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И ТЕХНОЛОГИИ

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EVALUATION OF THE BASIC PROFILE OF IT SPECIALISTS TRAINING IN THE FRAMEWORK OF NETWORKING INTERACTION OF HIGHER EDUCATION INSTITUTIONS

ЖОҒАРЫ ОҚУ ОРЫНДАРЫНЫҢ ЖЕЛІЛІК ӨЗАРА ӘРЕКЕТТЕСУІ АЛДЫНДАҒЫ IT-МАМАНДАРДЫ ДАЯРЛАУДЫҢ БАЗАЛЫҚ ПРОФИЛІН БАҒАЛАУ

ОЦЕНКА БАЗОВОГО ПРОФИЛЯ ПОДГОТОВКИ IT-СПЕЦИАЛИСТОВ В РАМКАХ СЕТЕВОГО ВЗАИМОДЕЙСТВИЯ ВУЗОВ

Abstract. *This research paper presents the results of the basic component structure of the educational program study, which is a prerequisite for the creation of a joint educational program within the network of universities. One of the most important components of technical areas development is the educational content of the program, its relationships with the forming competencies of students. "Educational content - competencies of students" system provides effectiveness and accordance with the demands of the consumer services market and employers, which are the priority task for technical universities today. The research paper proposes approaches and ideas for proposed system implementation. The system also takes into account the interest of the students themselves in the content of the educational program, which is the solution of the "Educational Content – students" system. The authors emphasize that project-based education, as the core of the educational program, has a practice orientation and applied significance in solving professional problems in the field of data processing and data analysis for healthcare and pharmacology, calculation of optimal designs in biomechanics, and ballistic design of space missions. The obtained results on the evaluation of the basic profile justify that only a potent basic portfolio of a graduate can ensure successful project-based education and mastering the core portfolio of a graduate.*

Keywords: *networking in education; basic competencies; professional competencies; learning results; IT education; employers' needs.*

Аңдатпа. *Бұл зерттеу жұмысында университеттер желісінде бірлескен білім беру бағдарламасын құрудың алғышарты болып табылатын білім беру бағдарламасын зерттеудің негізгі құрамдас құрылымының нәтижелері берілген. Техникалық бағыттарды дамытудың маңызды құрамдас бөліктерінің бірі бағдарламаның білім беру мазмұны, оның студенттердің құзыреттіліктерін қалыптастырумен байланысы болып табылады. «Білім беру мазмұны – студенттердің құзіреттілігі» жүйесі бүгінгі таңда техникалық жоғары оқу орындарының бірінші кезектегі міндеті болып табылатын тұтынушылық қызмет нарығы мен жұмыс берушілердің сұраныстарына сәйкестігін және тиімділігін қамтамасыз етеді. Зерттеу жұмысы ұсынылған жүйені енгізудің тәсілдері мен идеяларын ұсынады. Жүйе сонымен қатар «Білім беру мазмұны – студенттер» жүйесінің шешімі болып табылатын білім беру бағдарламасының мазмұнына оқушылардың өздерінің қызығушылығын ескереді. Авторлар жобалық білім берудің білім беру бағдарламасының өзегі ретінде денсаулық сақтау және фармакология үшін деректерді өңдеу және деректерді*

талдау, оңтайлы жобаларды есептеу, биомеханика және ғарыштық миссияларды баллистикалық жобалау саласындағы кәсіби міндеттерді шешуде тәжірибелік бағытты және қолданбалы маңызы бар екенін атап көрсетеді. Базалық профильді бағалау бойынша алынған нәтижелер тек қана түлектің қуатты базалық портфолиосы ғана жобаға негізделген табысты білім беруді және бітірушінің негізгі портфолиосын меңгеруді қамтамасыз ете алатынын дәлелдейді.

