Determinants of engineering thinking in the structure of the professional reliability reserv

Balakshina Yelena Vladimirovna
Candidate of Psychological Sciences, Associate Professor
TvSTU

Abstract. Scientific interest in the specifics of modern engineering activity, its psychological characteristics is due to the significance of the results of engineering work. Their active introduction into almost all spheres of society's life determines its special status and position among other types of professional activities. This trend is confirmed by the demand for engineering personnel in the labor market, the growing interest of young people in a number of engineering areas (information technology, nanotechnology, biotechnology). Over the course of historical development, engineering activity has become more complicated in accordance with the demands of society, and its successful implementation required a high level of specialized knowledge, a technical orientation of thinking with a creative component. In this situation, the ability to invert original, unexpected ideas, as well as the possibility of technical implementation of the solution conceived by the engineer at a high-quality and safe level are important criteria for the efficiency and reliability of his work. In this sense, tracking the general patterns of the development of engineering thinking at the stage of professional training allows you to reflect its features, taking into account the profile (specialization) and improve the training programs for future engineers.

Keywords: engineer, engineering activity, engineering creativity, creativity, reliability, professional thinking, professiogram.

Today the profession of an engineer plays one of the main roles in the life of society. Technical inventions created by modern engineers constantly satisfy social needs, become tools for solving global problems, as well as issues related to national security (military engineering). The availability of modern technologies and their implementation in various spheres of human activity and various labor sectors make a number of engineering areas especially valuable (operation, maintenance). These types are most often found in the labor activity of an engineer and testify to the close connection of his labor with technology, technical systems.

The variability of engineering professions is determined by the intensive development of the scientific and technological process and, as a result, the demand of the labor market for engineering personnel of new specializations, as well as the almost continuous adaptation of professions to these conditions within the already existing types of labor activity. An example is the presence of a wide

profile of engineering specialties related to computer technology (IT engineer, architect of living systems, development engineer, 3D printing engineer). This pattern can be traced in the classical versions of engineering work, which is partly dictated by the introduction of technical innovations and computerization of all industrial sectors. One of the objective reasons for this is the intensive transformation of the very sphere of engineering work, which is expressed in the almost continuous updating of the current list of specialties. At the same time, one of the leading trends is the integration in a specific type of professional activity of psychological content, previously presented in separate, independent types of activity [6].

The features of the work of an engineer are most fully reflected in the following definition: "An engineer is a specialist with a higher technical education, who uses scientific knowledge to solve technical problems, manage the process of creating technical systems, design, organize production, and introduce scientific and technical innovations into it" [4]. The concept indicates that in a number of leading professional competencies of an engineer, a special position is occupied by the ability to create, design, organize, and the ability to rely on scientific knowledge. Taken together, all of the above competencies can be combined with the word "create", that is, an engineer is a "creator of technology" Creativity in the activities of an engineer manifests itself from the moment of a conscious choice of his goal for the technical needs of the production cycle and society as a whole. The entire multi-stage process (from the need to solve a problem to the creation of an innovative technical model for industrial production) is called engineering creativity and is distinguished by a special internal organization.

However, not all products of the professional activity of an engineer, as exemplified by a specific type of engineering profession, are directly a technical object, even if there is a direct relationship to technology and its systems (design engineer: the result of labor is a graphic 3D model, drawing). This category includes engineering specialties related to programming, biosystems (biotechnology), nanoengineering, environmental engineer. Obviously, the ways to achieve high performance results in each specific case depend on a specific set of psychological characteristics of a professional, where thinking takes one of the first places.

The following are the leading features of engineering activities that leave an imprint on the psychological portrait of a new generation engineer, as well as affect the manifestation of a specific mentality:

1) the versatility of an engineer, which consists in the need to perform professional duties that go beyond the general awareness of technology and technical processes (management, planning, management, etc.) [8];

2) the need for an integrated application of classical forms of engineering activity to obtain optimal labor results (design and invention);

3) attention to the issues of professional training at all stages of professionalization as an important condition for leveling or reducing the risks of reproduction of erroneous actions [1];

4) the formation of an optimal set of psychological criteria for the reliability of an engineer's labor, including individual psychophysiological, psychological indicators;

5) the requirement of the ability to quickly apply a complex of technological, natural science, social and humanitarian knowledge to solve engineering projects, in which the speed of inclusion in the process of solving problems is ensured by individual psychological characteristics.

On the example of the production environment, the division of labor of an engineer occurs on a functional basis (production engineers, research engineers, systems engineers, production operations). Such diversity and multifunctionality require a special approach to the study of an engineer as a subject of professional activity [5]. The process of manifestation of the psychological uniqueness of the cognitive sphere of a future specialist at the stage of professional training as a period in which the "reserve" of professional reliability is formed through the acquisition of knowledge and competencies becomes especially interesting [1].

