TOWARDS A MULTI-LEVEL MODEL OF CONTINUOUS PROFESSIONAL AND TECHNICAL EDUCATION

RUMO A UM MODELO MULTINÍVEL DE EDUCAÇÃO PROFISSIONAL E TÉCNICA CONTÍNUA

HACIA UN MODELO MULTINIVEL DE EDUCACIÓN PROFESIONAL Y TÉCNICA CONTINUA

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ABSTRACT: The purpose of the study is to design a professionally directed scientific and methodological system. The design of the structure and content of fundamental academic subjects is carried out on the example of physics, which are basic in the training of engineers - electricians, power engineers, electromechanics and electronics. For the design of the training planning structure, the following research methods were chosen: professional orientation of training, when the system-forming core of training is the training direction, the future specialty; principle of integrative relationship of all educational academic subjects between defining and leading role of special academic subjects or block of special academic subjects. When designing a scientific and methodological system of professionally directed training in academic subjects, the main conceptual provisions of a system of general theoretical academic subjects are established, based on the designed model of professionally directed training in general theoretical academic subjects.

KEYWORDS: Fundamental academic subjects. General engineering subjects. Professional orientation. Methodological model.

***RESUMO**: O objetivo do estudo é desenhar um sistema científico e metodológico dirigido profissionalmente. O desenho da estrutura e do conteúdo das disciplinas acadêmicas fundamentais é realizado a partir do exemplo da física, que é fundamental na formação de engenheiros - eletricistas, engenheiros de potência, eletromecânica e eletrônica. Para o desenho da estrutura de planejamento da formação, foram escolhidos os seguintes métodos de pesquisa: orientação profissional da formação, quando o núcleo formador do sistema de formação é a direção da formação, a futura especialidade; princípio da relação integrativa de todas as disciplinas acadêmicas educacionais entre a definição e protagonismo de disciplinas acadêmicas especiais ou bloco de disciplinas acadêmicas especiais. Na concepção de um sistema científico e metodológico de formação profissionalmente direcionada em disciplinas*

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acadêmicas, estabelecem-se as principais disposições conceptuais de um sistema de disciplinas teóricas gerais, com base no modelo desenhado de formação profissionalmente direcionado em disciplinas teóricas acadêmicas gerais.

***PALAVRAS-CHAVE**: Disciplinas acadêmicas fundamentais. Disciplinas gerais de engenharia. Orientação profissional. Modelo metodológico.*

***RESUMEN**: El propósito del estudio es diseñar un sistema científico y metodológico dirigido a profesionales. El diseño de la estructura y el contenido de las asignaturas académicas fundamentales se realiza a partir del ejemplo de la física, que son básicos en la formación de ingenieros: electricistas, ingenieros de potencia, electromecánica y electrónica. Para el diseño de la estructura de planificación de la formación, se eligieron los siguientes métodos de investigación: orientación profesional de la formación, cuando el núcleo formador del sistema de formación es la dirección de la formación, la futura especialidad; Principio de relación integradora de todas las asignaturas académicas educativas entre la definición y protagonismo de las asignaturas académicas especiales o bloque de asignaturas académicas especiales. Al diseñar un sistema científico y metodológico de formación profesionalmente dirigido en materias académicas, se establecen las principales disposiciones conceptuales de un sistema de materias académicas teóricas generales, basado en el modelo diseñado de formación profesionalmente dirigida en materias académicas teóricas generales.*

***PALABRAS CLAVE**: Asignaturas académicas fundamentales. Asignaturas generales de ingeniería. Orientación profesional. Modelo metodológico.*

Introduction

The problem of the formation of high-level professional competencies among future specialists in technical areas of training largely depends on the depth and quality of mastering general theoretical disciplines that form the worldview and, at the same time, have a technical direction of content (for example, physics), which form a system of knowledge in this discipline, which is the basis for further general engineering and professional training of students at a technical university. In the scientific works of the authors G. M. Sultanalieva, A. V. Kosharnaya, V. V. Pak, S. E. Mansurova, I. G. Galeev, A. S. Shakirov, S. A. Kholina, and many others, it is noted that improving the quality of training of technical specialists, including in the direction of "Power and Electrical Engineering", is inextricably linked with a change in the structure of the construction, methodology and technology of teaching physics, eliminate elements of duplication of material, increase the motivation of learning by introducing problem solving and the implementation of professional projects corresponding to the profile of training, solve the important problem of increasing the level and quality for the formation of professional competencies of a specialist. A high level of quality of professional training in the direction of

