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PREPARING STUDENTS FOR INNOVATION IN THE LEARNING PROCESS

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Abstract
The article substantiates the relevance of preparing students for innovative engineering activities through the teaching of an integrated course. It clarifies the concept of innovative engineering activity as a purposeful process that includes the analysis of the current technological level, the synthesis of new technical solutions, the development and creation of new equipment and technologies brought to the level of marketable products. These products are represented by both intangible innovative outcomes-such as intellectual property protection documents, scientific-technical and technological documentation-and tangible ones in the form of goods, works, or services that generate economic, social, or other types of impact, thereby ensuring their competitiveness.
A model of a methodological system for preparing students of technical universities for innovative engineering activity within the learning process is developed. This model encompasses objectives, content, methods, forms, and tools of instruction, taking into account interdisciplinary integration and a competency-based approach.

Keywords: Innovation, integration, competence, intellectual activity, innovators (pioneers), innovators (implementers of innovations), infrastructure, motivation.

Introduction

Enhancing the competitiveness of goods and services, which constitutes a key component of the innovation system (IS) for economic development, is impossible without the modernization of the country’s technological infrastructure and the advancement of innovation activity (IA). IA encompasses a standardized set of

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activities of an innovative nature, including fundamental and exploratory research, applied scientific investigations, experimental design, and technological development. It also includes the implementation, production, and commercialization of new or improved technologies, goods, and services developed through the application of scientific and technological outcomes.

Innovation activity presupposes the incorporation of scientific and technological achievements-i.e., results of intellectual activity (RIA)-into the economic (civil-law) circulation. Accordingly, the education of students at technical universities must contribute to the development of competences that ensure their readiness for innovative engineering activity (IEA).

METHODS

Fostering legal awareness among the younger generation will elevate the innovation processes to a higher level. The application of fundamental, applied, methodological, and legal knowledge in deriving technical solutions and managing exclusive rights to RIA is a crucial aspect of preparing modern engineering specialists for IA.

Preparing students in technical universities for IA-through their education in engineering creativity and patent studies, utilizing innovative methods implemented within the framework of supplementary educational content-may serve as a creative approach to developing student competencies in the field of innovation activity.

For the purpose of this study, the innovation system is defined as the aggregate of subjects and objects engaged in innovation activity, interacting throughout the process of creation...

