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Agents of new industrialization: a theoretical research platform

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***Abstract*— The article deals with engineers as agents of new industrialization. The article gives a detailed analysis of specificity of engineering work, features and elements of an engineer's professional culture, engineering competencies. The article discusses factors dissatisfaction employed engineers and presents the theoretical foundations for the formation of effective incentives for changing the economic and social behavior of engineers that meet global technological and socio-economic challenges.**

Keywords*— *new industrialization, engineers, specifics of labor engineers, motives of engineers, engineering competencies.

I. INTRODUCTION

A great breakthrough of digital technologies occurred over the recent ten years, and their active implementation in all sectors of the economy resulted in establishment of a new society development paradigm in general that is called Industry 4.0 or the new industrialization. The notion of the new industrialization has an aggregate nature and includes such elements as reindustrialization, neoindustrialization, and overindustrialization [1]. This approach to the definition reveals all stages of economic development and transition to digital economy over the long run: from redevelopment to superior leadership.

Transition to the new industrialization is associated with changes in employment sector and revaluation of human capital assets' value [2]. Development and implementation of digital technologies is based on efficient generation and application of knowledge, skills, expertise of high qualification level in science and engineering, namely, engineers, and their readiness and ability for further development and complex-structured cooperation. The necessity to create, implement and master new products and technologies aiming at expansion of manufacturing capabilities results in changes in the content, nature, and composition of engineers' labor; consequently, it becomes necessary to change management and motivation tools. Generation of the efficient managerial solutions portfolio is impossible without understanding specific features of work done by people involved in the process of the new industrialization deployment, their professional culture, available and required set of skills.

The issues under investigation focus on determination of availability or deficit of skills, detection of motives and analysis of engineers behavior, selection of recommended management tools aiming at changing economic and social behavior of engineers.

Therefore, the object of research is engineers as the new industrialization agents.

The subject of this research is motives as well as social and economic behavior of engineers as the new industrialization agents.

The purpose of this research is development of theoretical principles to form efficient incentives for changing economic and social behavior of engineers as a key factor that determines humanization of labor relationship.

To achieve the goal set, the following tasks of the research were determined:

- Determination of specific features of engineering work.
- Determination of specific features of engineers' motives and behavior as the new industrialization agents.
- Presentation of theoretical background of generating efficient incentives to change economical and social behavior of engineers.

Basing on topicality and goal of this research, we suggest that engineers' motives and behavior are determined by peculiarities and specificity of their professional functions, and they may become a basis of making managerial decisions in order to change engineers' social and economic behavior..

II. LITERATURE REWIEW

Detailed analysis of professional identity that is based on finding specific features of an engineer's work is represented by the work of N.G. Bagautidnova. The author understands an engineer as a category as "an entire system of mutual relations between a human and machines created by that human's mind and hands in order to place the human in the center of social universe" [3]. The work by .G. Bagautidnova contains

classification broken down by types of engineers' functions, such as operating engineer and design engineer, and a list of skills required for efficient engineering activities.

The matter of content and generation of non-technical and profession-specific skills of a future engineer is reflected in the work of S.A. Tatyanenko, N.I. Gerches, and E.S. Chizhikov [4]. The authors analyzed content of professional activities of a today engineer and built a model of a system of skills that ensure productive labor; also, methodological recommendations for higher education institutions were presented that are designed for developing such skills in future engineers.

Of special interest is the study held by N.A. Shmatko that is devoted to comparative analysis of skills of engineering personnel in Russia and the EU countries [5]. Under the experiment, employees' self-assessment of existing and required skills was used, and the education level was compared with job functions; also, the need for and productivity of additional training and advanced training was assessed. The total sample scope is 3,158 responders divided by personnel involved in research and development and highly qualified engineers and technicians working at manufacturing enterprises.

The matter of efficiency of engineers' activities, improvement of the engineers' motivation system, and other economic aspects of engineers' activities are reflected in works of N.R. Terekhova. The author touches upon the matters of development of procedural motivation theory and payment for engineers' work basing on a flexible rating system of payment and final results incentives [6].

Social and psychological grounds for and peculiarities of engineering activities are considered in the work of L.V. Korel and V.Yu. Kombarov [7]. The authors touch upon the problem of opposition between the first principles of subjectivity and quasi-subjectivity of an engineering company's employee in the light of topical modernization challenges. An important moment in the works of L.V. Korel and V.Yu. Kombarov is an emphasis on humanization of employment relationship and the need for cultural management techniques.

Matters of professional engineers' culture are considered in the works of A.V. Kalekina and R.N. Abramov. A.V. Kalekina considered social and psychological aspects of professional culture of design engineers and related value orientations and professional attitude [8]. R.N. Abramov considers universal elements of engineers' professional culture [9]. The author points at specific features of engineers' professional culture in Russia, on the one hand, where elements of culture of soviet engineering staff were found, and, on the other hand, influence of global corporate standards revealed.