"Electricity and Electrical Engineering", begins with the design of the structure and content of the fundamental discipline physics, which is the basis for the training of masters (engineers) in this direction, considering the focus - a profile for the spheres of production, transmission and consumption electrical energy. The system of physical knowledge formed in the process of training, focused on a professional orientation, is a system-forming vector that determines the quality and level of professional competencies acquired by trainees. A low level of professional training, as a rule, is associated with a low level of fundamental education, including in the system-forming discipline, which is physics. Mastering theoretical professional knowledge, skills and practical knowledge in the absence of an understanding of the depth and logic of the relationship of physical phenomena and processes occurring in electrical and electrical power machines, apparatus and devices, does not allow to train a high-level, especially world-class specialist. Bachelor, master (engineer) with poor fundamental training is not able to solve professional problems and tasks (SULTANALIEVA; KOSHARNAYA, 2020; PAK, 2016; MANSUROVA, 2019; GALEEV; SHAKIROV, 2016; TRYNKINA; MOKROVITSKAYA, 2017).

When mastering fundamental disciplines, students develop a systematic approach to the process of designing and creating various technical devices, installations and technologies in senior courses, which consists in a deep understanding of the fact that the functioning of these technical systems and objects, efficiency, optimality, reliability and durability of their work based on objective physical laws, principles for various spheres of life. Consequently, in the structure of the physical system of knowledge, it is necessary to orient the content (explanation of laws, regularities, principles and methods using examples of the professional sphere of activity) towards a professional orientation, which allows, along with the explanation of natural phenomena, to reveal the pictures of physical processes that take place in technical systems and devices (GALEEV; SHAKIROV, 2016; DVOYASHKIN *et al.*, 2018; LARIONOV *et al.*, 2014).

Methodology

To solve the problem associated with the orientation of general theoretical training to the vector of professional training, a close interdisciplinary connection of the physics course with the backbone disciplines and modules of the general engineering and special block is proposed. In the training of specialists in the field of electromechanics, the backbone disciplines of the blocks are the theoretical foundations of electrical engineering and electrical machines.

The choice of these disciplines and modules as backbone, allows you to determine the boundaries of the content of physical knowledge that are necessary for the formation of professional competencies and that can be designed with a significant filling with tasks and examples of technical content in the direction and profile of training. The methodological basis for constructing a system of physical knowledge is the principles of interdisciplinary relations (MPS) and continuity of disciplines (PD) at all levels (stages) of the system of continuous multilevel vocational education (KALACHEV *et al.*, 2016; POSTNIKOVA *et al.*, 2016; VELIKOVICH, 2014; BELYAEVA, 1987; VISHNEVSKY; ARTYUSHKINA, 1981; NECHAEV, 1988). The peculiarity of the implementation of these principles lies in the orientation of the design of the content of the disciplines of general theoretical and general engineering blocks on the system-forming vector of a professional orientation, set by a special discipline or a group of special disciplines of the direction and profile of training. The system of physical knowledge, built on the basis of the principles of MPS, PD with an orientation to the system-forming vector of a professional orientation, makes it possible to realize the main functions of the educational process: educational, upbringing, developing, methodological, constructive, formative and others.

The educational function in the new system of physical knowledge makes it possible to significantly increase the breadth, depth and informational level of possessions, knowledge and skills by increasing motivation and activating students.

The educational function associated with the formation of moral, ideological, patriotic and other qualities of the student is based on the natural and necessary penetration into the educational process of elements of scientific, professional, industrial activity.

The developmental function, together with mastering the foundations of a creative approach to studying the content of disciplines, using technologies for independent solution of practical problems, allows students to reach an engineering level in solving educational problems of varying technical complexity.

The system of physical knowledge, built in accordance with the philosophical principle of consistency, determines the methodological function of the educational process, in which subsystems for one discipline, module of a section play the role of constructive functions (PAK, 2016; GALEEV; SHAKIROV, 2016; TRYNKINA; MOKROVITSKAYA, 2017; DVOYASHKIN *et al.*, 2018; KHOLINA, 2019; ABDEEV, 1994; BELYAEVA, 1987; KORNEV *et al.*, 1999).

Each level (stage of training) has its own system of physical knowledge based on the same principles of MPS and PD.

