law and the law of independence of forces. Dynamics problems. Solving the main problem of dynamics with the help of differential equations of motion in the coordinate and natural way of specifying the motion of a point. **Aerodynamics of aircraft flight.** Topic 2. Aerodynamic forces acting on the wing of the aircraft and their characteristics. Topic 3. Forces acting on the aircraft on the ground and in flight, aerodynamic characteristics of the aircraft. Forces acting on an aeroplane on the ground and in flight. Equilibrium and a pair of forces. Topic 17. Theorem on the change in the momentum of the system. The moment of the amount of motion of a material point relative to the centre and axis. Theorem on the change in the momentum of a point. The law of conservation of momentum of a material point. The kinetic moment of a rigid body relative to its axis of rotation. Differential equation of rotation of a rigid body around a fixed axis. **Aeroplane glider and it's systems.** Topic 3. Aeroelasticity. Influence of air elasticity on strength, stability and controllability.

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Continuation of table 1

№ q/n	The theme of the discipline "Physics"	The section on the subject of professional orientation, which is focused on this topic according to the EPP
		Theoretical mechanics. Topic 1. Introduction to solid statics. Power. Axioms of statics. Basic concepts of statics: force, the system of forces, equivalent and balanced systems of forces, equivalent. Topic 4. The system of converging forces. Equilibrium conditions. The concept of a system of converging forces. Finding an equivalent system of converging forces geometrically and analytically. Equilibrium theorem of a system of convergent forces: geometric and analytical equilibrium condition. Theorem on three forces. Topic 5. Theory of couples. A couple of forces. Power pair moment vector. Theorems on the equivalence of pairs of forces. Assembling pairs of forces. **Principles of aircraft flight.** Topic 4. Aerodynamic characteristics of the aircraft. Aerodynamic quality and ways to improve it. **Higher mathematics.** Topic 6. The concept of vector, actions on vectors. Topic 7. Scalar, vector and mixed product of vectors. Topic 12. Sequence boundary and function boundary. Topic 20. Integral. Properties of the integral.

between objects are the same size, but opposite in direction. These experiments also have problems with collisions between cars.

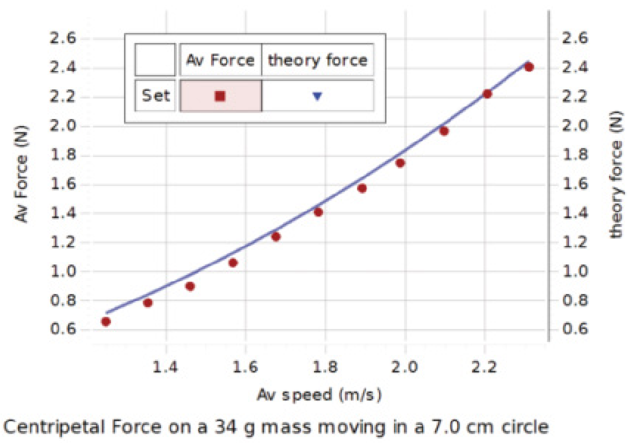
The advantage of PASCO over the traditional method: Smart Cart has all the necessary sensors, which allows you to quickly and easily make device settings. The integration between software and hardware helps students focus on studying physics.

2. *Determination of centrifugal force*.

Equipment: devices for determining the centrifugal force ME-8088; high-resolution power sensor PS-2189; photomatics head ME-9498A; large rod base ME-8735; stainless steel rod — 90 cm ME-8738; multi-clamp ME-9507; 45 cm stainless steel rod — 45 cm ME-8736; 5-fold red cord (5 pcs.) SE-9750.

The advantage of PASCO over traditional methods: students explore the relationship between mass, the radius of rotation, tangential velocity and centrifugal force. Constantly measuring the force as the speed changes, they observe the effect of speed on the centripetal force.

a)



b)

Fig. 2. Image of the installation to determine the centrifugal force: *a)* installation diagram; *b)* graph of force versus velocity [12]

