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ANALYSIS OF CRITERIONS OF FORMATION EVALUATION OF PROFESSIONAL COMPETENCE IN MATHEMATICAL MODELLING OF THE FUTURE ENGINEERS-MATHEMATICIANS

Statement of the problems and their urgency. Any pedagogical study on the formation evaluation of certain knowledge and skills of future specialists in universities has to be based on a clear system of indicators that correspond to the planned end of the experiment. Each of these indicators in the process of teaching and learning of students will vary, as evidenced by the level of formation of these qualities.

In the educational and skill characteristics (ESC) of engineer-mathematicians are offered the main production functions, typical tasks of activity and ability of solving typical tasks of the specialist this specialty. The future engineer-mathematician is preparing for the implementation of the project, analytical, technological, operational, forecasting, research and organizational activities. There are principal components:

• Development of production problems and performance of algorithms for their solution;

• Research and selection of modelling techniques for solving formulated problems;

• Analysis, information sources and approaches needed to solve the problems of choice and justification of the most adequate conditions of a particular object;

• Modelling the decision making process with the uncertainty;

• Construction and analysis of mathematical models of different objects or control systems;

• Construction of mathematical models of systems and processes, test their adequacy;

• Identification and verification of forecasts of engineering processes or systems;

• Research and selection of machine models and mathematical methods of forecasting performance of technical and organizational systems;

• Research and development of heuristic procedures and examination techniques for solving formulated problems;

• Definition of process operations and sequence of their execution;

• Estimating the size and distribution of work between actors, defining milestones and deadlines for their implementation, a production system;

• Organization of interaction, and a user information system or its fragment;

• Analysis and preparation of analytical reports on a particular problem (task);

• Ability to correctly analyze the purpose, objectives and practices of information service facilities;

• Development measures of processing of results of market research and identification of public opinion;

• Processing data using general purpose software.

Also, the following important factors of future social engineer-mathematics are added. There are:

❖ Ability to take into account in their specific features production of business relationships and personal responsibility for decisions;

❖ Skills to conduct and promote healthy lifestyles, encourage active style of behaviour and motivation of professional career, a positive attitude;

❖ Ability and skills to recognize different political, economic, cultural and social phenomena and events of components that contain positive and negative consequences through their analysis within the generally philosophical conceptions of society;

❖ Careful treatment of the environment, giving priority to management decisions that implement resource-saving technologies.

All the qualities were listed above, have been reflected in our model of professional competence in mathematical modelling of the future engineer-mathematicians, namely the theoretical and practical, design, value-motivational and communication components.

Thus, the formation evaluation of professional competence in mathematical modelling, creation of special model specialist training in engineering and mathematics area are very urgent and important tasks of higher technical school education.

Analysis of foreign and native psychological and educational literature indicates that there are many classifications of criterions for evaluating the quality and efficiency of education, learning outcomes. Preparing future engineers is topical issue of vocational education. Many scholars, such as O.G. Romanovskiy, O.S. Ponomarev, O.E. Kovalenko, L.B. Scherbatyuk, V.A. Petruk, O.A. Ignatyuk are researching the formation of various professional components models of future specialists in engineering area. In addition, great attention is paid to the development of professional competence of other professions like as teachers, economists, managers and another future professional (S.O. Sysoeva, L.G. Karpov, I.O. Zymnyaya, I.A. Abramov, and others). Interestingly, in our opinion, is the classification criteria, that was proposed Ogorodnikov I.T. The scientist divides all of criterions into two groups. There are criteria for quality learning information (systematic, strength, effectiveness of knowledge) in first group and criterions of independent and creative activity (the ability to analyze material, summarize, draw conclusions, the ability to apply knowledge and skills in the profession, independence of thinking curiosity) in other side [1, p.338].

Despite of the fact that a large number of studies in vocational education is dedicated to improving education quality, systematic model of professional competence of engineers and technicians, developing criteria for evaluating the quality of future engineers, the criteria of formation of professional competence in mathematical modelling is not sufficiently covered in the scientific literature educational research and are relevant to the professional training of future engineer-mathematicians to the profession.

Therefore, **in our article we tried to show** we have developed the basis criterions of the formation of professional competence in mathematical modelling of the future engineer-mathematician. Our criterions are based on developed model of professional competence in mathematical modelling.

The main material. The determination of levels of formation of professional competence in mathematical modelling of future engineers, mathematicians impossible without establishing specific evaluation criteria and evaluation indicators of formation of professional competence in mathematical modelling.

During the teaching experiment is necessary to constantly monitor the changes taking place and be able to correctly interpret and respond to them. Proper processing and analysis of information on the process of forming required properties allows adjust the follow-up teacher, on the formation of properties that are investigated. According V. I. Zahvyazynskiy, it's necessary to introduce a system of monitoring teaching experiment, based on certain structural elements (criterions) [2].