Түйін сөздер: *білім берудегі нетворкинг; базалық құзыреттер; кәсіби құзыреттіліктер; оқу нәтижелері; IT білім беру; жұмыс берушілердің қажеттіліктері.*

Аннотация. *В данной научной работе представлены результаты исследования базовой компонентной структуры образовательной программы, что является необходимым условием для создания совместной образовательной программы в рамках сети университетов. Одной из важнейших составляющих развития технических направлений является образовательное содержание программы, его взаимосвязь с формированием компетенций обучающихся. Система «Образовательное содержание – компетенции обучающихся» обеспечивает эффективность и соответствие запросам рынка бытовых услуг и работодателей, что сегодня является приоритетной задачей технических вузов. В исследовательской работе предлагаются подходы и идеи для предлагаемой реализации системы. В системе также учитывается заинтересованность самих обучающихся в содержании образовательной программы, что является решением системы «Образовательное содержание – обучающиеся». Авторы подчеркивают, что проектное обучение, как ядро образовательной программы, имеет практикоориентированность и прикладную значимость при решении профессиональных задач в области обработки и анализа данных для здравоохранения и фармакологии, расчета оптимальных конструкций, биомеханике и баллистическом проектировании космических миссий. Полученные результаты по оценке базового профиля обосновывают, что только мощное базовое портфолио выпускника может обеспечить успешное проектное обучение и освоение профильного портфолио выпускника.*

Ключевые слова: нетворкинг в образовании; базовые компетенции; профессиональные компетенции; результаты обучения; ИТ-образование; потребностей работодателей.

Introduction. The prerequisite for the study is the temporary changes that occured in the world economy. Due to the COVID-19 Pandemic, the entire global community of the educational space had to reorganize. Universities purposefully revised their educational content and mastered new technologies for online support of the educational process.

The aim of the study is to analyze and evaluate the basic profile of «Applied Mathematics and Informatics» educational program graduates in order to determine approaches to the network interaction of educational processes between universities. For the training of highly qualified personnel, the academic council of the educational program «Applied Mathematics and Informatics» has developed a structure that determines the relevance of the educational program and its goals, the area of professional activity, the requirements for the level of training (basic and professional competencies) of students, concepts of the project model and practice-oriented types of learning. The educational program «Applied Mathematics and Informatics» is aimed at training highly qualified specialists in the field of applied mathematics and informatics who are able to design, explore, interpret and optimize mathematical models for solving scientific and engineering problems using modern programming languages and technologies.

The educational program «Applied Mathematics and Informatics» has a unique structure, where an important role is given to the development of the basic training profile: in mathematics, programming and physics, with a special emphasis on project activities.

Review of the research. When studying published materials, it was revealed that a sufficient number of works have been published on the development of educational programs of universities with a focus on employers and the formation of professional competence among students studying in technical specialties ordered by employers.

The article [1] presents the results of a study of practice-oriented training of university graduates. To a greater extent, students have developed the necessary skills and competencies due to the

experience of learning at the workplace during the internship and, subsequently, during employment. The importance of teamwork, responsibility and collaborative learning have become the most important factors in the effective development of educational programs of universities with focus on employers. The papers [2-3] present studies in the field of modeling the advanced training of engineering and technical specialists based on the interaction of universities and potential employers, the development of a mechanism for managing vocational education and its consolidation with the global educational space. As a result of the study, the authors proposed a model and approaches for achieving an international level of professional qualifications by engineers and a high level of technological openness. In papers [4-5], the authors researched, studied and summarized the experience of foreign and Russian engineering universities in the development of a graduate employment management system through the introduction of innovative models for the organization of engineering education; the search for new areas of activity that positively affect the quality of continuous technical education and youth employment. The paper [6] is aimed at developing approaches to the formation of professional competence of future specialists in the IT field. In the results of the study, the authors propose to develop a structural model for the formation of professional competence of future programmers, teachers with a deeper analysis abilities of the individual components of the educational and scientific base of the formation of professional competence in order to meet the educational needs of a modern student and employer.

The development of practical experience, worldview and thinking of future teachers of technological education, the improvement of their professional competence, the logic of their attitude to their profession largely depends on the adequate formation of their professional skills and abilities. The article [7] analyzes the current professional activity of future teachers of technological education and the level of their practical training. The methodological and technological foundations of design in the formation of professional skills and competencies of future teachers of technological education, as well as scientific considerations for the application of technological education in the education system were described. The study pays great attention to the analysis of the publication of scientists on the training of future IT specialists and the features of teaching programming using online simulators. The authors have compiled a comparative description and analysis of various online platforms for programming education and selected the most effective and efficient online platforms for the formation of professional competence of IT students. It is noted in [8] that for the most part gamification in the process of training future IT specialists contributes to an increase in cognitive activity and intensive involvement of students in solving professional problems. In the papers [9-10], much attention was paid to the study of the professional orientation of educational programs, the assessment of the formed competencies and their compliance with the needs of consumers. According to the results of the survey among students, the design of the educational program was developed with an important component of professional standardization, which allows to ensure a high level of education in close cooperation with employers.