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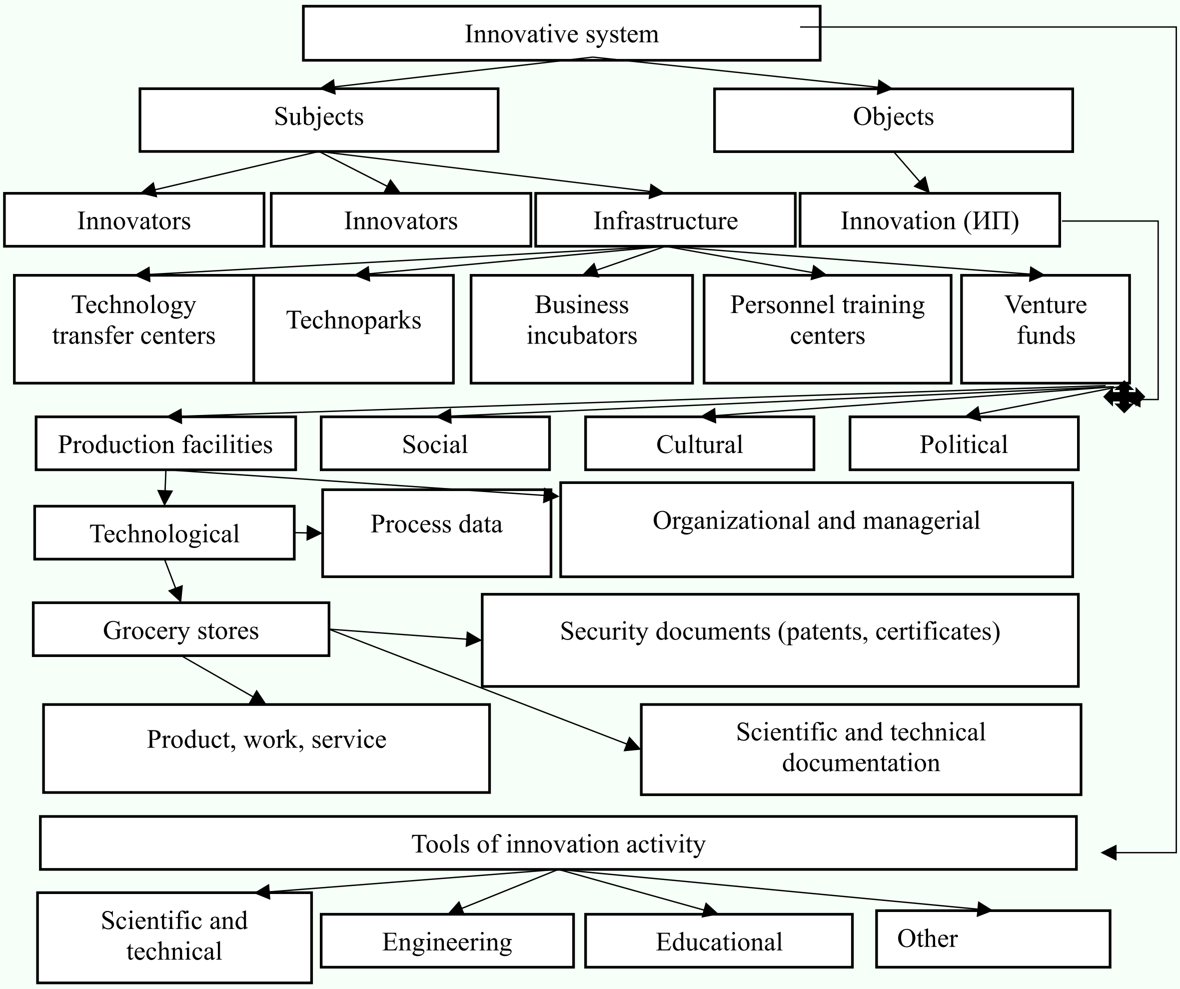

Fig. 1. The structure of the innovation system

The key subjects of the innovation system (IS) include innovators, implementers of innovation (innovators), and the supporting infrastructure. The infrastructure comprises innovation and technology centers, technology transfer centers, technoparks, business incubators, training centers for innovation activity (IA) personnel, venture capital funds, and other related institutions [1-4].

The objects of the innovation system (IS) are innovations, or innovative products (IPs). Innovative products are understood to be new, improved, or existing goods, works, and services produced through the application of novelties or required for their implementation, as well as exclusive rights to the results of intellectual activity (RIA) created within the framework of an innovation project and commercialized on the market. Various classifications of innovations are known;

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in this context, a generalized classification will be applied (see Fig. 1).

The principal tool of the IS is innovation activity (IA), which represents a full cycle of operations-from the creation of a promising innovative product, its development into an innovation (including securing exclusive rights and organizing industrial production), to its commercialization. The stages of IA include[5-6]:

1. scientific research and development; 2. personnel training; 3. production launch; 4. marketing of new products; 5. sale or acquisition of intangible technologies (patents, licenses); 6. sale of tangible innovative products; 7. preparation and organization of production.

An analysis of regulatory, legislative, and scientific-technical literature reveals that its foundation lies in the results of intellectual activity (RIA), which are intended for legal application in the practical life of individuals and enterprises. In other words, scientific and scientific-technical outputs-produced through the creative activity of individuals and legal entities-and the exclusive rights associated with them constitute an independent category of innovative products (IP). Thus, the core of an innovation-driven economy is information that has been granted legal protection in the form of exclusive rights to RIA and embodied in a demanded, novel product.

RESULTS

Innovative engineering activity (IEA) is defined as a purposeful process involving the analysis of the current technological state, the synthesis of new technical solutions, and the development and creation of new equipment and technologies that are brought to the level of commercial products. These products include intangible Ips-such as intellectual property protection documents, scientific-technical, and technological documentation-and tangible outputs in the form of goods, services, or works that deliver economic, social, or other beneficial outcomes, thereby ensuring their competitiveness.