The study in higher engineering education and analysis of required efforts to reform it are presented in the work of I.R. Agamirzyan, E.A. Kruk, and V.B. Prokhorova. The authors suggest that it is necessary to reform the system of engineering education by stages in order to reduce period of adaptation of a professional at a workplace and, therewith, accelerate implementation of new technologies and techniques into practice [10].

The mentioned studies significantly contributed to exploring the problem of engineering work specificity, peculiarities of an engineer's perception of his or her work, an engineer's motives and professional behavior; however, this problem is not exhausted. Theoretical principles of generating efficient incentives for measuring economic and social engineers' behavior that would meet global technological, social and economic challenges remain understudied.

Supplementing the methodology of engineering companies management with a dominant idea of efficient organizational and financial incentives to change engineers' economic and social behavior provides for prerequisites of solving the problem of humanization of employment relationship and production in general..

III. METHODOLOGY

In this research, anthropological and humanistic approaches as well as basic scientific methods, i.e. analysis and classification, were applied.

From the point of view of substructure of an engineer's personality, the major elements are substructure of experience, orientation, and capability that represent a general element of all personality's substructures [8]. The experience substructure represents an engineer's skills and facilitates development of his or her professional qualities, including a professional's training. The orientation substructure consists of relationship, assessments of personality, its interests, needs and beliefs that, as a whole, determine the world outlook of an engineer in general. It is orientation that, by accumulating life experience of the personality, expresses peculiarity of its interests and needs and is a social regulator of its behavior and activity. Again, orientation is based on a personality's motives, while behavior and activity motives generate from needs, interests, beliefs, and world outlook. Therefore, the motive to perform highly effective engineering activity must be supported by satisfaction from such engineering activity itself.

Highly qualified professionals of science and engineering who participate in the new industrialization development includes a wide range of professionals involved in engineering activities, such as design, construction, programming, production, and operation.

In the modern literature, when engineering is described as a type of activities, the main accent is given to creative part of labor, while an engineer is rather considered as a creator, subject and author of the technical culture that combines technosphere, biosphere, and sociosphere.

Analysis and systematization of features that characterize engineering activities, as found in modern literature, allows distinguishing the following basic features of an engineer's activities:

- Complex creative activity.
- Solution of engineering problems with multiple-choice uncertainty.
- Embodiment of scientific and engineering knowledge and ideas, innovative activities.
- Design and engineering activities for solving engineering problems.
- Social orientation of work.

Generically, engineering activates have to orientations: on the one hand, engineering activities provide for efficient operation of machines, complex systems and mechanisms, including their maintenance; on the other hand, it implies

generation of new systems and mechanisms that did not exist before, their development and implementation into production.

Therefore, the structure of an engineer's activities comprises all three components of labor: alpha (regulate), beta (creative), and sigma (spiritual) components. All three components exist in each orientation of engineering activities; however, for highly qualified professionals who are involved in promotion of Industry 4.0 the content of innovative or creative portion significantly prevails.

Increase in the portion of a creative component is also promoted by changes in the contemporary world (engineering, technical, and social) that result in creation of new interrelations between industry sectors. It entails expansion of the sphere of an engineer's professional interests: from certain profile of selected area of expertise to intersubject integration of engineering activities [9], as well as increase in types of work done [2].

The determined expansiveness of professional activities and revealed peculiarities of engineers' professional culture raise a question of skills providing engineers with successful participation in production process.

Contemporary discussions of engineering staff skills reduce to analysis of demand and offer of knowledge, skills, cognitive and non-cognitive skills of engineers, discovery of deficient skills and generation of solutions for reforming the engineering education system aiming at their formation.

Study and analysis of data on existing and required skills of engineering staff allows classifying them by the following categories (classification is based on the structure proposed by N.A. Shmatko [5]):

1. Professional competence: professional engineering skill; theoretical knowledge in the field of expertise; analytical skills; quick digestion of new knowledge, and digital literacy;
2. Cooperation: team work skills, critical assessment of own and others' ideas; mobilization and application of capabilities of colleagues/subordinate employees; search for compromise solution and achievement of consensus; ability to find new opportunities.
3. Managerial competence: skills and expertise in solving problems, organization and coordination of teamwork; time management, efficient embodiment of ideas; ability to sell product or service.
4. Personal performance: ability to make decisions, productive work in a team; productive independent work, functioning under stress; intelligible expression of ideas; defense of opinion.
5. Communication skills: communication ability, PC skills, Internet skills; preparation of reports, memoranda and other documents; presentation of work output to the audience; foreign language skills.

As we can see, the group hard skills includes skills from the category of Professional Competence; the rest of them may be referred to soft skills.