As mentioned above, modern engineering activity is a labor in which a new technical system is created and mechanisms are developed for the process of managing this system. It differs significantly from technical activity, which has a performing character, and is based on scientific knowledge, experience, intuition and "guesswork". An engineer, carrying out his activities, acts as an initiator-experimenter, based on two types of knowledge: natural science and technical. The fundamental point is the transition of engineering activity into the sphere of technical creativity, based on scientific knowledge and the ability to design. Proof of the creativity of an engineer is found in the nature of technical creativity in the transition from abstract thinking (the image of a technical object) to production practice. In its final form, this is demonstrated in a six-step cycle when working on a project (invention, design, design, engineering research, technology, organization and management of the process, operation and evaluation of equipment) [7].

Of course, a large number of related engineering specialties are represented on the labor market in the areas of construction, computer technology, chemical technology, electrical engineering and power grids, including areas related to the extraction of natural resources (we have not given it as an example). However, the features of mental activity (analytical thinking, spatial-figurative, logical), together with other cognitive processes in all documents, are on the first lines of psychograms, which can be traced in various versions of the generalized professiogram of an engineer. The study of the types of thinking and the ability to creative activity, as a resource for future reliability in work at the stage of vocational training in a higher educational institution, is becoming an important task [6]. It is here that the development of the main elements of the structure of engineering thinking (rational, sensory-emotional and axiological) takes place. Taking into

account the above, it can be concluded that logical thinking, a complex of specialized knowledge, ingenuity and creativity are the key determinants of professional engineering thinking.

Under the influence of a positive attitude to work, the formed professional thinking makes it possible to study and transform the world around us, depending on the goals and needs of professional activity, the meaningful orientations of a person [3]. The specificity of the diverse connections between the activity and the personality of a professional is determined by the peculiarities of the manifestation of mental regulation and the operational characteristics of thinking [2].

Regarding engineering activity, its warehouse, it should be noted that engineering thinking by domestic researchers is considered as a continuous socio-mental process associated with activities and its main components: polytechnic, integrative-simultaneous (the ability to versatile solution of applied problems), productive, team-based. The leading features of professional engineering thinking are continuity, national mentality, and social orientation. The frequency and direction of the professional tasks solved by the engineer determined three vectors that distinguish his thinking: artistic, practical, scientific.

Experts also note that engineering thinking is a special kind of professional thinking, through which innovative, safe, trouble-free and breakthrough technologies are developed that increase the efficiency of the production cycle, facilitate the work of technical personnel and reduce the economic costs of production. Requirements for the safety and reliability of equipment raise the issues of labor reliability during its operation, as well as the professional reliability of the engineer as a whole.

An important stage for the development of the main elements of the structure of engineering thinking (rational, sensory-emotional and axiological) is training in a higher educational institution. It is during this period that primary professional skills are honed and the features of mental activity are manifested, depending on the focus of engineering on the specificity of the leading professional tasks and functions that will be solved by young specialists at the enterprise (workplace). Knowledge about the specifics of the qualitative and quantitative composition of the indicators of engineering thinking, their analysis allows timely and quickly find the best ways to level production risks, erroneous actions [9]. Of particular interest are various studies of the formation of engineering thinking, its warehouse among the student body in specialized educational institutions.

At the Tver State Technical University, a study was carried out to determine the contours of technical thinking, taking into account its leading components. The locus of attention included second-year students of the faculties - information technology and construction (general specialized subjects in the selection for training: physics, mathematics, Russian). The total number (contingent) is 144 people, the age category is 18–21 years old.

Research methods and techniques. Psychodiagnostic tools were composed of three methods:

1. Methodology for diagnosing the type of thinking (author - Rezapkina G.V.). Through the scales proposed to her, the originality of thinking, the leading components, the level of expression of creativity are determined.

2. Bennett's technical comprehension test. The proposed stimulus material allows you to identify the development of technical abilities in the adult and youth contingent.

3. Methodology for the diagnosis of personal decision-making factors Kornilova T.V. The results show the severity of the leading components in the decision-making process (willingness to take risks or rationality).

Statistical and mathematical processing of psychodiagnostic data was carried out using the SPSS-18 program. The statistical methods used are descriptive statistics.

Research results. Determination of the prevailing type of thinking in the student sample of specialties in technical areas made it possible to establish a number of regularities: a) two types of thinking are most pronounced: substantively effective (5.6) and visual-figurative (5.4); b) verbal-logical (4.0) and abstract-symbolic thinking (3.9) are less pronounced; c) the level of the ability to think outside the box (5.1) - an irreplaceable quality for designing and creating everything new, corresponds to the level of expressiveness of quality "above average".