The process of preparing for IEA is understood as the intentional development of specific knowledge, skills, abilities, and distinctive competencies, as well as methodological and legal culture in the fields of engineering creativity and intellectual property. This preparation defines the competence of a specialist in IEA and is realized through the use of new technologies and teaching formats, innovative education programs with an innovation-oriented focus, and modern

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information and mass communication tools[8-9].

An understanding of the significance and essential characteristics of the innovation system (IS), as outlined above, has made it possible to identify the key components of a specialist's competence in innovative engineering activity (IEA). Competence is defined as a set of interrelated personal qualities-knowledge, skills, abilities, and aptitudes-associated with a specific range of subjects and processes, which are necessary for effective and high-quality professional performance in relation to those subjects and processes.

Competency, in turn, refers to the possession and practical mastery of the relevant competences by an individual, including their personal attitude toward both the competence itself and the object of their professional activity.

In addressing the task of preparing university students for innovation activity (IA) within the framework of the general engineering discipline "Engineering Creativity and Patent Science" (ECPS), we define competency in IEA as a combination of the following components:

- **Cognitive Component**:
  - General cultural competences (GCC) – mastery of fundamental knowledge in economics, ethics, and environmental science;
  - Professional competences (PC) – proficiency in general engineering, interdisciplinary, legal, and specialized knowledge.

- **Activity-Based Component**:
  - GCC – ability to make decisions, work in teams, search for and apply information, and use normative and legislative documents;
  - PC – ability to identify problems, perform analysis, formulate tasks, synthesize solutions, engage in design and invention, manage results of intellectual activity (RIA), present outcomes, and adapt and represent technical systems. This also includes skills in applying creative tools, such as methods for solving inventive problems and conducting patent research

- **Motivational Component**:
  - Reflecting both societal and individual needs.

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- **Psychological Component**:
  - Development of personal abilities and creative potential.

In order to assess the practical implementation of competence formation in innovative engineering activity (IEA) among university students, we conducted a diagnostic (ascertaining) study. As part of this research, a survey was administered to participants of the Republican Student Olympiads in the field of "Geoengineering," held over a period of 10 years at the Agrarian University. The primary tool for data collection was a questionnaire consisting of 17 questions, which allowed over 500 respondents from three universities in the Republic of Uzbekistan to evaluate their readiness to perceive and apply innovations[7-8].

The results of the survey revealed that courses covering topics related to engineering creativity and patent studies are offered in only two out of the three universities under consideration. At the same time, a significant majority of respondents (81%) indicated the necessity of including such disciplines in the educational curriculum, aimed at developing competence in IEA. This reflects a growing awareness among modern students regarding the importance of acquiring knowledge, skills, and abilities in engineering creativity and applying them in practice. Thus, the results of the diagnostic phase of the pedagogical experiment confirmed the assumption regarding the low level of student preparedness for innovative engineering activity (IEA) within the framework of traditional technical university education. This is particularly significant given that IEA constitutes a core procedural component of the innovation system (IS), thereby providing a compelling rationale for the development of integrated disciplines such as "Engineering Creativity and Patent Science" (ECPS), aimed at fostering competence in IEA.

Based on an analysis of the algorithm for obtaining intellectual property (IP), an integrated ECPS course was designed with a focus on developing students' competencies in IEA. This course includes modules such as the fundamentals of engineering creativity, basics of patent science, and foundations of patent research.

The first module integrates the theory of heuristic methods and the Theory of Inventive Problem Solving (TRIZ), serving as the foundation for training in technical creativity and the development of IEA competence. It also provides a

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reliable framework for solving creative technical problems at a high (competitive) level and is an effective tool for cultivating students' creative thinking. This area of innovative activity (IA) is a crucial domain that possesses technological, legal, economic, symbolic, and culture-forming functions.

Furthermore, knowledge of the global system of legal protection for the results of intellectual activity (RIA), including updates and opportunities within it, has become essential. Patent research is an indispensable component of IEA, as it enables the strategic use of patent information-both legal and technical-for the creation of competitive products, ensuring free market entry, and reducing legal and economic risks associated with intellectual property protection.