The influence of changes in mass and radius was also studied *(fig. 2).*

Thus, the analysis of works on the problem of studying the methods of teaching physics allowed to establish the following features of the methods of teaching physics and professionally-oriented disciplines based on technologies of STEM education in the ontological approach:

in the educational process of physics and engineering and technical disciplines in educational institutions outlined applied, professionally-oriented and ontological aspects in teaching and widespread introduction of integrated disciplines based on STEM education (physics, electrical engineering and radio electronics, aeronautics, flight principles and principles). etc.), as well as for the development and implementation of special courses that take into account not only the interests and wishes of students but also the preferences and professional level and capabilities of the teacher;

in the teaching of physics according to the working curricula according to the EPP in the speciality 272 "Aviation Transport" the ratio and combination of natural-mathematical and engineering-technical components of education, the optimal combination of their theoretical and applied components are traced (see table 1);

compulsory physical education and all its components based on STEM-education, among which the system of the physical experiment is recognized as an effective and efficient independent pedagogical system that significantly affects the learning outcomes of students in an ontological approach, as well as develops activity and interest students with the appropriate profile of oriented education in a technical institution of higher education;

introduction of STEM-learning technologies raises physics education to a higher level, as their use helps students to better acquire knowledge of engineering and technical disciplines using ontology;

inexpediency of complicating and overloading teaching material in physics with its theoretical content and mathematical elaboration, can not reject all possible examples of experimental study of physics content taking into account the concept of STEM-education, because it is the independent search activity of the student is the basis of active knowledge cadets to learn the applied direction of their field of study;

strengthening the role of independent cognitive and exploratory activities of students and taking into account their psychological and individual characteristics when studying physics based on STEM technologies for OPP specialty 272 "Aviation" and working curricula in the disciplines "Physics" meets modern requirements of the educational process and the innovative trend of Industry 5.0, which is outlined in our proposed method of teaching physics in the ontological approach.

To test and identify the effectiveness of the proposed method of teaching physics in the context of the development of STEM education in higher education institutions of the technical profile, a pedagogical experiment was conducted during 2016–2020.

Our assumption about the improvement of methods of teaching physics in the development of STEM education was not only the need to form in students (cadets) a certain system of knowledge, skills and abilities but also, accordingly, to raise the role of students and teachers in the study of physics-cognitive, independent activity; to promote the development of thinking and creative abilities; satisfy requests and wishes, inclinations and plans for the future of each person; to use such practical and experimental tasks in terms of content and scope, which will have practical application in the process of teaching physics in educational institutions of the technical profile of education.

At the first stage of the experiment such higher education institutions as Vinnytsia National Technical University, Kremenchuk National University named after Mykhailo Ostrogradskyi, Flyght Academy of the National Aviation University, National Aviation University, Cherkasy National University named after Bohdan Khmelnytskyi, National Center "Junior Academy of Sciences of Ukraine" were selected.

The results of the analysis of this stage of the pedagogical experiment allowed us to form assumptions about the possibility of improving the learning process by applying the proposed method of teaching physics and the formation of experimental skills. At this stage, a plan for further research and testing its effectiveness.

Many measures were aimed at ensuring compliance with the content of practical tasks to the purpose of each stage, selection and formation of the corresponding sets of tasks. A significant part of the tasks are various forms of test tasks, as well as tasks that were performed using modern learning technologies, such as a set of L-micro [9], which significantly increased students' attention, stimulated independence and educational and cognitive activities while studying physics in higher institutions technical training profile. Methods and forms of performing tasks with modern equipment were introduced, namely physical workshop works and research tasks [10] and the solution of physical problems using the concept of symmetry, which is given in the textbook [8].

The second stage of the pedagogical experiment included experimental training of students. Based on the analysis and the put forward conceptual bases of development of a technique of training of physics in higher institution of a technical profile, the corresponding tasks (research tasks, works of a physical workshop, and also a selection of physical tasks), and also the educational equipment and ICT were developed and checked; the methodology and technique of their introduction into the educational process in the process of teaching physics were worked out; developed a program of advanced training courses for teachers in the field of STEM education in the discipline "Physics".

At this stage of theoretical and experimental work, theoretical and empirical research methods were used. In particular, the analysis of philosophical, psychological-pedagogical, educational-methodical literature, recommended textbooks and manuals on methods of teaching physics in the context of the development of STEM education was carried out. Observations, questionnaires, testing, surveys, interviews with scientists and students were conducted. These experimental results were comprehensively analyzed and quantitative data were processed using the methods of mathematical statistics.