In indicators of formation the scientists understand like facts that allow revealing and evaluating the performance of each of the components investigated items and phenomenon. S. O. Sysoeva and T. E. Krystopchuk understand the concept of "criterions" as the signs on which to value a investigation object or phenomenon, which determine the real situation and the level of formation of the object [1, p.340].

The determination of levels of formation of professional competence in mathematical modelling of future engineer-mathematician has enabled us:

- to trace the dynamics of formation investigated object,
- to set the important missing and poorly developed components,
- to choose means and methods of influence on their positive trend.

To evaluate the formation characteristics of future engineers-mathematicians, we used the criterions that match the structure of professional competence in mathematical modelling, namely:

- theoretical and practical component – *the cognitive criteria;*
- projecting component – *the projective criteria;*
- communicative component – *the communicative criteria;*
- value-motivational component – *the value-motivation criteria.*

Our idea about overall structure of the classification of knowledge and skills for levels of formation of professional competence in mathematical modelling of future engineers-mathematicians seem to considerations V. I. Shekhovtsova, which conducts research in the field of projective culture in the formation of professionals in information technology. If we are speaking about the structure of professional competencies and classification level of formation of engineers or specialists in information technology, we could distinguish four major components: knowledge and understanding of the theory and technology, practical skills in their chosen field, the principles and rules of conduct future specialist in professional environment and motivation, attitude toward the world and yourself. V. I. Shekhovtsova calls this criterion like "value-reflective criterion" [3, p. 176].

Criteria for evaluation of formation of professional competence in mathematical modelling, we considered the degree of expression of each component. We set a five-point scale. In the forms for expert assessments allocated components of professional competence in mathematical modelling, which together characterize the level of its development of future engineers, mathematicians. Each component was determined on the basis of the manifestation of its elements quantified:

1. Element formed at the initial (poor) level;
2. Element formed on average (satisfactory, reproductive) level;
3. Element formed at a sufficient (productive) level;
4. Element formed at a high (creative) level.

Using four levels of formation of professional competence in mathematical modelling, we focus on the work V. P. Bezpalko, which identifies four levels of learning and skills of student in a subject. There are discipular, algorithmic, heuristic and creative levels. All these levels are formed in the process of solving professional tasks that are different levels of complexity.

In this task under the famous scientist understands the goal whose possible due to certain activities and in specific situations [4, p.55-57]. At the discipular level the problem has a clear purpose, situation and actions to address it. The student must answer the question of compliance with all three components in the structure of the problem. After that he has to perform the action, following the algorithm. At the algorithmic student knows the purpose and the external conditions of the common problem. The student will solve the problem yourself without a given algorithm, using previously learned steps to resolve it. At the heuristic level problem aims, but the situation is unclear (typical problem). The student performs a productive activity, searches on the basis of its expertise in solving professional problems getting new subjective information in independent work. At the highest level (creative level) the student knows only goal of task. The activity and the situation is unknown. At this level performs student makes research and inventive activity, creating new rules, receiving new information about the object of searching [4, P.56].

The set displays the relevant elements determines formedness of professional competence in mathematical modelling as an average of manifestations of relevant elements is due to

the fact that each of these components is an equal element of the overall structure of the formation of professional competence in mathematical modelling of future engineer-mathematics.

Offered criterions and associated indicators formed, which, in our opinion, can be assessed of professional competence of mathematical modelling of engineer-mathematics, presented in the table.

Criterions and indicators of formation evaluation of professional competence
Criterions and indicators of formation evaluation of professional competence of mathematical modelling of future engineers-mathematicians

Criterion	Indicator
1	2
Cognitive	• Evaluate the success (final results of comprehensive tests in the disciplines "Differential Equations", "Modelling the economic, environmental and social processes"; • estimates made by the laboratory and practical work; • the knowledge and skills to differentiate complex functions, the ability to find partial derivatives and differentials of complex functions; • availability of skills, skills and knowledge differentiation of complex functions, the ability to find partial derivatives and differentials of functions; • availability of skills, skills to use various methods of integration of functions; • ability and skills to solve differential equations of the first, second and higher order linear equations with variable and constant coefficients, equations Claire, using techniques such as: - construction of a differential equation to an equation with variables that are separated; - reduction of the differential equation; - euler's method; - bernoulli method; • Ability and skills to solve linear systems of differential equations with constant coefficients; • Ability and skills to solve land problems; • Ability and skills to find the stability region of dynamic systems; • Ability and skills to find the singular points of differential equations; • Ability and skill building phase plane system of differential equations; • Ability and skills to solve equations with partial derivatives of first and second orders • Possession of basic concepts and principles of mathematical modelling of complex dynamic systems; • Ability to obtain the transmission functions for the mathematical model. • Ability to solve problems of synthesis of (mathematical engineering) related to the formulation of differential equations modem dynamic systems
Projective	Possession of methods and techniques of construction, research and analysis of mathematical models for various problems of physics, mechanics, biology, economics, sociology, using the fundamental laws of nature, variation principles, the method of analogies; • use experimental and theoretical (analytical) approaches to the design of mathematical models of dynamic systems and its structural elements; • ability and skills to create mathematical models of dynamic systems with set specifications;