All these modules serve as vital tools for the efficient management of the processes of development, production, and commercialization of innovative products (IPs), contributing to enhanced competitiveness-in other words, the full cycle of IEA.

Thus, the ECPS discipline encapsulates the entire IEA cycle within a single academic course: problem formulation → generation of technical solutions → validation of competitiveness → acquisition of exclusive rights for RIA (i.e., obtaining a patent-the highest form of IP). This course provides an integrated view of the processes of design, development, and creation of innovative products, thereby forming the students' competence in IEA and supporting their preparation for innovation activity. A pedagogical model for preparing students for IEA is presented in Figure 2.

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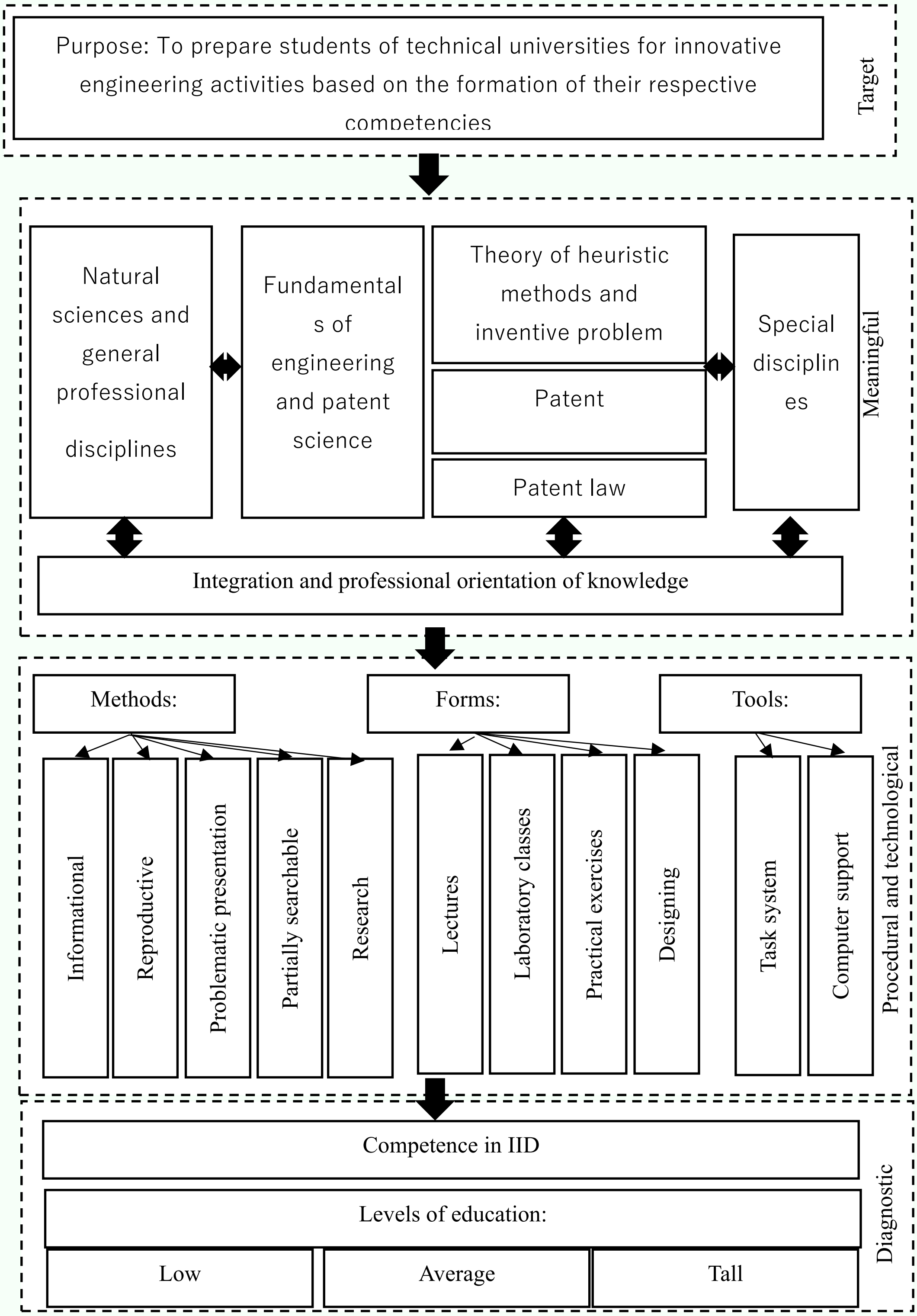

Fig. 2. Pedagogical Model for Preparing Students for Innovative Engineering Activity (IEA)

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The model consists of motivational-target, content, process-technological, and diagnostic components.

