MODELLING OF ECO-ENVIRONMENT OF INFORMATION-ANALYTICAL SYSTEM FOR TRAINING OF SCIENTIFIC PERSONNEL BASED ON E-LEARNING

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Abstract

Improving the quality of education is a global trend of providing opportunities for self-improvement and self-realization for the individual and thus forming the intellectual potential of human communities. In this sense, among the main areas of priority are the introduction of effective modern technologies and the latest advances in scientific and methodological support of the educational process; integration of education and science, psychological and pedagogical support based on advanced world experience. Thus, the training of highly qualified scientific personnel using the ECO-environment of the information-analytical system (hereinafter – In-ECO IAS), using e-learning will ensure their effective activity in various subject areas (technical, engineering, etc.), and therefore is relevant for solving complex problems in professionals in the field of conducting independent research in higher education institutions. The purpose of the research is to substantiate the theoretical and practical aspects of modelling the In-ECO IAS of scientific training using e-learning technologies and develop methods for its implementation in the educational process taking into account current trends in Industry 4.0. (STEM education, elements of artificial intelligence, 3D-modelling, robotic systems, etc.) employing modelling programs. The object of research is the process of modelling the In-ECO IAS of scientific training based on e-learning. The subject of the research is models, methods and software of In-ECO IAS of scientific personnel training in the context of e-learning. The concept of the research is the formation and development of hard and soft skills in future researchers in the educational process of higher education institutions to model the In-ECO IAS on the basis of e-learning, which is required to obtain certain indicators of their training in professional science. To achieve this purpose and concept, the following research methods were used: methods of systematic and comparative analysis to substantiate the relevance and formulation of the scientific problem; methods of mathematical statistics: mathematical processing of experimental results to substantiate and apply the result of modelling the In-ECO IAS on the basis of e-learning (obtained by research model); expert evaluation of the proposed system of ECO-environment for the training of scientific personnel and means of its implementation on the basis of e-learning. The reliability and validity of the research results are ensured by the compliance of the main provisions with the leading directions and the level of development of innovative trends in modelling the In-ECO IAS; confirmed by positive results of the scientific and pedagogical experiment, completeness and statistical significance of empirical material, thorough analysis, active discussion of the results in a wide range of participants in scientific and practical activities using innovative technologies, and testing methods of teaching academic disciplines on the basis of e-learning. The total number of participants in the experimental study is 327 respondents (of whom 157 – control groups and 170 – experimental). The authors emphasize the need to introduce e-learning in the In-ECO IAS using modelling programs, which allows to obtain analytical data on the activities of future scientists and make adequate decisions to improve the research process. The role of teachers who train scientific personnel at a certain stage of the educational process is also actualized, which is partially reduced in the direct implementation of e-learning, u-learning, but their function in developing the necessary electronic educational and methodological support is growing.

Keywords: Eco-Environment, Information-Analytical System, Professional Training, Scientific Education, E-Learning, Higher Education Institutions, Scientific Research Institute, Innovative Trends in Education, Modelling, Model.

1 INTRODUCTION

The goals of the Ukraine education are integrated into the world scientific and educational space - reproduction and strengthening of the intellectual potential of the state, including scientific training and ensuring the comprehensive development of scientific personnel based on the formation of soft-skills specialists in popular professions. These tasks facing higher education require shifting the emphasis of the educational process from the passive accumulation of knowledge to the formation of the creative active personality of the scientist, hard work and development of individual abilities and talents, development of readiness for self-education by mastering the experience of modern methodology. These priority areas of development of the scientific and educational environment in higher education institutions (hereinafter – HEI) are implemented through the improvement of the educational process in the proposed In-ECO IAS, in particular – developing e-learning tools. The educational process is defined as purposeful consciously organized, dynamic interaction of teachers and subjects [1], which solves the problem of education in the context of innovative change, namely the introduction of e-learning in the In-ECO IAS for training of scientific. Innovative educational processes (hereinafter – IEP) are universal and function following certain laws, principles and a set of conditions that determine the direction and content of novation's, as well as provide a systematic level of their implementation. Their basic laws include scientists include: irreversible destabilization of the innovation environment, stereotyping of pedagogical innovations, cyclical IEP and patterns of the final implementation of innovations in the training of scientific personnel by e-learning (I. Dychkivska [2], O. Popova [3], N. Yusufbekova [4] et al.). At the same time, realities of modelling of the In-ECO IAS determine features of the development of IEP (introduction of e-learning, cloud technologies, elements of virtual and augmented reality, 3D-printing, robotic systems, etc.) and cause the need for a more thorough understanding of their patterns and conditions that determine the effectiveness of innovation in the training of scientific personnel in HEI.