When analyzing the basic component of the educational program «Applied Mathematics and Informatics», interesting approaches were explored by the authors in [11-15]. The authors emphasize the importance of mathematical education in the study of the theory of the laws of physics and programming. The basis of this strategy is that mathematical knowledge is a preliminary step and a basic platform for solving professional problems in the field of modeling processes and systems, developing applications and teaching physics. For the successful implementation of research projects in programming, a high level of mathematical literacy and mathematical apparatus is a necessity.

In paper [16] the authors pay great attention to research in terms of the formation of

information and communication, mathematical competence in the graduate's competence portfolio. The authors propose a holistic model that contains the target, content, technological and productive components. This model will work to form a graduate's readiness to apply mathematical knowledge, skills, as well as ICT tools for searching, critical analysis and synthesis of information, solving complex problems in professional and subject areas. The authors have devoted their work [17] to the study of various approaches and technologies of mathematical education. The authors propose to introduce computer algebra systems as one of the infrastructural methods and effective approaches in strengthening the role of mathematical education. To complete the assessment of the content of educational programs, achievements in the digital support of the educational process were also studied.

In [18-19], the authors paid great attention to research in the field of higher education in the online learning environment. The authors note the relevance and effectiveness of learning in asynchronous learning networks (ALN) in higher education in the works of scientists and propose a more effective model «Learning Presence». A clear understanding of the prerequisites for quality online learning, related primarily to faculty readiness, is essential to creating an effective program. In this paper on online learning, the authors highlight the importance of past statements that student-teacher and student-student interactions, where one of the variables, is most strongly correlated with student satisfaction. The results of the study show that among the three mentioned systems «student-teacher», «student-content», «student-student», the first two systems were highly rated. In papers [20-21], the authors direct their research on the role of mobile technologies as a learning tool for students in a distance learning environment, analyze the classifications of numerous examples of mobile learning and assess its potential. The authors carried out a comparative analysis of three learning technologies: mobile learning, e-learning and ubiquitous learning. Assessing mobile learning as a more effective type of technology in the process of teaching and learning, the author modified the theory of transactional distance and singled out four types of mobile learning for research, respectively, with high and low transactional distances. The study [22] of the authors aims to identify the transformation of offline learning into online learning due to Covid -19 in the perception of students at a public university in Indonesia. To this end, using a narrative approach, the impact on the education sector was studied to adapt to new situations and conditions. As a result of the study, the authors found that the implemented form of online learning is considered more flexible, efficient and effective in terms of time use, as well as in terms of costs and energy, but with various obstacles and problems that are noted in the form of non-optimal interaction or sudden changes of schedule.

The main content of the article [23] is aimed at analyzing violations in the educational context and detailing the adaptations that can contribute to the effectiveness of educational processes. In addition, the authors discuss the pedagogical, methodological, didactic and evaluative aspects of changing education. The article also offers some guidelines for training on both synchronous and asynchronous platforms. The trends associated with these changes are analyzed to offer a perspective on education in a post-pandemic world with the need to use digital tools and resources to support education.

In [24-25], the authors presented in more detail the results of a study on changes in the educational process at French universities associated with the emergence of a new form of coronavirus (COVID-19). The search for better solutions by teachers and the manifestation of initiatives leads to the use of various tools of video conferencing, chat, social networks. The many ideas presented and the opportunities for online learning at a reasonably good level could provide a continuity in learning that complements the activities available in the digital work environment.