The motivational-target component of the model includes a hierarchy of objectives, the primary of which is to ensure high efficiency in preparing specialists for IEA by developing their competencies in IEA. The specific objectives are as follows:

- To foster students' motivation for consciously striving to develop their abilities and pursue innovation activity (IA);
- To cultivate a creative personality in students, capable of solving non-standard problems;
- To teach students modern methods for solving scientific and technical problems;
- To prepare students for making optimal choices in the strategy and tactics of finding non-standard solutions to scientific and production challenges;
- To instill in students the ability to recognize and adapt to emerging challenges and opportunities.
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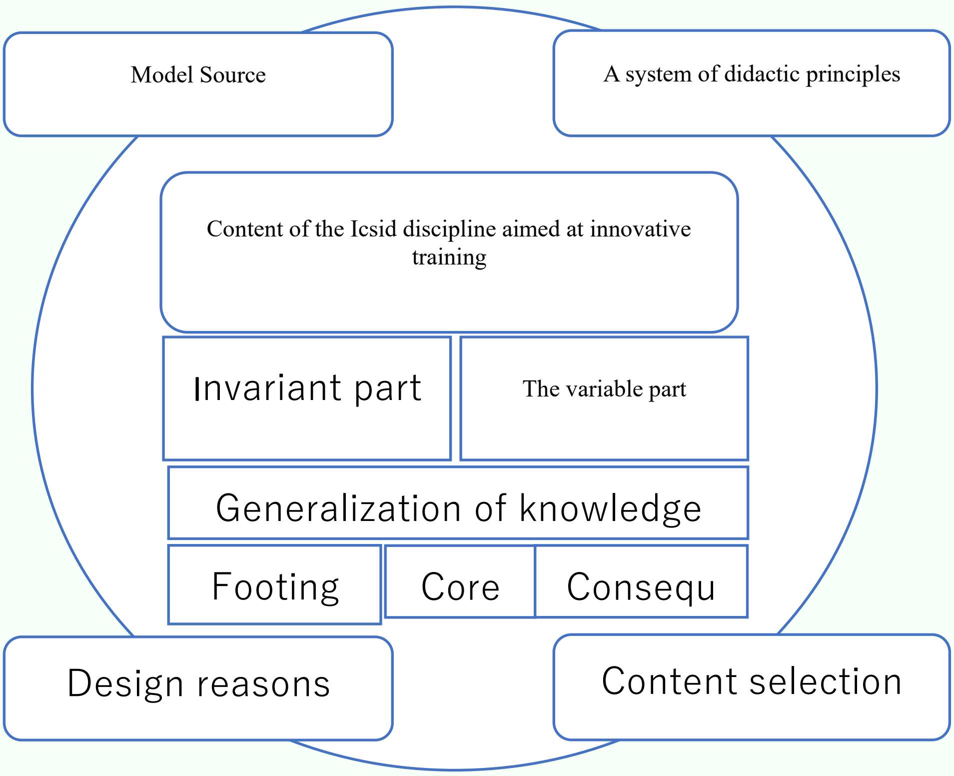

Fig.3 Designing the ICU content

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The motivational-target component of the model includes a hierarchy of objectives, the main one being to ensure the high efficiency of preparing specialists for innovative engineering activity (IEA) by developing their competencies in IEA. Specific objectives include:

- Developing students' motivation for consciously striving to enhance their abilities and engage in innovation activities (IA);
- Cultivating a creative personality capable of solving non-standard problems;
- Teaching students modern methods for solving scientific and technical problems;
- Preparing students to make optimal decisions in the strategy and tactics of finding non-standard solutions to scientific and industrial problems;
- Instilling skills and a culture of creative engineering work;
- Providing students with a general understanding of the intellectual property (IP) legal protection system;
- Teaching students the knowledge and skills related to the protection, defense, and use of IP rights and associated means of identification;
- Developing students' skills in conducting patent research and applying it in the management of IEA.