Regularities of functioning of IEP in e-learning express the stable relationship between new and traditional in the education system, in particular in the field of engineering and software [5, 6], including – in physics and professionally oriented disciplines [7, 8]. This is outlined by the laws of development of the information-analytical system itself. That such patterns are manifested as external relations of IEP in In-ECO IAS with other social phenomena and systems, as well as internal structural and functional connections that are inherent in the innovation process. The general regularities – characteristic for the innovation process of modelling of In-ECO IAS as a whole, and partial, local – are inherent in a certain type of innovation process, or its separate stages. Note that the study of V. Palamarchuk [9, p. 79-80] on the theory and practice of innovation in education make adjustments to the patterns that are reflected in the modelling of In-ECO IAS, namely: the trend of spreading innovations is that education absorbs innovations and changes only partially (structurally, functionally, substantively); innovation is not always realized, such a transition is influenced by social, political, economic, psychological, pedagogical and other factors; the emergence of innovation is associated with transformations in society, reforms, progressive movements. In the research, we have outlined the main innovative models, which are determined by the substantiation of theoretical and practical principles of modelling the In-ECO IAS for training scientific personnel in the context of digitalization changes. The results of the analysis prove that the following models of education operate in the world: Model of Education as a State-Departmental Organization, the Model of Developmental Education, the Traditional Model of Education, the Rationalist Model of Education, the Phenomenological Model of Education, the Non-Institutional Model of Education [10, 11, 12, 13]; the Model of Transdisciplinary Education (uses an vision of maximum integration of subjects, the purpose of which is an interdisciplinary relationship, which is considered as a whole to improve the understanding of science and practical principles) [14, 15, 16, 17, 18, 19]. Thus, given the position of knowledge management in scientific training in In-ECO IAS, we consider that competitiveness and innovation, its ability to respond quickly to changes in the modern economic space is determined by what knowledge it has, creates new, how intensively uses, increases the available intellectual resources and how to learn [20].

The study focuses on the existence of hidden knowledge (personal knowledge of the specialist, directly related to his soft skills) and mechanisms that allow the increase of this type of knowledge and enhance their practical application in the training of scientific personnel. Therefore, modern models of the IEP are primarily related to the transdisciplinary strategy of rapid-learning to share knowledge and experience in studying the main sources of knowledge. This expands the range of opportunities to respond quickly to external changes and the needs of the market of scientific and educational services, which, in turn, affects the demand for training of scientific personnel on the requests of stakeholders. Thus, appreciating the research of specialists in innovative educational management, we note that as various companies (including educational institutions) realize the need to become more innovative, flexible and fast, they are increasingly beginning to see in management and exchange knowledge of how to increase the efficiency of human resources and obtain in this sense important competitive advantages.