Results of research held that was devoted to analysis of engineers' skills reveal interesting trends:

1. Along with European companies, such soft skills as ability to solve problems and make decisions, organization and self-organization skills, effective communication and learning ability, are in demand in Russia, and their importance escalates with an engineer's carrier promotion.
2. Only hard skills such as technical expertise and skills of solving core competence engineering tasks are insufficient for the contemporary labor market aiming at the new industrialization; an employee is expected to have managerial skills and other social (soft) skills.
3. Dissatisfaction of employees with the level of their education and readiness to expand and develop available skills at their own cost was found. This readiness for development on the part of engineers is an evidence of labor potential that may be applied by managers of manufacturing and engineering companies.
4. Unfulfilled demand for non-customary combination of skills was detected (for example, ability to solve problems, make decisions, creative leadership) and readiness of companies to offer high monetary remuneration for work done by an employee who has such skills.
5. Engineering staff engaged in up-to-date engineering companies (such as commissioning organizations, technology parks, engineering companies, etc.) has higher level of activity in professional communications, advanced professional development and motivation for carrier development as compared with engineers from conventional organizations.

In terms of engineers' skills in question, particular importance is given to analysis and detection of skills that are significant today for the new industrialization aiming at their development in graduates of technical universities.

A number of studies related to contemporary approaches to engineering education, by analyzing trends in the engineering job market, present new basic skills required by graduates for successful start of carrier. To such skills, the authors refer concentration and attention control, structural form of mentality, creativity, and digital literacy (ability to operate in digital environment), and business skills. These skills are combined with peculiarities of engineers' work and, at the same time, reflect contemporary economic situation.

Under globalization of contemporary society, and, in particular engineering work, it becomes necessary to develop intercultural or global competence in future engineers who are engaged in manufacturing process by now.

Global competence allows successfully interacting during team work in international projects, overcome intercultural and linguistic differences as well as differences in special knowledge. One of possible tools of global competence development is cross-border higher education that is evolving in Russia due to the signed Bologna Declaration. Besides traditional form of cross-border education, i.e. students' mobility (ability to move between subject, universities, and countries), some new forms of it appeared: program mobility (distance learning with elements of intramural education in partner institutes), university partnership, and institutional mobility [11]. Advanced training through cross-border education or by more conventional forms of education results in enrichment of experience substructure that is an important element of an engineer's professional culture.

Notwithstanding an area of activities, an engineer has professional culture that ensures his adaptation to external professional requirements and, to certain extent, determines his or her life attitude. Research in specificity of engineers' professional culture makes it possible to establish the degree of engineers' readiness for new facts of industry.

In Russian engineering practice, there are the following universal elements of professional culture of professional engineers and technicians [9]:

- Rationality and consistency during the work process as well as of the world outlook in general.
- Orientation of overcoming engineering challenges by searching for the best engineering solution.
- Creativity as the basis of engineering activities.
- Decreased level of professional independence due to global corporate standards that influence engineers' activities.

Analysis of social and psychological factors that impede productive work and growth of engineers' labor efficiency is reflected in a number of research works. For instance, the most significant human factors restricting production capability were detected: imperfect system of monetary incentives, dissatisfaction of engineers with the social relationship area and outdated management model, application of outdated technologies and lack of opportunities to self-actualization [7]. Low interest of engineering staff in innovations and, their implementation in work was revealed, and, to the greatest extent, this trend is expressed in conventional companies [12].

The matter of professional burnout is important when speaking of restriction of labor productivity growth among engineers. Professional burnout starts with violations in actualization of personal aspects in the course of professional activities. According to data, employees with experience in a relevant profession from 3 to 5 years are most prone to this phenomenon. Among the most probable reasons are employees' dissatisfaction with the balance between work and private life as well as business processes in a company.

The revealed factors of dissatisfaction with labor activities, financial as well as social and psychological, point at existing labor motives of engineering staff and they must be reflected in the efficient incentives system, such as financial and organizational incentives. Such incentives must facilitate changes in content, forms, and work practices of engineers, for example:

1. It is necessary to implement mechanisms of assessing available skills of employees not to deprive them of benefits rather than to select directions of individual and corporate training.
2. Scope of corporate training programs must be enhanced basing on prospective development in the economic sector as well as a set of existing cognitive and non-cognitive skills of employees.
3. Company's employees must be provided with information on monetary remuneration system to the sufficient degree and ensure its transparency.
4. A system of flexible working hours and differentiated work load must be developed for those categories of engineers who demonstrated signs of decreased involvement in activities and loyalty to the employer.
5. Business processes existing at an enterprise must be improved to reduce employees' stress.

IV. CONCLUSIONS

The detected dissatisfaction of engineers with labor activities indicate that it is necessary to develop and implement a set of measures that would allow reducing employees' stress and, finally, increase labor productivity. Those measures must be based on specificity of engineers' work, their professional culture, personal motives, and behavior.

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