In order to identify the effectiveness of the proposed method of teaching physics in the performance of practical and experimental tasks, students in experimental and control groups conducted testing, research and physical work on physics. The results of the analysis of which gave grounds for formulating the main working hypothesis of the study. Much attention is paid to the fact that many works of the physical workshop have a rather low grade, or are not performed at all when studying physics in free economic zones of different types and profiles due to lack of equipment and methods of its use. The low level of preparation of students for the performance of works of a workshop on physics, characteristic of the existence of new receptions of performance of component tasks, achievement of the purpose of a task in the presence of auxiliary factors, definitions of not basic sizes, etc. is noted. For experimental groups, new options and methods of performing a physical workshop on physics in the context of the development of STEM education were proposed.

At the third stage of the pedagogical experiment based on scientific and theoretical analysis of psychological, pedagogical and methodological literature studied opportunities to improve the quality and efficiency of the educational process in physics in higher educational technical profile, taking into account trends in STEM education, analyzed trends in methodological and material support. At the same time, during the second and third stages of the pedagogical experiment, the results of the whole pedagogical research were summarized: the results were regularly reported at all-Ukrainian and International scientific-practical conferences in Berdyansk, Budapest, Yekaterinburg, Kyiv, Kropyvnytskyi (Kirovohrad), Lutsk, Kerch, Kamyanets-Podolskyi, Moscow, Mozyr, Sumy, Ulyanovsk, Kharkiv, Kherson, Chernihiv, as well as published materials of these reports.

In the process of pedagogical experiment, we used the Kolmohorov-Smirnov criterion, which is determined to be sensitive in application to find any difference in the distribution function of this property in some of the considered sets.

In the experimental (EG) and control groups (CG) laboratory work on optics "Determination of light wavelength using a Jung interferometer" was performed according to various methods. During this work in the experimental groups used modern learning technologies and textbooks developed for this set and guidelines, which greatly facilitate the performance of laboratory work in physics in the context of the development of STEM education, and in the control, groups used traditional methods.

Students from Kropyvnytskyi, Kyiv, Vinnytsia, Kremenchuk and Cherkasy took part in the experiment. In the conducted experiment all requirements necessary for the performance of the Kolmokhorov-Smirnov criterion as mathematical statistics of a nonparametric method in pedagogical research for the definition of efficiency of an experimental technique are fulfilled. The results of student's laboratory work were evaluated on 6 levels, aimed at performing experimental and computational skills.

In order to determine the performance of laboratory work, we divided the scope and results of its implementation into 6 levels, which corresponded to its main objectives:

1. Recording and clear formulation of the topic, purpose of work and equipment.

2. Carrying out and availability of records necessary for measurements and calculations, the correct filling of the made table.

3. Performance of calculations, measurement errors with the indication of deviations of separate values of one size.

4. Execution of a drawing or graph that accurately illustrates from a physical point of view the progress of work and the accuracy of the measured values, the results of calculations.

5. Formulation of the conclusion at which it is necessary to specify regularities of the investigated size.

6. Execution of an additional task or answer to controlling questions.

Accordingly, during the pedagogical experiment, the hypothesis $H_0 : F(x) = G(x)$ or assumption about the uniformity of the functions of distribution of scores on the performance of laboratory work in physics among students of experimental and control groups according to traditional and experimental methods was tested.

For this purpose, 341 students from the number of students who performed laboratory work in physics and studied according to different variants of the methodology were taken to the control group (CG) and 353 students to the experimental group (EG). As a result of random selection, two samples were formed (f_1 — students who studied according to the experimental method; f_2 — according to the traditional method), respectively, $n_1 = 353$ and $n_2 = 341$ the student.

Data for finding the characteristics of Kolmohorov-Smirnov are shown in table 2.

An alternative hypothesis $H_1 : F(x) \neq G(x)$ assumes that the functions of distribution of scores are not the same in the two considered sets of students.

The maximum value of the expression for the difference of accumulated frequencies in samples 1 and 2 $\left|\sum f_1 - \sum f_2\right|$ is 12.