In articles [26-27], the authors have paid great attention to social networks as new technologies

for the exchange, creation and interaction between students and teachers in online learning. The researchers note that the Technology Acceptance Model (TAM), which focuses on perceived ease of use and perceived usefulness, is becoming popular among university students and faculty. This paper [28] presents the result of a study of the process of online learning according to the "pretest-posttest" scheme for one group. The data analysis technique used a paired T-criterion with an error rate of 5%. Based on the results of the correlation analysis and discussion, a conclusion was made about the growth of online learning in the era and after the Covid-19 pandemic through the use of WhatsApp to increase motivation for learning. The paper [29] provides a study of the advantages and disadvantages of online learning during the Covid-19 pandemic. Due to the offer of commercial digital learning platform providers, many online educational technologies are presented as business models that are aimed at making a profit. This article provides an analysis of various problems of online learning. The presented commercial digital educational technologies in the full sense do not always reflect the best pedagogical practices and can harm the student in the psychological aspect.

The paper [30] provides a study of authors in the field of educational technology and the level of access of students to hardware and software technologies to support teaching and learning due to existing inequalities in US families. An assessment is given through the prism of a cross and digital gap on the level of knowledge gained by students in interaction with a parent. New approaches to the development of network interaction of educational programs of partner universities are proposed in [31-32]. In [31], the authors note the key factors that directly affect the sustainable development of universities at the international level. The main drivers of change are the presence of "connections" with society, the presence of coordinating bodies and projects, as well as the availability of funding, which is important for progress. Increasing interdisciplinarity is a strategic goal of almost all of these universities. These universities are demonstrating important strategic efforts and initiatives that drive and generate change for sustainable development resulting from a combination of driving forces. In [32], the author notes that for the sustainable innovative development of a higher educational institution, it is necessary to make changes to approaches in three areas: mobilization; implementation; and institutionalization. The author makes a proposal to create innovative communities between higher educational institutions, which will ensure productivity and leadership in the global educational space.

Materials and methods of research. For the purpose of conducting research, the disciplines of the basic profile are presented in the following coding type, indicating the volume of study:

BD – Basic Discipline
BD 1.4 Discrete Mathematics 4
BD 2.4 Algebra 4
BD 3.4 Theory of functions of a complex variable 4
BD 4.4 Differential equations 4
BD 5.4 Equations of mathematical physics 4
BD 6.4 Optimization methods 4
BD 7.4 Operating systems 4
BD 8.5 Theory of random processes 5
BD 9.6 Theoretical mechanics 6
BD 10.7 Numerical methods 7
BD 11.7 Control theory 7
BD 12.8 Probability theory and mathematical statistics 8
BD 13.9 Functional analysis 9
BD 14.10 Linear algebra and analytic geometry 10

BD 15.11 Physics 11

BD 16.12 Algorithmization and programming 12

BD 17.19 Mathematical analysis 19

The graduate competency portfolio contains 10 universal and 18 professional competencies. For a complete assessment, each discipline of the basic profile is matched with its brief description and learning outcomes aimed at the formation of relevant competencies. The sample determined the learning outcomes that correspond to the disciplines of the graduate's basic profile. The universal and professional competencies in the basic profile have been assigned the following codes:

UC-1 Ability to learn, acquire new knowledge, skills in professional fields, as well as in non-professional.

UC-3 Ability to solve problems in professional activities based on analysis and synthesis.

PC-1 Ability to conduct a systematic analysis of manufacturing, economic, technical and other complex processes, including the analysis under conditions of uncertainty and risk.

PC-3 Ability to analyze the developed technical solutions based on their interpretation and evaluation of possible options.

PC-4 Ability to design and develop software components based on modern paradigms, technologies and programming languages.

PC-10 Ability to apply knowledge of fundamental mathematics and natural sciences in the development of mathematical models and methods for objects, processes and systems in engineering.

PC-11 Ability to use and develop methods of mathematical modeling and apply analytical and scientific software packages.

PC-12 Ability to reasonably select, refine and apply mathematical methods and models to solve research problems, check the adequacy of models, analyze and interpret the results, and evaluate the reliability and quality of systems functioning.

PC-13 Ability to plan scientific experiments while working in research laboratories, research and technology departments of enterprises and companies.

PC-14 Ability to interpret and analyze the results of scientific experiments for all types of activities.

PC-16 Ability to work with various sources of information, to filter and narrow the array of knowledge for the given task.