The analysis of the theoretical and practical content of the discipline of physics in the context of the logical connection of the system of physical knowledge with the backbone general engineering and special disciplines within the system of continuous multilevel vocational education for the direction "Electric power and electrical engineering" showed that some branches of physics, for example, "Electrodynamics" are the basis for the formation of both electrical engineering knowledge in the general engineering discipline "Theoretical Foundations of Electrical Engineering" (TOE), and constitute the basis of professional knowledge of backbone special (profile) disciplines. The main content of the TOE discipline, which consists in studying the methods, principles and technologies for calculating the electric, magnetic fields of direct and alternating current, as well as the theory of the electromagnetic field and electromagnetic waves described by Maxwell's equations, is completely based and determined by the physics section "Electrodynamics". The system of electrical knowledge, formed sequentially by the disciplines of physics and TOE, is the basis for building a system for the formation of professional competencies in the development of special disciplines. The revealed logical relationship is the basis for the development of interdisciplinary structural modules that integrate laws, patterns, principles, technologies for calculating and researching practical professional tasks mastered in systemic general theoretical, general engineering and special (profile) disciplines at various levels of learning. The development and implementation in the educational process with the subsequent assessment of the effectiveness in the formation of professional competencies of intersubject modules of backbone disciplines is the purpose of this scientific methodological research. The statement that the system of physical knowledge is considered not only as the basis for the formation of electrical knowledge, skills and possessions, but also represents the basis on which the study of the block of system-forming special (profile) disciplines of various levels is built, as well as the long-term theoretical and practical research allow us to state that the development of interdisciplinary modules of backbone general theoretical, general engineering and special (profile) disciplines plays the role of increasing the significance and importance of the physical knowledge system in improving the level and quality of professional training at all levels of the system of continuing professional education (SULTANALIEVA; KOSHARNAYA, 2020; MANSUROVA, 2019; GALEEV; SHAKIROV, 2016; DVOYASHKIN *et al.*, 2018; BAKHAREV; LAVRENINA, 1999; IBATOVA, 2020).

In the development and construction of a system of physical knowledge, intersubject modules of backbone disciplines, theoretical and experimental modeling of the pedagogical process, the principles of continuity of - Carrying out the educational process of training

specialists in the field of "Electricity and electrical engineering" of various profiles for all levels of professional education.

Results

The conducted research on the profile of "electromechanics" identified a block of backbone special disciplines, among which "Electric machines" formed the basis of this block. The content of this discipline is saturated with information, theory, practical research on various physical aspects of the use of magnetic and electric fields of direct and alternating current, a description of many design solutions and designs of devices that provide electromechanical conversion of energy, the creation of magnetic fields of various shapes and purposes (rotating, pulsating, pulse), generation of various voltage systems (direct, alternating, pulsed current) with an arbitrary number of phases. The next step in the research is the establishment of interdisciplinary structural modules and their logical connection in the chain of general theoretical - general engineering - special (profile) discipline. Such a chain in the "Electromechanics" profile is the following disciplines: physics, TOE, electrical machines, and the backbone section in the physics discipline is "Electrodynamics", on the basis of which the system of physical, electrical and professional knowledge is formed. The main argument for the presence of a close logical relationship of inter-object structural modules is the operation of the same physical concepts: electric charge, current strength and density, voltage, electric and magnetic field strength, magnetic induction and flux, self-induction and mutual induction, inductance, capacity, active, inductive, capacitive resistance and many others. The explanation of the principle of operation, the idea of constructing the design of electrical machines is possible using the physical laws of the section of electrodynamics and methods for calculating TOE: the laws of Lenz, Ohm, Faraday, total current; Kirchhoff principles; Maxwell's equations; Gauss's theorem and much more.

Accurate or approximate analysis, study of electromagnetic, electromechanical processes occurring in electric machines is impossible without building pictures of the magnetic field in the space of air gaps and magnetic systems of windings covered by conductors, through which direct and alternating electric current flows. The graphic image of the pictures of the magnetic, electric field allows you to determine the magnitude and direction of action on various devices and elements of electrical machines of the emerging electromagnetic forces. Determination of the values and directions of electromagnetic forces is based on the knowledge of the laws of electrodynamics, studied in the discipline of physics (laws: full current, Bio-

Savart-Laplace, Ohm, Kirchhoff; the principle of superposition, Gauss's theorem and much more). Electrodynamics forms a deep understanding of the main characteristics and parameters of the magnetic field: the magnitude and direction of the magnetic induction vector B, the magnetic field strength H, the magnitude of the magnetic flux, flux linkage. The magnitude and direction of the electromagnetic force generated in the machine is determined in accordance with the picture of the magnetic field according to Maxwell's equations or according to Ampere's law, guided by the practical rules of "left and right hand".