Indeed, researchers are now expected to be much more active than before, to generate ideas and solve problems, and to perform more tasks in a short time. Since the main capital of the organization is human resources, more and more importance is given to self-education and self-education of scientific staff, advanced training of researchers, exchange of experience with colleagues and partners. In the near future, according to experts, knowledge management becomes almost the only opportunity to maintain a leading position in a highly competitive environment, because in modern conditions wins the one who can work faster and more efficiently, and therefore the one who owns and manages knowledge [21, p. 27-30]. According to E. Fromm, the development will be determined not so much by what a person has, but by what he imagines, what he can do with what he has [22, p. 10]. Based on many years of experience in knowledge management, K. Janetto and E. Wheeler [21] conclude that "projects in this area fail, mainly due to too much attention to technology and lack of consideration at different stages of the project (planning, preparation, implementation, etc.) of human or cultural factors. Meanwhile, the main thing in knowledge management is not computer networks, but people" [21, p. 12]. The relevance of this statement is supported by the opinion of researchers L. Gerasimov and G. Ilyukhin, who rightly note that "... innovation is a purposeful realization of the potential that lies in the creativity of the individual; the specificity of innovation as an activity gives rise to a certain type of personality" [23, p. 12]. The solution of the main task of the modern education system is determined by the trajectory of innovations, which are aimed at training of a new generation of people. To our mind, the educational system should contribute to the creation of appropriate conditions for the formation and development of the country's human capital (scientific, intellectual, labour) as an important component of the knowledge economy [18, p. 6]. Thus, in modern models of innovation processes, the focus is on a person with a constant desire to realize their potential for knowledge, creation and development of new things in interaction with others.

Based on a comparative analysis of the advantages and disadvantages of different models of IEP, we can conclude that the most productive of them are models based on the methodology of transdisciplinary to build innovation networks, information and analytical systems, rapid learning strategies and exchange of knowledge and experience, conditions for fruitful interaction of subjects of innovation environment, cooperation, cooperation of scientists and development of their competence and motivation in mastering and realization of innovations (STEM, modelling means of training, elements of artificial intelligence, etc.). The regularities of IEP in the modelling of In-ECO IAS, considered by the authors of the study, are proposed to study as a set of adaptive processes in education – institutional, sociocultural, organizational and managerial, psychological and pedagogical, economic conditions that reproduce the necessary links between innovative and traditional, as well as socio-pedagogical systems of HEI relations with the external innovative environment, which will have a positive impact on the training of scientific personnel.

2 METHODOLOGY

The purpose of the research is to substantiate the theoretical and practical aspects of modelling In-ECO IAC training of scientific personnel using e-learning technologies and develop methods for its implementation in the educational process taking into account current trends in Industry 4.0. (STEM education, elements of artificial intelligence, 3D modelling, robotic systems, etc.) using modelling programs. The object of is the process of modelling In-ECO IAS training of scientific personnel based on e-learning. The subject of research is the models, methods and software of In-ECO IAS training of scientific personnel in the context of e-learning. The concept of the research is the formation and development of hard and soft skills in future researchers in the educational process of higher education institutions for modelling In-ECO IAS based on e-learning, which is required to obtain certain indicators of their science training in profession. The leading idea of the research is that the formation and development of soft skills in future researchers, based on the principles of fundamentalization, taking into account methodologies of transdisciplinary, competency and systems approaches that provide subjects with a certain level of readiness to solve scientific and educational problems, required for their training in the professional field of activity. The research concept contains the following concepts: methodological – reveals the relationship and interaction of different approaches to solving the problem of formation and development of the scientific component in the educational process of training scientific personnel by modeling In-ECO IAS; theoretical – defines a system of basic definitions, patterns, principles underlying the understanding of In-ECO IAS in the learning process of Applicants for Science Education (hereinafter – ASE); features of educational and cognitive activity of ASE on the basis of transdisciplinary, competence and system approaches to their preparation in HEI taking into account e-learning tools; acquisition of professional qualifications, determination of levels of development of key professional and STEM-competencies; as well as the formation of transdisciplinary and professional STEM competencies; methodical – provides for the development and description of a methodical system of continuity of training (training of students of scientific education), for example, in software engineering, including – physics and professionally oriented disciplines, based on e-learning in free technical education, determining the stages of its application and implementation in practice of IT disciplines, physics and professionally oriented disciplines with a combination of interdisciplinary integration in the transdisciplinarity of In-ECO IAS.