The content component (Fig. 3) is based on fundamental laws, concepts, and scientific and technical theories taught in natural science, general professional, and specialized disciplines, professionally oriented towards solving problems in engineering fields. It consists of the laws of technological development, methods of engineering creativity, and techniques for its intensification. It also includes legislative and normative documents regarding the exclusive rights to intellectual property (IP), methods of conducting patent research, norms and rules for preparing and filing application materials for issuing protective documents for IP, and means of identification. This component is grounded in general didactic and subject-specific didactic principles, as well as corresponding criteria for selecting teaching materials[9-10].

The educational goals and content of the course on Engineering Creativity and Patents (ECP) for technical universities are implemented within the procedural-technological component of the model. This component includes methods, forms, and tools of instruction. The principle of integrating fundamental, professionally oriented, project-based, and inventive knowledge and skills is realized through teaching methods. The methods applied in the educational process contribute to the

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formation of the necessary competency components in students, ensuring their success in future innovative engineering activities (IEA).

Reproductive methods (informational, illustrative) are used to introduce the initial stage of the ECP course. During problem-based presentation, the instructor formulates the problem in the form of a quasi-professional task, the solution to which requires the students' creative abilities. If the instructor solves the task, it is done with active student participation, but more often, the instructor creates conditions for the students to solve the problem independently. With the partially-exploratory method, students independently explore parts of the educational material and solve the given problem using the methods and algorithms they choose for inventive problem-solving. The main distinction of the research method lies in the independence of solving the tasks presented to the students (business games, inventive and rationalization activities, etc.).

Alongside traditional forms of teaching (lectures, design work, laboratory practices, practical sessions, etc.), innovative teaching forms (team-based learning, learning through scientific and technical research, personal experience, business game "Firm," etc.) are used to prepare students for IEA.

The result-diagnostic component of the methodological system model assumes regular monitoring and diagnostics of the level of competency formation in students, determining their readiness for Innovative Engineering Activity (IEA). This component is implemented through a system of information and computer support for the course (developed, created, or used electronic teaching aids, software products), multi-level assignments, a system of tests, questionnaires, and presentations that assess the formation of motivational, content-related, and procedural components of IEA.

Thus, as a result of the conducted research, a methodological system for preparing university students for IEA has been developed, along with its model, within the framework of teaching creativity and patent studies.

The theoretical justification of the model of the methodological system for preparing university students for IEA within the framework of teaching Engineering Creativity and Patents (ECP) and the development of its specific content enabled the construction of the methodological system for preparing students for IEA. A specific methodological system has been presented, along with its implementation within the aforementioned components. An expert system has been developed and implemented for diagnosing the results of students' learning in this discipline, including tests, questionnaires, discussions, interviews, and presentations[11-12]. The content of the discipline is implemented in all forms of educational activities. The professionally-oriented content of the discipline is defined based on an interdisciplinary approach.

Method of Forming the Work Program:

1. **Based on Natural Science Theories:** The method is based on the knowledge of natural science theories, which serve as the foundation for the analysis, synthesis, and design of technical systems with optimal operational characteristics. It also relies on the fundamental principles of general engineering disciplines and their application to professionally-oriented problems.
2. **Incorporation of Engineering Creativity and Patent Information:** It includes information from the field of engineering creativity, patent information, and patent research, as well as the management of intellectual property rights (IPR).
3. **Consideration of Fundamental and Applied Topics in General Engineering Disciplines:** It takes into account the realization of fundamental and applied topics in general engineering disciplines in the form of algorithms, design calculations, models, and projects, which are integrated into various components of a unified methodological system.