With a careful consideration of the logical chain of communication of electrodynamics, the section of the general theoretical discipline physics with TOE (general engineering discipline) and electrical machines (special discipline), the following conclusion can be formulated:

1. The system of physical knowledge is based on interdisciplinary connections of system-forming general theoretical engineering and special disciplines for each level of training in accordance with the direction and profile.

2. The content of the electrodynamics section of the general theoretical course of physics should be completed with theoretical and practical modules corresponding to the profile and level of training.

3. The system of physical knowledge is the basis, the basis for the formation of electrical and specialized training of a specialist in a specific direction and level.

We will develop a model of a physical knowledge system that provides a scientific study of the problem of the formation of high-level professional competencies based on the study of system-forming general theoretical disciplines that have a professional vector, using the example of the discipline "Physics" for the direction of training "Electric power and electrical engineering". The theoretical and practical basis of the process of obtaining a model is made up of proposals and thoughts of scientific research in the fields of philosophy, psychology, professional pedagogy, methodology and methodology of the theory of continuous multilevel professional education (BAKHAREV; LAVRENINA, 1999; BELYAEVA, 1987; KUSTOV *et al.*, 1999; VISHNEVSKY; ARTYUSHKINA, 1981; DAVYDOV, 1972; NECHAEV, 1988; IBATOVA, 2020).

The model of the physical knowledge system with the vector of professionally directed learning consists of the following set of interrelated subsystems:

- a block of goals and objectives that determine the process of forming a system of physical knowledge, skills and possessions that have a vector of professional orientation, which in turn is determined by the direction, profile and level of professional training;

- content architecture, which has a system of logical and interdisciplinary connections, built on the principle of continuity for each level of professional training;

- a set of teaching aids and educational technologies;

- organization and methods of ensuring the educational process;

- forms and methods of the learning process and the formation of competencies;

- a variety of forms, methods and ways of monitoring the process and the level of competence formation;

- systems for assessing, analyzing the results and results of achieving the set goals and objectives.

The design of a model of a system of physical knowledge with a vector of professionally oriented teaching in physics was carried out in accordance with the following conceptual provisions:

- the content of the physics section "Electrodynamics" corresponds to the vector of professional orientation to the level of specialist training;

- the structure of horizontal and vertical interdisciplinary connections of general theoretical and general professional disciplines - the basis for the formation of professional competencies of a given profile and level of training;

- the basis for the content and logic of constructing the process of sequential formation of competencies is the principles of didactics, structural and logical schemes, generalizations and systematization;

- the basis of the model of the system of physical knowledge is made up of laws, principles, theories of the concept of a picture of the world;

- creativity in solving practical problems with a wide range of information content, connection with modern production, the products of which meet world-class requirements - the basis for the formation of professional knowledge, skills and possessions at all levels of training;

- regular monitoring of the level of competence formation and diagnostics of the quality of mastering the system of physical knowledge - a necessary condition of the educational process.

Conceptual provisions determine the structure of subsystems of the pedagogical process of the formation of physical knowledge, including goals, objectives, content, methodological and organizational forms of conducting classes, pedagogical technologies, a monitoring system, and more. The content is determined by the requirements of educational and professional standards, the vector of the professional orientation of training, modern technical information

material, which is reflected in the work programs of the discipline for various levels of training. The discipline of physics in the process of mastering should be scientific, ideological in nature, have the maximum possible approximation to modern discoveries, theories of the structure of matter and the universe, which implies its continuous renewal. The discipline contains theoretical and experimental methods of scientific research, since the formation of a system of physical knowledge is inextricably linked with the idea of mandatory confirmation of ideas, conclusions of scientific theory by practical, scientific experimental research. Such an approach to teaching allows students to form a special technical form of thinking (theoretical and practical thinking) necessary for a bachelor's degree, master's degree (engineer) in the technical direction of training.

