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Humanitarian Meanings of Engineering Activity and Their Actualization Among Students During University Education Process

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Abstract

In modern education, the issue related to acquisition of axiological basis of engineering activity is still solved in compliance with knowledge approach. The authors substantiate the potential of integrating humanitarian and technical components of education content through activation of psychological and pedagogical mechanisms of meaning-making. This makes it possible to establish a meaningful axiological attitude among students - future engineers, to lay humanitarian meanings and values at the basis of their professional activity.

Key words: engineering education, meaning making, pedagogical hermeneutics, humanitarian senses of engineering activity, meaningful value-semantic position.

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The higher the level of technical and technological perfection of society, the more important is the degree of understanding by engineers of the meaning of changes, which their activities bring to the modern world. Today, the words of N.A. Berdyaev, "The question about technology has become a question about the fate of man and the fate of culture" [1, p. 147] become more relevant.

The question about technology has become for us a spiritual question, a question about the fate of man, about his relationship to God.

In the age of constantly accelerating scientific and technical progress, the role of engineers exceeds the limits of transformation ways of man's interaction with nature. This role has an increasingly tangible impact on public life. Thanks to modern information and communication technologies, the sphere of social communications has developed new spaces. Management processes in life-support systems of production, economic and social complexes are impossible without technological innovations.

Modern biotechnologies can not only significantly prolong human life, but also prevent formerly incurable diseases. In everyday life, in various situations, people pursue their actions through the use of modern technical devices. The main trends of modern technical innovations, such as machine learning, the development of personal digital devices including 3-D printers, "smart things", "smart medicine", automation and self-controlled devices, personal means of energy production, algorithmic design, etc. are user-oriented and can radically change the quality of life.

In general, we can state that there is a snowballing advance of engineering achievements into sociocultural reality. Today, engineers are actors of social transformation. Through their activities, engineers ensure the practical implementation of the most important humanitarian values. First of all, it concerns life and health of people, their comfort and safety, which affect personal well-being, social integration and creative activity of modern people. As O.D. Garanina states, "In the technical society, the engineer becomes a key figure not only in the spheres of production and economy, but also in the regulatory and spiritual spheres of society" [2, p. 99]. As the engineering influence extends and penetrate all new sociocultural processes and interactions, the humanitarian component of modern engineers' activity becomes increasingly important. According to V.M. Rozov, it is required to include this impact in understanding of engineering and technology processes [3, p. 8-9]. Special research efforts in engineering ethics are indicative of the qualitative change in axiological orientations of engineering activity in the context of significant extension of social institutions and spheres, which can be impacted by engineers' activities. As a result, the engineer's fundamental standard of responsibility, which involves "profession service", "proper operation", currently includes the requirement for social responsibility. In addition, standard of responsibility becomes "polycentric" (A.Yu. Sogomonov) [4, p. 70]. Contemporaneously, modern engineers should entirely focus on serving the society, nature and culture. Therefore, axiology and reliance on humanitarian meanings become the most significant features of engineering activity.

The requirement for meaning orientation of engineering education, noted by Yu.P. Pokholkov and B.L. Agranovich, plays an important role. According to the above-mentioned scholars, "To become professional engineers, students must leave the space of knowledge and enter the space of activity and life meanings. Knowledge and methods of activity must be combined into the organic integrity, which system-forming factor consists of certain key values" [5, p. 8]. In accordance with these ideas, at the stage of university training, it is required to strengthen the personal orientation of educational process and, first of all, to increase the meaningfulness of students' axiological stance. It is also required to create conditions that would allow students to understand the axiological basis of their professional activity, to place humanitarian meanings into consciousness of future engineers, These are "really acting" rather than "known" motives (A.N. Leontiev), which would perform activating, directing, regulative and meaning-making functions with regard to professional activity. The problem is that in order to achieve this goal, the traditional approach to constructing the education content is not sufficient, since it is required to offer students not only a vast array of humanitarian knowledge, but also to contribute to interiorization of values.