To achieve this purpose and hypothesis, the following research methods were used: methods of systematic and comparative analysis to substantiate the relevance and formulation of the scientific task; methods of mathematical statistics: mathematical processing of experimental results to substantiate and apply the result of modelling In-ECO IAS based on e-learning (obtained by research expert and intellectual models); expert evaluation of the proposed In-ECO IAS system for training scientific personnel and means of its implementation based on e-learning. The theoretical significance of the expected results includes: conducting theoretical and logical-methodological analysis of the problem of development of scientific and educational complex in accordance with the training of scientific personnel on the basis of e-learning in technical HEI and Scientific Research Institute (hereinafter – SRI); substantiation of theoretical and practical principles of modeling of In-ECO IAS for training of scientific personnel in HEI and SRI; determining the content of methods of teaching scientists in software engineering and the fundamentals of physics on the specifics of professionally oriented disciplines, etc., as well as the disclosure of scientific factors on the basis of e-learning in HEI and SRI; use of fundamental theories from software engineering and physics courses in the context of transdisciplinary opportunities of e-learning technologies and STEM-technologies, as well as implementation of their theoretical generalization taking into account transdisciplinary links with disciplines of professionally-oriented education in HEI and SRI.

The practical significance of the expected results are: a methodical system of training scientific personnel in software engineering has been introduced into the educational process of technical free economic zones, including in physics and professionally-oriented disciplines in the context of modelling In-ECO IAS (the total number of participants in the experimental study – 327 people, (of whom 157 people – control groups and 170 – experimental; outlined transdisciplinary principles of science-based on STEM and e-learning technologies [8, 18, 19, 25, 26]; developed and implemented a textbooks [7, 24, 25, 26, 27, 28], guidelines for laboratory work and practical classes using STEM-technologies [8], in particular in English for applicants for the education of technical HEI; the International scientific-practical seminar "STEM-Education – Problems and Prospects" (http://www.glau.kr.ua/index.php/ua/home-ua/1830-stem2018ua), the International scientific-practical conference "Actual Aspects of STEM-Education of Natural Sciences" (http://www.glau.kr.ua/index.php/ua/home-ua/2481-iv-stem-70), Forum SOIS: The Development of the Unified Open Information Space in Lifelong Education [17, 29], etc., where highlights the fundamental problems of transformational innovation of the world education, which largely provides a great basis for improving the quality of scientific training personnel at the highest institutional level. For example, experimental verification of current research results (2016-2020) was carried out at the Flight Academy of the National Aviation University (hereinafter – FA NAU), Vinnytsia National Technical University, Cherkasy Bohdan Khmelnytsky National University, National Aviation University. Experimental research provides a new impetus for further exploration, testing and implementation in the context of the outlined issues. The reliability of scientific results and conclusions is ensured by: methodology of research starting points, compliance of research methods with its purpose, representativeness of the sample, comprehensive testing of the main provisions of the research in pedagogical experiment and implementation of the developed methodological system for teaching scientific disciplines in software engineering. oriented disciplines and physics with the use of In-ECO IAS in free economic zones and SRI, discussion of theoretical positions and specific research results at various levels of conferences and scientific seminars, application of a set of research methods appropriate to its subject and objectives; verification of the obtained model of In-ECO IAS training of scientific personnel in the HEI and SRI.