That is:

$$T_1 = (\frac{1}{n_1}) \cdot \max\left|\sum f_1 - \sum f_2\right| = (\frac{1}{353}) \cdot 12 = 0{,}034;$$

$$T_2 = (\frac{1}{n_2}) \cdot \max\left|\sum f_1 - \sum f_2\right| = (\frac{1}{341}) \cdot 12 = 0{,}035.$$

The critical value of the criterion is found by the formula for relatively large samples (n > 40). Accordingly, for our case, the experimental values of $n_1 = 353$ and $n_2 = 341$.

$$W_{1-\alpha} = \lambda_\alpha \frac{\sqrt{(n_1 + n_2)}}{n_1 \cdot n_2}.$$

For the value $\alpha = 0,05$ we matter $\lambda_\alpha = 1,36$

Table 2

Table of data for finding statistics of the Kolmogorov-Smirnov criterion based on the results of laboratory work "Determination of light wavelength using a Jung interferometer" in experimental and control groups

№ q\n	Number of correctly completed tasks	Absolute frequency in sample 1 (EG), f_1	Absolute frequency in sample 2 (CG), f_2	Accumulated frequency in the sample 1 (EG), $\sum f_1$	Accumulated frequency in the sample 2 (CG), $\sum f_2$	The difference of the accumulated frequencies in samples 1 and 2 $\left\|\sum f_1 - \sum f_2\right\|$
1	6	118	115	353	341	12
2	5	88	86	235	226	9
3	4	67	64	147	140	7
4	3	44	42	80	76	4
5	2	30	30	36	34	2
6	1	6	4	6	4	2

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$$W_{1-\alpha} = 1,36 \cdot \frac{\sqrt{694}}{120373} \approx 0,0003$$

Thus, the inequality holds:

$T_{obs} > W_{1-\alpha}$, that is (0,035 > 0,0003).

Therefore, we conclude that following the rule of decision on the null hypothesis H_1 is rejected and an alternative hypothesis is accepted, which indicates the difference in the distribution of scores for laboratory work in the process of teaching physics in the context of STEM education, traditional methods in educational institutions of technical training.

Accordingly, the increased level of knowledge and skills of students in experimental groups, we explain the sufficient effect of the developed methods of teaching physics using modern teaching aids in the development of STEM education due to student's practical and experimental tasks in physics. It is established that the proposed method of teaching physics in higher educational technical profile of study is appropriate, productive and necessary, as it promotes the development of educational and cognitive, independent activities, helps students to perform more creative tasks, activates search activities in the implementation of innovative STEM-technologies learning in terms of ontological approach.

The results of the third stage of the pedagogical experiment indicate the effectiveness of strengthening the role and importance of methods of teaching physics in the development of STEM education, namely the organization of student's practical tasks, skills and abilities in laboratory work on physics and ICT.

Conclusions and prospects for further explorations in this direction. Thus, the introduction of the STEM training system in Ukrainian technical free economic zones will contribute to the modernization of the system of psychological-pedagogical, methodological, practical training of future applicants for higher education based on STEM education; establishing the production of domestic educational STEM equipment and didactic tools STEM teaching physics; application of STEM approach to the educational process, which involves the development of personality, aimed at active and constructive entry into modern innovation processes and achieving a high level of self-realization in the teaching of physical and technical disciplines.

The analysis of the best domestic and world experience confirms the conclusions that the introduction of methods of teaching physics under these requirements helps to solve the problems currently facing STEM education, improves the quality of basic demonstration educational experiments in physics, activates and expands independent learning activities students, contributes to the prestige of physics education in the higher institutions of technical profile.

Prospects for further research are to study the problem in terms of developing methods of teaching physics and professionally-oriented disciplines in the context of adaptive learning, taking into account the concept of STEM education.

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МЕТОДИЧНІ ОСОБЛИВОСТІ ПРОФЕСІЙНО ЗОРІЄНТОВАНОГО НАВЧАННЯ ФІЗИКО-ІНЖЕНЕРНИХ ДИСЦИПЛІН НА ОСНОВІ STEM-ТЕХНОЛОГІЙ: АСПЕКТ ОНТОЛОГІЧНОГО ПІДХОДУ

