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Scientific and Methodological Aspects of Preparing Future Engineers for Scientific and Research

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ABSTRAC

This article explores the theoretical and methodological foundations of preparing future engineers for scientific-research activities. And in this article, the formation of scientific interest, the development of independent research skills, the possibilities of using modern information technologies, and the specific features of the educational process based on an integrated approach are scientifically analyzed. In addition, effective pedagogical conditions for the formation of research competencies in engineering education are substantiated.

Keywords: Future engineer, research activity, methodology, competence, technical education, innovative approach.

INTRODUCTION

An engineer who is ready to solve research problems must have a number of characteristics and a set of special skills. The most important of them are the ability to see the problem, formulate a hypothesis, observe, conduct experiments, and other skills.

In addition, he must also have the following special engineering abilities and skills:

- the ability to feel the problem, the ability to be "surprised";

- the ability to find real scientific and research problems, to present them to the student in a clear form;

- interest in significant problems;

- the ability to perform the role of coordinator in research and investigation;

- tolerance for mistakes made in attempts to find a solution to the problem;

- support and comprehensive development of the attitude to the research process;

- encouragement of proposals for improving work and coordination of the promotion of new original research directions.

Based on the analysis of research works of various scientists, we have found that the majority of research engineers lack sufficient knowledge of the methodology of their discipline. Therefore, eliminating this problem is one of the main tasks of all engineers engaged in research activities and a system-forming factor in the training of future engineers in order to increase their professional competence [4].

In modern science, methodology is considered in two aspects: a theoretical organization closely related to the epistemology of philosophical knowledge, and a practical organization aimed at solving problems and changing the world. It requires thinking about the methodological research training of future engineers, clarifying the concept

of "methodology of scientific research activities" and considering the methods used, classified according to various criteria.

Scientists who study methodology as a general scientific basis (M.S. Burgin [7], B.S. Gershunsky [8], M.I. Rojkov [10], N. Saidakhmedov [11] and others) emphasize that the methodology of knowledge should be grouped as a scientific - a doctrine of cognitive activity and the knowledge that is its result, its defining criteria, forms and methods of activity aimed at mastering knowledge, as well as the methodology of practical activity as a specific structure of activity, the logic of its organization, methods and means.

For example, B.S. Gershunsky, N.D. Nikandrov [8, 9], noting that pedagogical methodology can have a practical orientation, put forward the following opinion as an exception: "Of course, this situation cannot be distorted. In particular, it would be wrong to perceive any practical recommendations indicating methods for performing certain specific actions as a special form of methodology. Excessive abstraction of methodology, any generalization, any theoretical conclusion divorced from practice, and in some cases, the recognition of the idea that justifies the importance of the ideas put forward by the author as a methodological concept are clear examples of its distortion [8, 9]". At a time when the situation of incorrect interpretation of pedagogical terms is becoming more and more obvious, it is impossible not to agree with this opinion.

Thinking about the method, the English philosopher and mathematician A. Whitehead believed that any method, the significance of which is determined by theory, determines the "method of action" with data and evidence [12]. The characteristic features of the scientific method include: objectivity, expressiveness, heuristics, necessity, accuracy, and others.

Currently, in philosophy and scientific methodology, methods are also classified according to the field of application: philosophical methods; general scientific methods; special scientific methods; interdisciplinary research methods. The most popular among philosophical methods are dialectical and metaphysical methods. Each philosophical concept has a methodological function and is considered its own method of intellectual activity. Therefore, philosophical methods are not limited to the two methods above mentioned. They can also include analytical (typical for modern analytical philosophy), intuitive, phenomenological, and others [5, 6].

Considering the general scientific approaches and research methods that have achieved wide development and application in modern science, we can come to the following conclusion: philosophy is considered an intermediate link between the fundamental theoretical methodological positions of special sciences. Scientific concepts often include the concepts of "information", "model", "structure", "function", "system", "element", "optimality", "probability" and others.

The characteristic features of general scientific concepts are: firstly, a special feature in their content, the integrative nature of concepts from a number of special sciences and philosophical categories, and secondly, the possibility of their formalization, clarification of mathematical theory by means of the logic of signs.