The almost equal degree of manifestation of the first two types of thinking in the process of mastering engineering specialties testifies to its synthetic nature. The necessary professional knowledge (for a successful entry into the working environment in the future) is acquired by students mainly through direct acquaintance with the subjects of the production process (machines, computers, apparatus, etc.), which occurs in practical classes, during practical training (consolidation of theoretical material). Reliance on images and representations contributes to the implementation of engineering projects on paper, for example, in the construction sector - the development of an architect. It should be noted that the maximum level of creativity, according to the methodology key, is 8 points. The obtained level for the sample corresponds to the value "above average". Creativity as the ability to think creatively and make extraordinary decisions is characteristic of young engineers. A vivid expression of creativity is possible with their direct participation in technical developments and the attention of the teaching staff to the manifestation of initiative.

The data of diagnostics of formation and manifestation of technical abilities are of particular interest. The final result corresponds to 51.6 points (high level). This level of expressiveness of technical abilities is typical for both boys and girls. Low and medium abilities are characteristic of a single study participant. Developed technical ability is the leading criterion for showing that students have an understanding of the subject area in which they will be working. Students are

ready to understand technology, implement technological processes.

The study of the rational component of engineering thinking among students of a technical university revealed the following features: the scale of rationality corresponds to an average statistical value of 6.7 points; risk readiness scale - 4.1 points. The first indicator is approaching the average level of quality, the second value is included in the range "below average". Students of technical specialties show rationality in the decision-making process, tend to think about behavior and actions, and have a constructive attitude towards criticism from society.

Conclusions. As the results of the study of the foundations of professional engineering thinking of students studying in technical areas have shown, at the stage of mastering knowledge about the subject area, it is characterized by the following patterns:

1. An important condition for the formation of engineering thinking in the process of professional development of a future specialist is active preparation for admission to a higher educational institution through the assimilation of specialized subjects (mathematics, physics, chemistry, computer science). Mastering the basis of knowledge in the necessary disciplines at a high and stable level becomes a guarantee of overcoming obstacles associated with new forms of organizing educational activities, and a positive attitude towards the chosen profession.

2. A rational attitude to the knowledge acquired, an understanding of its importance for successful employment, testifies to a responsible attitude towards the subject and object of the future professional sphere, increased attention to the theoretical basis.

3. Most of the students demonstrate the applied and theoretical orientation of mental activity, which is due to the need to quickly merge into the future professional world after graduation. Success in this case is achieved by participation in industrial practices, activity in laboratory and practical classes, which determine the way of processing information, logic and techniques of engineering thinking.

4. Engineering thinking is presented as a systemic type of thinking that includes elements of creative activity and is part of the structure of the reserve of professional reliability. The direct influence of engineering activity on the quality of life of society makes the development of this problem urgent.

Conclusion. Specific features of the content of engineering work, its different types, become factors that determine the set of requirements for the personality of an engineer, knowledge, skills, abilities, as well as its psychological foundations. Together with professional thinking, they are acquired and honed from the student's bench and polished at other stages of professional development. The presence of professional thinking can be traced in the choice of approaches when performing work duties and testifies to the professionalism of the employee. An attempt to determine the originality of engineering thinking and to trace its dynamics at the stage of training

serves as a necessary basis for adjusting the trajectories of training engineering personnel for the modern economy.

References

1. Dashkova M.O. The main changes in the legislation of the Russian Federation in the scientific and technological sphere for 2018 // Management of science and scientometrics. 2020. V. 15. №. 1. P. 72–91.

2. Kashapov M.M. Formation of professional creative thinking. Yaroslavl: YarSU, 2013. 136 P.

3. Mazilov V.A. Theoretical methods in psychology: return from exile // Methodology of modern science. 2020. № 11. P. 199–211.

4. Povolyaeva M.N. Essence and features of engineering activity // Technologies of electromagnetic compatibility. 2016. № 1 (56). P. 13–19.

5. Rubtsova N.E. Integrative application of methodology in describing the activity of the subject of labor // Integration in psychology: theory, methodology and practice: materials of the III National scientific and practical conference with international participation / edited by V.A. Mazilova. Yaroslavl, 2020. P. 134–140.

6. Rubtsova N.E. The main directions of classifications of professional activity // Psychology and psychotechnics. 2015. № 5 (80). P. 501-510.

7. Tarasova E.V., Panova O.S. Heuristic methods (intuitive engineering creativity) as a way of cognizing original ideas and management decisions // Economic and mathematical methods for analyzing the activities of agricultural enterprises: materials of the II International scientific and practical conference / ed. S.I. Tkacheva. Saratov: LLC "Amirit", 2018. P. 444–446.

8. Sheinbaum V.S. Engineering activity as a design object: a pedagogical perspective // Kazan pedagogical journal. 2020. № 6 (143). P. 18–29.

9. Electronic museum of professions https://profvibor.ru/catalog/?SECTION_ID=159&sort=name&order=asc&arrFilter_pf%5BDRUPAL_2599%5D%5B0%5D=99&set_filter=Y (appeal date: 27.04.2021)