	• ability and skills to change the system settings for optimal performance of a dynamic system that is projected; • ability to perform selection of the parameters of the dynamic system in the absence of a single solution, that it was in the zone of stability; • skills of designing systems that are managed (work with automated systems management);
1	2
	• ability to draw block diagrams of dynamic systems, ranging from the functional circuit, which consists of the relevant elements of the system, taking into account external influences on the system and adjustable internal components (magnitude) dynamic system; • skills of designing feedback mathematical models of dynamic systems; • ability to use information technology and practical application of MATLAB (dynamic systems modelling Simulink) to create comfortable and visually-oriented visual analysis tools, identification, construction and simulation of dynamic systems; • skills of designing models of complex dynamic systems, which consist of separate blocks (components) by means of dynamic systems simulation package Simulink (MATLAB), using the methods and algorithms of computational mathematics
Communicative	• Ability to describe the main structural elements of the mathematical models of complex dynamic systems; • ability to present a mathematical model of the projected system, and support one's point of view; • ability to find, evaluate and, if necessary use other design professionals of the industry, making information search in the global Internet; • ability to work to develop a mathematical model in a team at any place, including as the head; • ability and skills to find a variety of methods for cooperation within the team, avoiding or resolving conflicts; • ability to transfer accumulated expertise to develop mathematical models of dynamic systems in the public interest
Value-motivation	• A motivation for professional work (designing mathematical models of various systems); • motivation for continuous self-development, self improvement, self-study and improve skills, increase professional competence in mathematical modelling; • motivation to work independently to improve the professional qualities of mathematical modelling; • availability of motivation and interest in achieving the goals the best way (motivation to succeed); • a tolerant attitude to other reasons for the development of mathematical models, an adequate perception of the comments and criticism; • ability to take responsibility for their developments and decisions taken during the simulation; • the priority of human values in achieving the goal of professional activities

On the basis of the material can make the following conclusions.

Based on our analysis of scientific literature on the quality of vocational and technical education requirements for engineers, educational qualifications and characteristics of the programs for professional specialty "engineer-mathematician" modern educational research, the requirements of society, was formed the model of professional competence on mathematical modeling and criteria its formation.

We have four main component formed, corresponding to a model of professional competence in mathematical modeling of future engineers-mathematicians. There are cognitive, projective, communicative and value-motivational criterions. Each criterion is a necessary component of assessment and equivalent quality of training future engineers and mathematics to the profession.

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АНАЛІЗ КРИТЕРІЇВ СФОРМОВАНОСТІ ПРОФЕСІЙНОЇ КОМПЕТЕНТНОСТІ З МАТЕМАТИЧНОГО МОДЕЛЮВАННЯ МАЙБУТНЬОГО ІНЖЕНЕРА-МАТЕМАТИКА

У статті проаналізовано критерії сформованості професійної компетентності з математичного моделювання майбутніх інженерів-математиків. Також розглянуто основні складники професійних якостей інженера-математика, які відповідають освітньо-кваліфікаційним характеристикам та освітньо-професійними програмам підготовки інженера-математика. У статті сформульовано основні показники, що характеризують кожен із зазначених критеріїв професійної компетентності з математичного моделювання майбутніх інженерів-математиків.

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АНАЛИЗ КРИТЕРИЕВ СФОРМИРОВАННОСТИ ПРОФЕССИОНАЛЬНОЙ КОМПЕТЕНТНОСТИ ПО МАТЕМАТИЧЕСКОМУ МОДЕЛИРОВАНИЮ БУДУЩЕГО ИНЖЕНЕРА-МАТЕМАТИКА

В статье проводится анализ критериев формирования профессиональной компетентности по математическому моделированию будущих инженеров-математиков. Также рассмотрены основные составляющие профессиональных качеств инженера-математика, которые соответствуют образовательно-квалификационным характеристикам и образовательно-профессиональным программам подготовки инженера-математика. В статье сформулированы основные показатели, характеризующие каждый из перечисленных

критериев профессиональной компетентности по математическому моделированию будущих инженеров-математиков.

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