In science, a model of dividing scientific methods into empirical and theoretical levels is known, in which experiment is presented only as an empirical method. On the basis of general scientific concepts and concepts, appropriate methods and principles of knowledge are formed, which ensure the connection and optimal interaction of philosophy with special - scientific knowledge and its methods. General principles and approaches include systemic and structural-functional, cybernetic, probabilistic, modeling, activation, and a number of other principles and approaches.

One of the dominant methods in the analysis of the research situation, using rational methods based on the theory of inventive problem solving (TIPS) and functional-evaluative analysis (FEA), is the method of systematic analysis, which allows for a clear structuring of the problem [1].

The term "methodology" comes from the Greek words "methodos" - path, method and "logos" - concept, idea. Methodology is not a set of separately taken methods, their "mechanical unity", but a way of organizing research.

The result of the process of preparing future engineers for research activities can be defined as the personal and professional development of the learner, expressed in the system of knowledge formed as a result of research activities, practical readiness to carry out research activities, and a scientific worldview formed in the need to

improve professional and pedagogical activities. The decisive result in this is the development of research skills in the future engineer [2].

In the process of creative approach, the orientation of the student to scientific research activities, in our opinion, consists of the following main components:

1. Formation of scientific interest. The student's personal interests, sensitivity to problems and desire for innovation are stimulated. Introduction to scientific news, innovations, inspiring conversations, seminars are organized.

2. Creation of a problem situation (Problemization). Identification of a scientific question through a real or conditional problem. The student's need for independent research is awakened through questions such as "Why?", "How?".

3. Development of a research strategy. Search for ways to solve the problem, selection of research methods (experiment, analysis, observation, experience). Research design, drawing up a plan-graph.

4. Creative thinking and creative research. Creation of an environment that allows the student to express original ideas (brainstorming, design thinking). Development of an independent idea and its defense.

5. Integration with practice. Linking a scientific idea to production, technological process or software. Demonstration of the result through a startup, project or prototype.

6. Using scientific information sources. Teaching the student to search, select, analyze and use information (Google Scholar, Scopus, eLibrary). Formation of skills in creating an annotation, analytical review, bibliography.

7. Writing and presenting a scientific text. Teaching how to prepare a scientific article, thesis, report, presentation. Formation of a culture of substantiating one's opinion, providing evidence, using references.

8. Reflection and evaluation. The student's ability to self-analyze, work on oneself, learn from mistakes. Exchange of ideas with a scientific supervisor, analytical evaluation, updating.

The development of students' research activities usually involves practice, study, and reflection, which allows students to improve their skills and create more complex and impressive compositions, and in organizing them, we present an integrative structure of research activities (Figure 1).