The entire educational material for the discipline is divided into completed blocks (e.g., "Fundamentals of Engineering Creativity," "Fundamentals of Patents," "Fundamentals of Patent Research"), modules, and submodules (for example, the "Patent Law" module includes submodules such as "Subjects of Patent Law," "Objects of Patent Law," "Registration of Exclusive Rights on IPR," "Management of Exclusive Rights," and "Protection of Exclusive Rights"). After studying each of these components, intermediate knowledge assessments are conducted using a specially developed system based on a differentiated approach within the utilized teaching methods.

The formation of these modules is based on the following key principles for selecting and choosing educational material:

- **Generalization of Educational Material:** Generalizing the material for comprehensive understanding.
- **Systematic Structuring:** Structuring the material based on a systems approach.

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- **Flexibility, Continuity, and Dynamism:** Ensuring the knowledge control system is flexible, continuous, and dynamic.
- **Awareness of the Need for Competency Formation for Innovative Engineering Activities (IEA):** Emphasizing the awareness of the need for competency formation for IEA.

Each block (module, submodule) is presented in both paper and electronic formats and includes the following structure: description of the module and its objective, informational section, diagnostic questions for self-assessment, and educational creative or situational tasks based on the topic presented in the module. In the framework of modular training in Engineering Creativity and Patent Law (OIT and P), students are involved in the following types of Innovative Engineering Activities (IEA):

1. **Scientific Research Activity:** This involves the development of skills to quickly and accurately analyze the structure of technical systems, use the most general methods for their research, analyze their operation through drawings and diagrams, determine kinematic and dynamic parameters, and widely employ computer technologies.
2. **Subjective Scientific Research and Experimental-Design Activity (Synthesis of Technical Solutions):** This includes activities aimed at forming competencies in IEA, where students develop skills to identify problems, formulate tasks, and solve creative engineering problems at the level of inventions using the Theory of Inventive Problem Solving (TRIZ), the Algorithm for Solving Inventive Problems (ARIZ), the "Inventive Machine," heuristic methods, etc. It also involves constructing both typical and original devices, conducting patent research, and determining the competitiveness of Intellectual Property Rights (IPR).
3. **Innovative Production Activity:** This activity focuses on obtaining intellectual property (IP) through non-material means (by managing IPR, acquiring exclusive rights, using and disposing of them) and material means (by introducing IPR into the production environment). This involves engaging students in professional activities that contribute to forming competencies in IEA.

CONCLUSIONS

The structure of the innovation system has been identified as a combination of subjects (innovators, innovators, infrastructure) and objects (innovations –

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innovative products and processes), interacting in the process of creating and implementing Intellectual Property (IP), with innovation activity serving as its primary tool. The meanings of all its components have been specified. It has been shown that: 1) currently, only in some universities in the country are disciplines offered that promote the preparation of students for innovative activities; 2) although students recognize the need for innovation training, they do not have an understanding of innovation processes, methods of finding technical solutions, patent research, and intellectual property law; 3) despite the need to prepare specialists capable of engaging in innovative engineering activities (IEA), most teachers continue to educate students according to the established traditional disciplinary and sequential system. It has been demonstrated that students can be prepared for innovative engineering activities based on the formation of competence in IEA. This competence is presented as a set of components: knowledge-based (general cultural competencies (CC) – mastery of fundamental, economic, ethical, and ecological knowledge; professional competencies (PC) – mastery of general technical, interdisciplinary, legal, and specialized knowledge), activity-based (CC – mastery of decision-making, teamwork, information retrieval and usage, the use of normative and legal documents; PC – skills in problem identification, analysis, task setting, solution synthesis, design, invention, management of intellectual activity results, presenting solutions in final form, representing and adapting technical systems, and using creative activity tools – methods of solving inventive tasks, patent research); motivational (needs of society and individuals), and psychological (development of potential and specific abilities). A possible direction for further work could be the improvement of the methodological system for preparing university students for innovative engineering activities (IEA) by: 1) modernizing the methodological support, including the course's electronic support system, by expanding the capabilities for monitoring students' knowledge through these systems; 3) expanding the capabilities of TRIZ (Theory of Inventive Problem Solving) for solving professional tasks; 4) expanding the range of applied software packages used for analysis, synthesis, and design of technical systems, as well as databases for conducting patent searches.

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