At present, the national and international engineering education is mainly represented by versions of interdisciplinary integration of its humanitarian and technical components by the principle of complementation. These components include the reinforcement of educational programmes in technical fields with humanitarian topics and projects (K. Chau, P. Christensen, X. Du, N. Dubreta, M. Lehmann, M. Thrane, R.W. Welch (Denmark, USA, China, Croatia), integrative training courses, which combine humanitarian and professional units (G.V. Panina, A.S. Sokolov, L.V. Yuzhakova, A. Agogino, C.T. Hendrickson, H.S. Matthews, M.W. Bridges et al. (Netherlands, Australia, USA, Russia, etc.), integrative educational programmes (H. Blottnitz, D.M. Fraser, R.C. Hudspith, F.J. Lozano, O.M. Zamyatina, M.V. Lychayeva, P.I. Mozgaleva et al (Canada, South Africa, Russia). At the same time, modern national and international regulatory documents, such as CDIO, ABET, professional standards, FSES, the description of qualities of modern engineers include the ability to take a holistic approach to solving professional tasks. This implies a deeper integration of meaningful and professional-practical aspects of engineers' activity. For the design of engineering education content, the idea that "the harmonious unity of natural-science and humanitarian culture

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of cognition and activity, the unity based on mutual understanding and dialogue is the axiological feature of engineering education humanitarization" plays an important role [5, p. 8].

The integration of humanitarian and technical components of education content based on meaning-making mechanisms, which ensure the transformation of educational, scientific and technical information into personal meanings, is a productive way of reinforcement of axiological orientation in training of modern engineers. Unlike "impersonal" information, personal meanings, or "living knowledge" (G.G. Shpet, V.P. Zinchenko) have been lived through and are internally accepted by individuals as a value. These personal meanings act as regulators of practical activity. In the context of the proposed problem, modern studies of regularities and ways of actualizing the meaning-making in the learning process (I.V. Abakumova, E.G. Belyakova, I.A. Rudakova), the ideas of pedagogical hermeneutics and methods of text interpretation as the means of developing personal meanings (A.F. Zakirova) are of interest. The mechanism, which assists in penetrating into humanitarian meanings of engineering activity, is based on developmental potential of textual activity, where the multilateral understanding of the subject and humanitarian content of technical information takes place. This activity is also accompanied by understanding its meaning in the context of the unity of culture, nature, society and man. The integration of humanitarian and technical content components of engineering education is implemented through the synthesis of various ways of understanding information, such as cognitive (mental) and interpretational. The latter are based on axiological relation to the subject of understanding. Ways of understanding information are mediated by personal values. The axiological stance, which in the course of professional activity is a decisive subjective factor for making responsible decisions, is the result of integration.

In line with these approaches supplemented by concepts and technologies of contextual training (A.A. Verbitsky), the technology of humanitarian meanings development in engineering in the context of university education (A.A. Melikhova) was established. Along with technical and humanitarian texts, this technology involves the use of special "humanitarized" technical texts. Their understanding requires both cogitative activity for the analysis of their subject content and the interpretation of humanitarian meanings, which reflect value aspects of engineering activity.

Actualization of humanitarian meanings of texts takes place in the form of the "multiangle" hermeneutic dialogue, which makes it possible to reveal the meanings in correlation with personal, sociocultural, meaningful and professional contexts. The work with technical texts is a stagewise process. It involves 1) the actualization of humanitarian meanings in the context of professional activity, 2) the understanding of subject and axiological content of "humanitarized" technical texts, 3) the "humanitarian translation" and interpretation of technical texts, 4) the projection of humanitarian meanings in practical engineering activity in simulated or real professional situations.

This technique was successfully tested at the Tyumen Industrial University and involved 110 students, 23 teachers of subject disciplines and supervisors of curricular practical training. According to the results of diagnostic cross sections, over 80% of students in the experimental groups demonstrated a significant increase in the level of meaningfulness of humanitarian aspects of engineering activity.