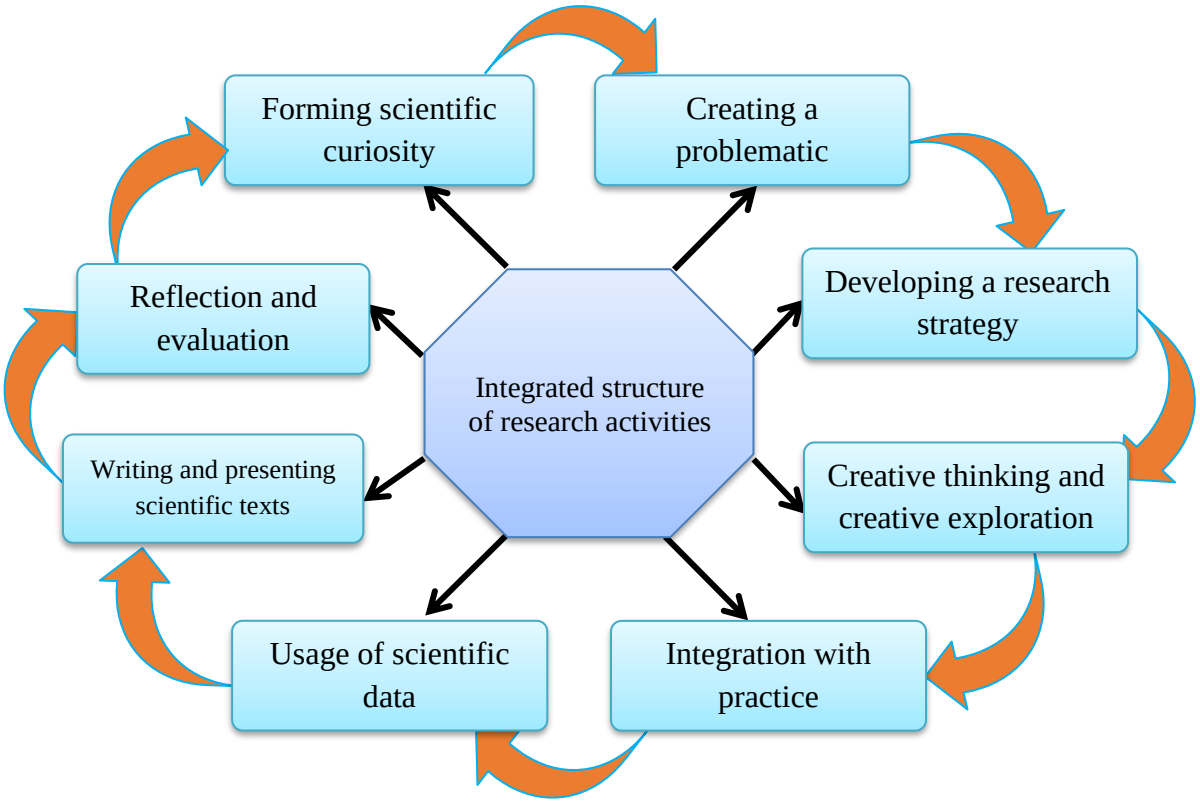

Figure 1. The integrated structure of a student's creative activity in the process of preparing students for research activities based on a creative approach

The description of the process of training future engineers for scientific and research activities in accordance with the formulated goals includes the following:

- training should be universal, that is, it is necessary to form a general idea of the structure and sequence of actions for training future engineers for scientific and research activities in the context of the innovative process in specific socio-economic, political, pedagogical and scientific and technical conditions;

- the training process should be technological, it should be possible to effectively implement it in specific educational practice conditions, and the description of the process in question should include instructions for the technology, form and means of training, as well as the requirements for readiness for scientific and research activities;

- the training process should include psychological-pedagogical, engineering-technical, production-technological components and be built on the basis of their interrelation. This ensures an increase in the quality of training future engineers for research activities.

A comprehensive description of the developed process of training future engineers for research activities should be presented at the level of conceptual justification, at the general didactic level and at the level of specific methodologies.

The basis for building the process of training for research activities is the deep integration of students' academic and extracurricular research activities, which leads to the need to introduce clearly structured and meaningful characteristics into the process of professional training of future engineers. The general didactic description of the process of training future engineers for research activities includes a statement of theoretical approaches and principles that determine the foundations of their training for research activities.

The process of its implementation in the selected type of

activity is considered within the framework of the project: it is carried out in a certain time sequence in phases, stages and sub-stage elements, while the sequence is common to all types of activity.

The completion of the activity cycle is determined by the following three phases:

- the design phase, the result of which is the construction of a model of the system being created and a plan for its implementation;

- the technological phase, the result of which is the implementation of the system;

- the reflexive phase, the result of which is the evaluation of the implemented system and the need to correct it or "launch" a new project.

The stages of analyzing existing evidence, posing a problem, putting forward hypotheses, planning and implementing logical-theoretical and material-oriented actions, processing, analyzing and summarizing the results obtained are considered as its integral components in the structure of experimental research.

Preparing future engineers for scientific research activities is an important strategic task in the context of modern technologies, innovative development of industry and the advancement of science. A well-thought-out scientific and methodological approach is necessary for the effective organization of this process. Scientific research activities are aimed not only at acquiring theoretical knowledge, but also at forming specialists who can solve practical problems and create innovations.

In the process of preparation, the development of goal-orientedness, a step-by-step approach, interdisciplinary integration and independent research skills is of primary importance as scientific and methodological aspects. The formation of students' competencies in critical thinking, identifying scientific problems, applying scientific research methods, analyzing results and applying them in practice is one of the main directions of scientific and methodological work.

In addition, the development of students' scientific potential is achieved through mentoring, scientific supervision, project development, laboratory training, participation in startups and innovative projects. In this, educational and methodological support, modern teaching methods (PBL, design thinking, digital simulations), as well as the formation of a culture of using scientific information sources play an important role. In general, scientific and methodological approaches to preparing future engineers for research activities not only increase the quality of the educational process, but also ensure the creative and intellectual development of students, helping them to become competitive, innovatively thinking and inventive specialists in the future.

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