PC-17 Ability to understand and analyze socially significant problems and processes of modern society that form the composition of professional tasks, as well as determining the social consequences of their solution.

Probabilistic-statistical methods were applied to analyze and evaluate the content of the educational program «Applied Mathematics and Informatics» basic profile. Evaluation of learning outcomes are displayed in Table 1, which is a statistical series of correspondence of learning outcomes to the educational content of basic profile disciplines and Table 2, which is a statistical series of correspondence of basic profile disciplines to their learning outcomes based on the following criteria:

1. accordance with the demands of the market and employers;
2. accordance with the educational content of disciplines;
3. accordance with the criteria of attainability and measurability.

Table 1. Statistical series of correlation between learning outcomes and assessment criteria

Learning Outcomes	UC-1	UC-3	PC-1	PC-3	PC-4	PC-10	PC-11	PC-12	PC-13	PC-14	PC-16	PC-17
X_i	0,5	1	1,5	2	2,5	3	3,5	4	4,5	5	5,5	6
n_{i*} - 1st criterion	14,5	14	7	4	3	12,5	5,5	10,5	1	2	14	1
n_{i**}- 2nd criterion	16,5	13	8,5	3	3	13,5	7	10,5	0,5	1,5	15	1
n_{i***}- 3rd criterion	17	9	8,5	4	2,5	11,5	4,5	10	0	2	13	3

Table 2. Statistical series of correlation of basic profile disciplines to assessment criteria based on learning outcomes

Discipline codes	BD1.4	BD2.4	BD3.4	BD4.4	BD5.4	BD6.4	BD7.4	BD8.5	BD9.6	BD10.7	BD11.7	BD12.8	BD13.9	BD14.10	BD15.11	BD16.12	BD17.19
Y_i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
m_{l*}-	6	2,5	2,5	6,5	5	7	5	7,5	3,5	6	9	7,5	2	3,5	6,5	4,5	4,5
m_{l**}	6	3,5	3,5	7	6	6,5	4	7	4,5	5	8,5	8	4	4,5	5,5	4,5	5
m_{l***}	5	3	3,5	6	5	6	4,5	6,5	3,5	6	8	8	3,5	3	4,5	4	5

Results and discussion. The results of the study have shown that in the context of the assessment criteria, the development of all disciplines of the basic profile of the educational program «Applied Mathematics and Informatics» is aimed at forming the learning outcomes of UC-1, UC-3, PC-16 among graduates. These disciplines have the highest weight in the graduate's portfolio of competencies, equal to 1. The learning outcomes of PC-10, PC-12 are located below according to the weight.

The results of training the basic profile when ranking according to the total criterion assessment by «weight» are arranged in the following form:

PC-4 Ability to design and develop software components based on modern paradigms, technologies and programming languages.

UC-1 Ability to learn, acquire new knowledge, skills in professional fields, as well as in non-professional.

PC-1 Ability to conduct a systematic analysis of manufacturing, economic, technical and other complex processes, including the analysis under conditions of uncertainty and risk.

PC-11 Ability to use and develop methods of mathematical modeling and apply analytical and scientific software packages.

PC-12 Ability to reasonably select, refine and apply mathematical methods and models to solve research problems, check the adequacy of models, analyze and interpret the results, and evaluate the reliability and quality of systems functioning.

PC-10 Ability to apply knowledge of fundamental mathematics and natural sciences in the development of mathematical models and methods for objects, processes and systems in engineering.

PC-16 Ability to work with various sources of information, to filter and narrow the array of knowledge for the given task.

PC-3 Ability to analyze the developed technical solutions based on their interpretation and evaluation of possible options.

PC-14 Ability to interpret and analyze the results of scientific experiments for all types of activities.

UC-3 Ability to solve problems in professional activities based on analysis and synthesis.

PC-17 Ability to understand and analyze socially significant problems and processes of

modern society that form the composition of professional tasks, as well as determining the social consequences of their solution.

PC-13 Ability to plan scientific experiments while working in research laboratories, research and technology departments of enterprises and companies.

The projecting of universal and professional competencies into the learning outcomes of the discipline in accordance with the assessment criteria led to the following results, which are presented in Charts 1 and 2.