Анотація. *У статті розглядається актуальність проблеми взаємозв'язку навчання фізики і професійно зорієнтованих дисциплін на основі STEM-технологій в умовах онтологічного підходу у процесі підготовки здобувачів освіти з інженерного та технічного напрямів за освітньо-професійною програмою спеціальності 272 «Авіаційний транспорт». Розроблена та запропонована методика навчання фізики на основі STEM-технологій з урахуванням дефініції онтології спрямована на формування у суб'єктів навчання STEM skills, що зумовлено поставленим перед освітніми закладами завданням значно підвищити якість знань студентів, роль навчання у формуванні їх стилю мислення і пізнавальних здібностей в умовах розвитку STEM-освіти. Визначено, що одним з інноваційних напрямів сучасної освіти є впровадження STEM-освіти, яка передбачає об'єднання наук, спрямованих на розвиток STEM-технологій, на інноваційне мислення та забезпечення потреби в добре підготовлених інженерно-технічних фахівцях. Обґрунтовано методичні особливості професійно зорієнтованого навчання фізико-інженерних дисциплін на основі STEM-технологій з урахуванням онтологічного підходу. У процесі проведення педагогічного експерименту застосовувались теоретичні та емпіричні методи дослідження. Зокрема, здійснено аналіз філософської, психолого-педагогічної, навчально-методичної літератури, рекомендованих підручників і навчальних посібників з методики навчання фізики в контексті розвитку STEM-освіти. Проводилися спостереження, анкетування, тестування, опитування, бесіди з науковцями та студентами. Отримані результати всебічно проаналізовані та опрацьовані за допомогою методів математичної статистики. Результати проведеного порівняльного експерименту з виявлення ефективності запропонованої методики навчання фізики в контексті STEM-освіти показали, що рівень сформованості фізичних знань, умінь і навичок студентів у контрольних групах є нижчим, ніж відповідний рівень в експериментальних групах.*

Ключові слова: *фізика, особливості методики навчання фізики, STEM-освіта, онтологічний підхід, педагогічний експеримент, професійно зорієнтовані та інженерні дисципліни.*

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МЕТОДИЧЕСКИЕ ОСОБЕННОСТИ ПРОФЕССИОНАЛЬНО ОРИЕНТИРОВАННОГО ОБУЧЕНИЯ ФИЗИКО-ИНЖЕНЕРНЫМ ДИСЦИПЛИНАМ НА ОСНОВЕ STEM-ТЕХНОЛОГИЙ: АСПЕКТ ОНТОЛОГИЧЕСКОГО ПОДХОДА

Аннотация. *В статье рассматривается актуальность проблемы взаимосвязи обучения физике и профессионально ориентированным дисциплинам на основе STEM-технологий в условиях онтологического подхода в процессе подготовки слушателей инженерного и технического направлений по образовательно-профессиональной программе специальности 272 «Авиационный транспорт». Разработанная и предложенная методика обучения физике на основе STEM-технологий с учетом дефиниции онтологии направлена на формирование у субъектов обучения STEM skills, что обусловлено поставленной перед образовательными учреждениями задачей значительно повысить качество знаний студентов, роль обучения в формировании их стиля мышления и познавательных способностей в условиях развития STEM-образования. Определено, что одним из инновационных направлений современного образования является внедрение STEM-образования, которое предполагает объединение наук, направленных на развитие STEM-технологий, на инновационное мышление и обеспечение потребности в хорошо подготовленных инженерно-технических специалистах. Обоснованы методические особенности профессионально ориентированного обучения физико-инженерным дисциплинам на основе STEM-технологий с учетом онтологического подхода. В процессе проведения педагогического* *эксперимента применялись теоретические и эмпирические методы исследования. В частности, осуществлен анализ философской, психолого-педагогической, учебно-методической литературы, рекомендованных учебников и учебных пособий по методике обучения физике в контексте развития STEM-образования. Проводились наблюдения, анкетирование, тестирование, опросы, беседы с учеными и студентами. Полученные результаты всесторонне проанализированы и обработаны с помощью методов математической статистики. Результаты проведенного сравнительного эксперимента по выявлению эффективности предложенной методики обучения физике в контексте STEM-образования показали, что уровень сформированности физических знаний, умений и навыков студентов в контрольных группах ниже соответствующего уровня в экспериментальных группах.*

Ключевые слова: *физика, особенности методики обучения физике, STEM-образование, онтологический подход, педагогический эксперимент, профессионально ориентированные и инженерные дисциплины.*

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