Let us illustrate the technique of humanitarian meanings development of engineering activity on the example of the class scenario. The subject was "Structure and Properties of Materials" as part of "Construction Materials Engineering" course, "Production Machines and Equipment" training programme. In order to actualize humanitarian meanings of

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engineering activity, students were offered a small video clip with an overview of technical and humanitarian causes, conditions and effects of the world's largest derailment of the inter-city express train near Eschede, Germany, in 1998. In the course of dialogue and subsequent discussion, students vividly realized that the results of engineering activities, in this case connected with adequate and timely testing of materials, directly depended on human factor. Negligence in the use of materials, improper maintenance control, neglect of safety techniques, inattention to extraneous noise led to fatigue of metal and microcracks and, ultimately, caused the catastrophe. In addition, the company's striving for immediate profit and reluctance to come to a well-planned, but postponed result associated with costs of modernizing the fabrication technology of electric train wheels, in their totality caused one of the world's largest rail accidents. At this stage, it is very important that students not only understand, but also emotionally feel the gravity of the engineer's role in this situation.

At the stage of object and axiological comprehension of "humanitarized" technical texts, the teacher's lecture dedicated to properties of structural materials was the method of submitting the material. The lecture was enriched with humanitarian accents and supplemented by appeals to personal experience, examples from history, illustrations of real objects and their application in Russia and abroad. This made it possible to attract students' interest to the diverse role of the engineer, emphasize the humanitarian side of their activity, make the material more open to dialogue during its further discussion. For example, "The development of biofuels, solar energy, optoelectronic devices, pharmaceuticals, medical studies for analysis of different samples, which include designed nanoparticles, nanostructures, biological polymers, cells of plants and tissues, play a significant role in the growth and well-being of society. It was exactly the goal that stood before Laurene Tetard and other researchers from Florida, USA, when they developed the photon-nanomechanical force microscopy method. Based on the analysis of vibrations produced by exposure to light waves of different lengths", this method determined mechanical, chemical and physical properties of materials. This diverse content of the lecture provides the basis for multi-contextual comprehension of technical information with its relation to the human personality, society, eco-cultural and natural environment, medicine and history.

At the stage of interpretation and "humanitarian translation" of technical texts, students were offered a task that contained both technical and humanitarian aspects. Students were to (1) prepare technical descriptions, formulae and calculations on "Mechanical Properties Detected Under Static Loading: Tensile Tests (Elasticity, Strength, Plasticity), Hardness Tests (The Brinell, Vickers, Rockwell Method), Fracture Toughness Tests: Tests At Dynamic Loading: Tests On Impact Strength, Cold Resistance Tests; Tests Under Cyclic Loading: Fatigue Tests"; (2) identify humanitarian problems in the topic under study, such as examples of human participation in this process, possible negative risks, capabilities, hazards and benefits.

The results demonstrated that with appropriate formulation of the task based on preliminary work on actualization of humanitarian meanings of engineering activity and understanding "humanitarized" technical texts (Stages One and Two), at Stage Three students could independently identify a wide range of relevant humanitarian aspects of engineering activity in the context of studied material. For example:

- according to NPO Saturn, Russian aircraft engine manufacturer, testing of thermobarrier coatings with low thermal conductivity under TheBarCode project, enhances the efficiency of energy production and reduces fuel consumption in aircraft engines. Ultimately, it has a significantly favorable effect on the environment;

- disasters associated with untough tests for metal fatigue. For example, the negligence of pilots to landing technique led to the crash of the Antonov-10 aircraft near the city of Kharkov, Ukraine, in 1972. Also, the violation of occupational safety and health rules led to the accident at the Sayano–Shushenskaya Dam in 2009. As a result, it caused environmental pollution, loss of life, panic and economic damage. The priority of financial issues over the value of human live led to the bridge collapse at Pushkino station, the Moscow Railway, in 1999. The bridge collapse caused loss of life and injuries;
- the socio-cultural aspect involves problems of cold-resistance testing of materials, which are relevant for Yakutia, where people and animals live in low-temperatures and life of plants stops;
- solid bodies of vehicles made of steel manufactured by Nippon Steel, Japan, can provide a greater security for passengers. This steel can withstand mechanical pressures up to 1,470 MPa. Additionally, in comparison with alloy steel, it is lighter and less expensive;
- increased crack resistance, hardness, plasticity, high operating temperature and other properties of nanocomposite materials developed for extreme conditions of space and nuclear energy will allow people to go beyond their capabilities in the future.