Analyzing the position of Ukraine in international indices, the current system of education and partnership in the triangle "business universities-education", we offer discussion questions on: development of a methodology for assessing the indirect economic impact of the costs of free economic science/research institutions and the formation of an appropriate statistical database through In-ECO IAS in the process of implementing e-learning; creation of favourable conditions for improving cooperation between business and free HEI/SRI for training scientific personnel, namely: simplification of transfer of equipment from business to HEI/SRI to improve the quality of the educational process and stimulate scientific activity; launching a system of vouchers for research and development necessary for business, which will reflect the innovative trends in the development of educational institutions; creation of platforms for the exchange of ideas and developments between business and HEI/SRI (hubs, innovation centres, research laboratories (Research & Development); ensuring financial transparency of the HEI, through the publication of expanded data on official websites, as well as the introduction of ideas for adaptive management of the educational process to improve it by introducing stakeholders to the governing bodies; strengthening the strengths of HEI and SRI, in particular, the high quality of teaching natural sciences, through the development and implementation of a program for the development of scientific specialities (for example, the STEM concept); joining other rankings and programs (for example, PISA), which will help improve the reputation and quality of Ukrainian education, as well as the introduction of e-learning [30, 31] in the process of outlining the scientific component in the In-ECO IAS; raising the scientific level of training of company personnel in business structures and increasing the cost of research (training of scientific personnel through the interaction of the three branches of business, education, science) and increasing quantitative and qualitative indicators of scientific and methodological support for the modernization of scientific training in the field software engineering, including – physics and professionally oriented disciplines. Thus, the implementation of the above ideas and the achievement of the outlined goals in this regard, in our opinion, achieves a certain effective result in the functioning of the appropriately modelled In-ECO IAC (definition of appropriate modelling tools for e-learning). For example, to form an idea of some aspects of modelling In-ECO IAS, we propose to consider the educational environment of a particular HEI.

In this sense, it should be noted that the D. Kostyukevich defines the educational environment as an organized system, the components of which contribute to the achievement of goals in the educational environment HEI. Sharing his the opinion [32, p. 53-65] in study will consider the modelling of In-ECO IAS technical freelance for the following main components: resource-subjective – defines the subjects of educational ECO-environment (researcher as the organizer of the scientific-educational educational environment and head of educational and cognitive activities of ASE in this environment and ASE as objects of pedagogical the impact of this scientific environment); material and technology (educational and methodical) base (offices, laboratories with the appropriate equipment, various technical means of teaching, including computer and appropriate equipment, digital equipment, visual aids, etc.) and educational and methodical complex (educational and methodical and scientific literature, pedagogical software, atlases, posters, videos, etc.); deological and technological – is determined by indirect links with the real world, which are formed in the life of the subjects of the scientific and educational process. Thus, at the organizational level of cognition, i.e. in the process of mixed activities aimed at the object of cognition, when the pedagogue helps the ASE to overcome difficulties, it is expected to achieve the predicted results of the pedagogical experiment. After all, in the process of creating a quality In-ECO IAS there are a number of ambiguities, the elimination of which can contribute to targeted research in this vector. In particular, the results of the analysis of research of such scientists as: A. Gurzhiy, Yu. Zhuk, V. Volynskyi [33], allow us to determine the factors that will increase the efficiency of modelling In-ECO IAS: strengthening the material and technical base of HEI/SRI; definition (substantiation) and provision of organizational and pedagogical conditions for effective use of modern teaching aids, including e-learning (digital equipment); development of methods of effective use of e-learning based on methodologies of transdisciplinary, competence and system approaches; creation of an information-analytical database on the development, testing and implementation of STEM-learning tools in the process of teaching engineering sciences in the HEI/SRI; preparation and creation of a funding program to ensure a transdisciplinary strategy at the point of development of STEM tools. Having analyzed the scientific research of scientists A. Kukh, O. Kukh [34], we have our vision for determining the specific pedagogical goals of modelling In-ECO IAS in HEI/SRI for the training of scientific personnel, namely: intensification of the scientific and educational process, increasing its efficiency and quality in the teaching of software engineering, natural sciences and other technical disciplines; implementation of the social order conditioned by the information of modern society, i.e. training of scientific personnel in this subject area and training of users using e-learning technologies, in particular in the field of STEM-education [35]; development of the creative potential of scientists (including abilities to communicative actions, skills of experimental research activities) through the use of e-learning technology, which is an integral part of the development of transdisciplinary component in vocational education (STEM-education) (Fig. 1).