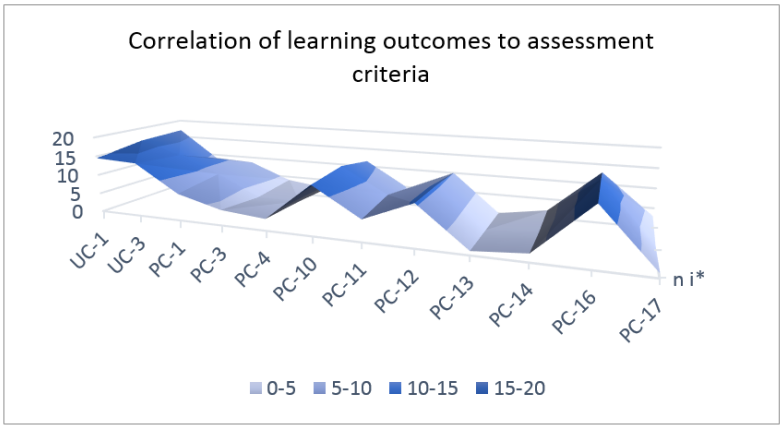

Figure 1. Correlation of learning outcomes to assessment criteria

The learning outcomes corresponding to the competences of UC-1, UC-3, PC-1, PC-6, PC-7, PC-8, PC-11, PC-12, PC-16 represent the characteristics of the assessment criteria.

Using the well-known formula of classical probability in the normalized form (1), it is possible to determine the probabilistic assessment of the correspondence of learning outcomes to three criteria:

$$P(k) = \frac{\frac{1}{\sum\limits_i n_i^k} \sum\limits_j n_j}{\frac{1}{\sum\limits_l m_l^k} \cdot m_l} \qquad (1)$$

where, *k is* the evaluation criterion, *j is* the results of training corresponding to the discipline m_l.

As a result of all calculations, it was found that the probabilistic values of the correspondence of learning outcomes to the specified three criteria are close to 1, which mathematically substantiates the conclusion: all learning outcomes are important in the formation of a future "Applied Mathematics and Informatics" graduate professional portfolio.

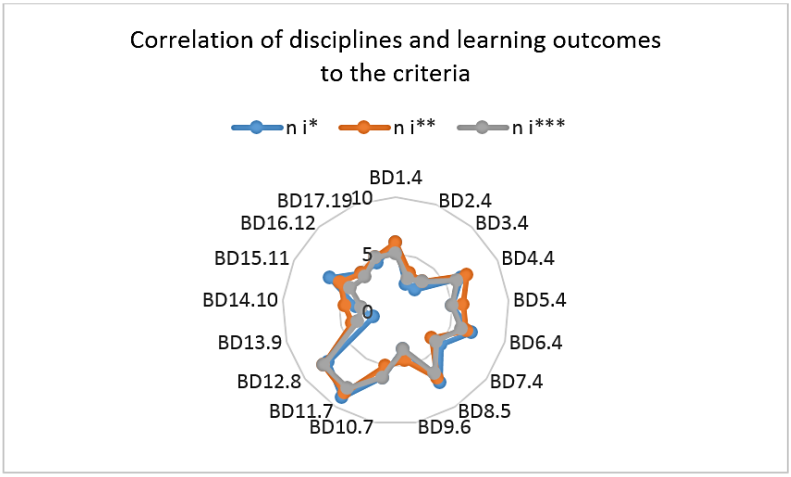

Figure 2. Correlation of disciplines and learning outcomes to the criteria

Conclusions. The studied content of the "Applied Mathematics and Informatics" educational program basic portfolio provides students with the necessary basic competencies, which are an important component in the formation of professional competencies in the field of mathematical modeling, development and implementation of modern information technologies and systems, analytics and business.

The presented basic educational environment defines the introduction of the priority direction of innovative education as a project model of education. The concept of a project-based educational model displays the most effective and optimal method of organizing work, which is transparent and understandable for both the employer, industrial enterprises and the IT sector representatives.

The resulting assessment shows the qualitative and quantitative characteristics of the «Applied Mathematics and Informatics» educational program content basic profile, as a finished educational product for universities networking.

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