The model of the physical knowledge system is built in accordance with the principle of consistency and systemicity, which presupposes the logical and visual construction of all subsystems, the construction of content with the establishment of logical interrelationships of concepts, definitions, laws, principles and their mutual conditioning (from simple to complex and more complex). The principle of visibility is important in the process of forming a system of physical knowledge. Various types of physical experiment: laboratory, computer (imitation, mathematical) presuppose scientific character, clarity, connection with professional activity. Modern computer technologies make it possible to create interactive computer programs and teaching aids, with the help of which it is possible to carry out various types of scientific experiments, both in the classroom and independently. The active and independent learning of the modern student is of great importance today. The formation of a system of physical knowledge necessarily presupposes active independent work of trainees and active joint work of a student and a teacher. The role of a teacher in a modern technical university is that such teaching methods as information-receptive (explanatory-illustrative), reproductive, problem presentation method, research, heuristic (partial search) are practically impossible without the active presence of a teacher - scientist. Any digital technology of these methods can only simulate the sequence of presentation of the material, depriving it of spirituality and emotionality, which is important for the process of mastering and understanding the essence. Applying the method of scientific research in the process of studying the discipline, the teacher formulates the research problem, builds a trajectory and formulates the conditions for solving this problem. So, any educational question turns into a solution to an interesting scientific problem or technical problem, which leads to the activation of the student's mental activity, which manifests itself in an increase in the motivation for studying a discipline and in an increase in the student's desire to independently solve a problem or task.

In a technical university, the heuristic method has a particularly important role in teaching. Many problematic technical problems in various disciplines at different levels of education are successfully solved on the basis of the methodology of creativity, the development of which makes it possible to form the competence of the trainees necessary for a modern specialist (bachelor, master, engineer) of a high (world) level.

A special place in the model of the system of physical knowledge is occupied by the structural-logical scheme, which integrates the content-temporal sequence of all subsystems of the educational process on the basis of cause-effect relationships and the rules of formal logic. The formed visual picture of structural and logical connections allows students to imagine the process of mastering as a holistic one, which provides a systemic understanding and deep assimilation of physical knowledge.

The backbone of the scientific and methodological system of physical knowledge is the joint activity of the teacher and the trainees, carried out in accordance with didactic and psychological and pedagogical conditions, which ensure the focus of students' attention on the educational topic, problem, task and form the cognitive, professional nature of the motivation for mastering. In this case, it can be argued that the depth and quality of the studied content of the subject increase. Considering the psychophysiological peculiarity of the student, which is that the visual channel of perception greatly exceeds the auditory channel, the teacher pays attention to the illustration of the educational material, using audio and video technologies of computer presentations. A modern high-level teacher knows the art of oratory and acting, which, together with the methods of generalizing and systematizing the knowledge being mastered, allows them to successfully form professional competencies in students in the process of transferring educational information.

Considering the peculiarities of the modern educational process, which consists in increasing distance and remote forms of education, it is necessary to increase attention to the formation of educational content, designing their content, taking into account didactic principles and the need for them to contain not only elements of theory, but also elements of independent practical activity, physical and model scientific experiment. In vocational training, it is important to teach students to be creative in solving technical problems, which is possible if the content includes many problem situations when studying educational topics. In this case, students become more motivated and conscious of independent learning.

The final stage in the creation of a scientific and methodological system of physical knowledge is the design of a monitoring system for the formation of professional competencies, followed by an analysis of the results and the introduction of various types of corrections into

the educational process. The designed content on the discipline should be a constantly developing and improving system.

The model of the scientific and methodological system of physical knowledge is created based on the following psychological and pedagogical conditions:

- the content of the discipline and the organization of the educational process is based on didactic principles;

- conceptual provisions of the scientific and methodological system of physical knowledge include professional orientation and pedagogical system of the learning process;

- in the subsystem "Professional orientation" integrated intersubject communications and the structural-logical system of the educational process are designed;

- the pedagogical system determines the goals, content, methods, means, organization of the educational process, didactic principles of the formation of professional competencies, the subsystem of interaction "Teacher - student" and the subsystem for monitoring the formation process, assessment of the level, quality of professional competencies;

- the inclusion in the content of the content of the discipline the development of a subsystem for the independent formation of professional competencies by trainees on the basis of solving a set of technical problems and problems using methods of creativity and heuristics;

- continuity of monitoring to determine the level and quality of the formation of professional competencies.

Conclusion

1. As a result of theoretical and experimental studies of the training of bachelors and masters of the direction "Power supply and electrical engineering" of various training profiles, it has been established that the successful formation of a system of knowledge in a general theoretical discipline (for example, physics) in conditions of continuous multilevel professional education requires the construction of a model scientifically-methodical system of professionally directed discipline teaching.

2. Various subsystems of the model have been established and developed, including the basic conceptual provisions of the scientific and methodological system of the general theoretical discipline (for example, physics).

3. The model of the scientific and methodological system of professionally oriented teaching in general theoretical disciplines (by the example of physics) makes it possible to

facilitate the formation process and improve the quality and level of professional competencies of students of a technical university.

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