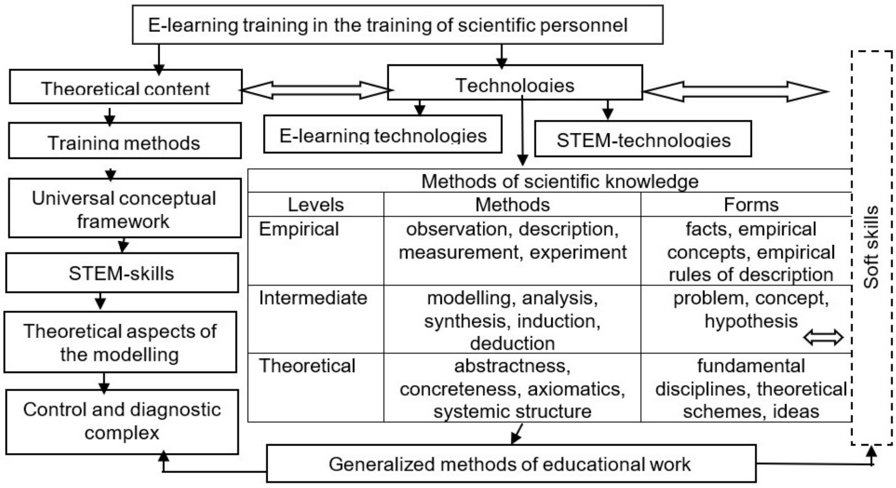

Figure 1. Implementation of e-learning in modelling the ECO environment.

The outlined components of modelling of In-ECO IAS in HEI/SRI provide the performance of the basic functions: identification, disclosure and development of abilities and potential opportunities of ASE for creative initiative; creating conditions for the independent acquisition of knowledge and their quality assimilation; providing automation of research results processing processes based on e-learning tools; diagnosing, managing and forecasting the individual achievements of ASE employing In-ECO IAS. Thus, modelling of In-ECO IAS training of scientific personnel is also a method of scientific knowledge, is part of the content of mastering scientifically oriented educational material in fundamental disciplines (eg, software engineering, physics, etc.) and is an effective means of studying them.

3 RESULTS

To test the results of modelling the In-ECO IAS in the free HEI and SRI, a pedagogical experiment was conducted (2016-2020), which allowed to gain new knowledge and a new vision of research prospects – and to identify the effectiveness of the model strategy to improve the quality of training of scientific personnel by building on the obtained model of In-ECO IAS. A new hypothesis has been put forward, which encourages further analytical actions. Agree with the opinion of N. Tverezovska and V. Sydorenko [36] that the research hypothesis will perform its function only when it meets the following conditions: be a reasonable prediction, not a hasty guess; be simple and clear in wording; be an adequate answer to the question; correspond to the facts based on which it is formulated and to explain which it is intended; take into account previously discovered patterns, but do not contradict the already known research results; explain a certain range of phenomena of reality; anticipate new facts, phenomena and connections between them; be subjected to empirical verification. Our assumption on the substantiation of theoretical and practical bases of modelling of In-ECO IAS of training of scientific shots in HEI/SRI was reduced not only to the necessity of formation of the necessary system of knowledge, abilities and skills but also to raise their role and teachers in the process of the scientific approach to the study of disciplines in software engineering, including – physics and professionally-oriented disciplines, to intensify educational and cognitive, independent activities; promote the development of critical thinking and creativity; satisfy the requests and wishes, inclinations and plans for the future of each ASE; to use such practical and experimental tasks in terms of content and scope, which will have practical application in the process of scientific knowledge and study of the basics of a certain scientific specialization.