At the final stage, students were offered to perform tasks intended to demonstrate students' personal axiological stance in the course of making responsible decisions. Thus, it created conditions for establishing relations between humanitarian meanings and real professional and practical activity and also for reinforcement of its value-based mediation. In developing the catalogue for practical application of the non-sample method and its advantages based on the generalized analysis of other basic methods, students generated written reports. They included traditional for this work technical descriptions of the non-sample method as the most economical and simple. The reports also contained conditions and scope of method application, operating principles of the portable device and strength tests of material. In their oral presentation dialogue on the subject "Social, Psychological, Economic, Environmental and Other Issues of Non-Sample Control Application in Comparison with Other New Methods that Require the Use of Samples", students displayed the humanitarian aspect of the task to be solved. For example, they managed to identify advantages of the non-sample method, which in their view, complied with significant humanitarian values and meanings of engineering activities. The advantages included non-destructive effect on technical objects, fast evaluation in emergency situations, minimization of harmful effect on the environment, population and personnel due to the lack of large production facilities, capability of automation and preservation of human resources during remote control, the capability to determine hidden deformations to exclude human error, provision of universal security, application in difficult weather and natural conditions and non-standard situations in such spheres as aviation, space, nuclear power, shipbuilding, etc.

At various stages, work with scientific and technical texts can involve methods of contextual learning, which make it possible to simulate the real professional context, including business games, socio-technical design and socio-cultural analysis of production situations. To activate meaning-making, such interactive methods as dialogue, polylogue and discussion are the required forms of conducting classes. Technology can be employed system-wide in the course of teaching social, humanitarian, natural science and professional disciplines, thus ensuring its high productivity.

To summarize, we emphasize that due to the growing role of modern engineers in improving life quality of people, the meaningfulness of professional activity, the reliance on value consciousness, the receptivity to humanitarian meanings, the ability to project these meanings in situations that require responsible decisions belong to current issues in the course of training modern engineers. The tasks of technical education include the development of students' capacity to axiological reflection of engineering activity, their readiness for constructive and meaningful dialogue in the context of differences in social interests and values.

REFERENCES

1. Berdyaev, N.A. Chelovek i mashina (Problema sotsiologii i metafiziki tekhniki). Voprosy filosofii [Man and machine. (Problem of sociology and engineering mataphysics)], 1989, no. 2, pp. 147–162.
2. Garanina, O.D. Inzhenernaya deyatel'nost' v kontekste sotsial'noi otvetstvennosti [Elektronnyi resurs]. [Engineering in the context of social responsibility [Electronic resource]] Mezhdunarodnyi nauchno-issledovatel'skii zhurnal, 2016, no. 4 (46), ch. 4, pp. 98–100. Zagl. s ekrana (data obrashcheniya: 28.11.17). DOI: https://doi.org/10.18454/IRJ.2016.46.108
3. Rozov, V.M. Ponyatie i sovremennye kontseptsii tekhniki [Notion and contemporary concepts of engineering]. In Rozov V.V. Moscow: IF RAN, 2006, 255 p.
4. Sogomonov, A.Yu. Eticheskie strategii v inzhenernoi professii [Ethycal strategies in engineering profession]. Vedomosti prikladnoi etiki, 2014, no. 44, pp. 67–82.
5. Poholkov, Yu.P. Podkhody k formirovaniyu natsional'noi doktriny inzhenernogo obrazovaniya Rossii v usloviyakh novoi industrializatsii: problemy, tseli, vyzovy [Approaches to formation of the national doctrine of engineering education in Russia in the context of new industrialization: problems, goals and challenges]. Pokholkov Yu.P., Agranovich B.L. In Inzhenernoe obrazovanie, 2012, no. 9, pp. 5–11.

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