For the experiment, technical HEI were selected that correspond to the optimality conditions. In these free economic zones, scientific work with ASE was also carried out at the appropriate level, which contributed more to the experiment and created the necessary conditions in the context of e-learning. Scientific and cognitive groups were selected in such a way that they corresponded to the conditions of the pedagogical experiment, namely the number of ASE in groups. Experienced scientific and pedagogical workers worked in the selected technical HEI, who expressed their desire and readiness to work according to the proposed methods of teaching IT, physics and professionally-oriented disciplines in the In-ECO IAS. At the first stage of the research (2016-2017) a plan for prospects and testing a result its effectiveness was drawn up. Measures were aimed at ensuring compliance with the content of practical tasks to the purpose of each stage, selection and formation of appropriate sets of tasks. An important part of the tasks is various forms of test tasks, as well as tasks performed using modern e-learning technologies, such as a set of "L-micro", which significantly increased the attention of ASE and outlines the fundamentals of the conceptual apparatus of IT disciplines, including – physics, stimulated independence and educational and cognitive activities in the educational process of technical education. The research laboratory "STEM-education and innovative education" was opened at the FA NAU. This laboratory is part of the "STEM-Center" of the Academy (which is a structural unit), provides research in e-learning and STEM-education for pedagogical and scientific-pedagogical workers and ASE. The main objectives are: pooling of intellectual, financial and logistical resources in the implementation of research in the field of STEM education; introduction of research results into the educational process of the academy; personnel, logistical, legal and information support of research at the academy, taking into account the concept of STEM education; publication of research results (except in cases related to confidentiality) at conferences, seminars and scientific journals; development of human resources of the academy; study of innovative processes taking place in educational institutions, scientific and methodological support for their transfer to the mode of experimental work on the development of scientific and educational activities; development of conditions for successful adaptation of new educational programs, textbooks, technologies, training of advanced education projects; development of experimental educational programs (including author's), analysis of scientific hypotheses and concepts of development of the course of natural sciences in the field of STEM-education, rational learning modes, introduction of new pedagogical theories and practices, methods and techniques of educational technologies and research programs [37].

In the second stage of the research (2018-2019) 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 professions in software engineering, including – physics, in the context of the development of transdisciplinary education, in particular – STEM education. Observations, questionnaires, testing, surveys, interviews with scientists and ASE were conducted. These results of the experiment were comprehensively analyzed. Quantitative data were processed using the methods of mathematical statistics. Dynamics of change of knowledge of ASE in the process of implementing the methodological system of teaching IT-disciplines, including – in physics and professionally-oriented disciplines based on e-learning and STEM-technologies in In-ECO IAS HEI/SRI [38] (Fig. 2).

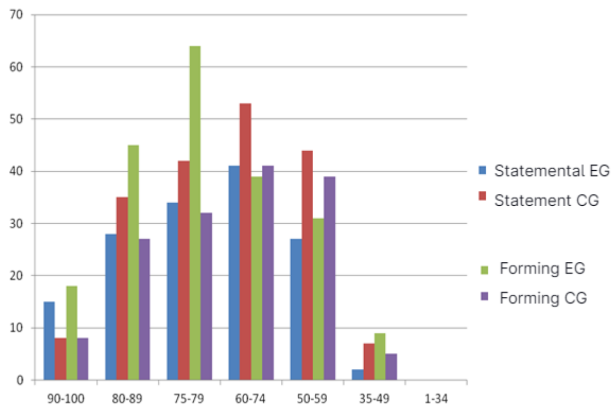

Figure 2. Dynamics of the quality indicators of the achievements of ASE in the implementation of the methodology of scientific and educational activities in the In-ECO IAS.

Let us denote p_{1i} (i = 1,2,3,4,5,6,7) the statistical probability of performance of work by ASE of the first sample for evaluation i; p_{2i} (i = 1,2,3,4,5,6,7) – the statistical probability of performance of work by ASE of the second sample for evaluation i. Based on the experimental data shown in the table above, we test the null hypothesis *Ho*: $p_{1i} = p_{2i}$ for all categories (C=7). An alternative hypothesis for *H1*: $p_{1i} \neq p_{2i}$ at least one of the seven categories mentioned. We calculate experimental statistics according to the formula [39, p. 106]:

$$T = \frac{1}{n_1 \cdot n_2} \cdot \sum_{i=1}^{c} \frac{(n_1 \cdot Q_{2i} - n_2 \cdot Q_{1i})^2}{Q_{1i} + Q_{2i}} \quad (1)$$

According to tabulation data [39, p. 130] α=0,05 and the number of degrees of freedom $\nu=C-1$=7-1=6 we find the critical value of the statistics of the criterion T: $x_{1-\alpha}$ = 12,59 i.e. $T_{critical}$ = 12,59.

For control (CG) and experimental (EG) samples before the experiment T_{obs}. <$T_{critical}$ (6,98 <12,59), which is the basis for accepting the null hypothesis. Control samples before and after the experiment also have statistically significant differences T_{obs}. <$T_{critical}$ (26,822> 12,59). Control and experimental samples after the experiment have statistically significant differences because of T_{obs}. >$T_{critical}$ (17,8> 12,59). Following the decision-making rule, the obtained results allow to reject the null hypothesis H_o and accept the alternative H_1.

Thus, we can conclude that ASE experimental groups during the implementation of tasks in IT-disciplines, including and in physics and professionally-oriented disciplines based on e-learning and STEM technologies showed better results than subjects who studied without the use of experimental methods. The results of the third stage of the research (2019-2020) indicate the effectiveness of strengthening the role and importance of In-ECO IAS training of scientific staff of the HEI and methods of teaching IT disciplines, including physics and professionally-oriented disciplines based on e-learning and STEM-technologies on the basis of transdisciplinary, competency and system approach.

4 CONCLUSIONS

It was found that the development of innovative trends in science and education affects the needs of the market of educational services and the labour market, in particular in the training of scientific personnel in the technical speciality. Therefore, in the course of the research, the expediency was established: 1) taking into account psychological and pedagogical factors of formation of In-ECO IAS HEI/SRI (in the process of modelling In-ECO IAS should pay attention to the compliance of its components, structure and functioning of general pedagogical principles, considered in the works of various authors, and which should be taken into account in any socio-pedagogical systems based on systems modelling and fundamentalization disciplines in software engineering, including – physics and professionally oriented disciplines); 2) the application of the principle of fundamentalization of education in the context of specialization of their profession in defining the principle of scientificness involves the acquisition of certain competencies and actually forming each subject of learning personal knowledge system endowed with properties of depth, integrity, universality, has a fundamental basis development of innovative education taking into account e-learning; 3) involvement of the principle of excellence in modelling and construction of In-ECO IAS training of scientific personnel, consists in "ensuring technological orientation and structural compliance of information scientific and educational environment with the tasks of open socio-pedagogical systems"; 4) application of the principle of innovation, which is realized through the ability to order and pay for the supply of STEM-technology and e-learning tools as they are used, which significantly increases the freedom of choice and experimentation with different types of tools (electronic resources, software, computer platforms and technologies), expands the share of research approach in the teaching of IT disciplines, including – physics, promotes the development of skills of joint processing and analysis of data and results of collective study of phenomena and processes.

There is a need to create and substantiate the process of modelling In-ECO IAS, which will provide a full level of knowledge for the study of scientifically and professionally-oriented disciplines in HEI/SI. The types of existing models are analyzed, which stimulated the substantiation of theoretical and practical principles of modelling of In-ECO IAS training of scientific staff of HEI/SRI; its place, main elements and structure are determined; the implementation of e-learning technologies in the training of scientific personnel is revealed. The pedagogical goals of modelling In-ECO IAS and supporting its functioning during a long period of application are revealed. The results of the comparative experiment to identify the effectiveness of the proposed modelling In-ECO IAS and the corresponding technology of its construction, which includes methods of teaching IT disciplines in the context of specialization in software engineering, including – physics and professionally-oriented disciplines, make it possible to diagnose the formation of soft skills in ASE in the field of science – in the control groups is lower than the corresponding level in the experimental groups. In the future, research on this issue can be conducted in the following perspectives: information and analytical support for the process of improving the content and teaching system of IT disciplines, including – physics and professionally-oriented disciplines, taking into account digitization technologies; strengthening the connection between the teaching of the courses of these disciplines with the scientific orientation of acquiring professional competence in the field of non-physical specialities of technical institutions of higher education and research in the context of transdisciplinary, in particular – STEM-education.

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