

Improving Competences of Engineering Students in Terms of Development of Research Function

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ABSTRACT

Among the priorities of the vocational education reformation, highlighted in the concepts of development of vocational and technical (professional) education, the need to develop the standards of professional expertise for the professions and types of work is identified with regard to the prospects of development of production and scientific research. Main contradictions of development influencing the state of higher education in the regions emphasized on the basis of theoretical analysis were observed and used. Signs of the education revolution in the early 21st century are increase in the requirements to a specialist and the transition of the educational priorities from the order for assimilation of future specialists of certain information amounts to the qualities of the building, contributing to the implementation of a specific creative activity, so now the development of new approaches for improvement of training of highly qualified specialists is an extremely urgent problem. The main indicator of the future engineering specialist's professional competence is the established professional way of thinking, which represents his or her intellectual ability to solve professional problems.

KEYWORDS

Student, training, engineering, competence, research function, the learning process

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Introduction

Society as well as humanity in general is currently being influenced by powerful globalization processes, quick changes of life conditions, enhancement of competitive bases, and establishment of innovative type of development, upheaval of value orientations and strategies of human living. The new challenges require adequate modernization of education system as the leading

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factor of social and cultural reproduction, successful human life and activities as well as further improvement (Law & Breznik, 2016).

Nowadays state requires not so much greater number of specialists, as the specialists capable of upheaving the most important branches of industry and the spheres of social life, with humanistic way of thinking and universal knowledge. That's why the main goal of modernization of education is the improvement of professional training of the specialists who would be able to solve industrial and scientific problems in close connection with the problems of preservation and enrichment of human values (Cyguleva & Fedorova, 2016). Among the tasks currently requiring primary solution the first position is occupied by effective training and development of competence of engineering staff.

A perspective direction of satisfying the needs of both graduates and their employers is application of competence-based approach to the preparation of future specialists in the higher educational institutions.

Analysis of the Previous Researches

In the pedagogical study improvement of the education system by means of applying competence-based approach is being actively discussed. The opinion of the scientists on the primacy of integration into education of such concepts as 'expertise', 'competence' and 'competence-based approach' is debatable. At the same time it is stated that exactly in the pedagogical social institution subjectiveness of personality is primarily being formed, it means personal expertise as the leading condition for formation of the other competences.

In this regard exactly in the psychological and pedagogical sciences the problem of formation of expertise is being studied in different directions and aspects integrally. For example, the problems of the competence-based approach towards the organization of educational process in the secondary-level education are studied by N.M. Vostrikova & N.P. Bezrukova (2016). The system of professional staff training in the industrial, social and cultural spheres on the basis of the expertise standard is studied by G.I. Muhamedrahimova & A.A. Sujundikov (2016).

Adjective

Substantiation of the problem and development of brand new approaches towards the formation of professional expertise of future engineering specialists in the higher educational institutions under modern conditions.

Materials and Methods

There are the following main contradictions of development influencing the state of higher education in the regions emphasized on the basis of theoretical analysis:

1. Complicated economic conditions in the country, insufficient financing of education do not allow developing material base of the higher educational institutions in accordance with the requirements of the time;
2. The rates of growth in the number of higher educational institutions significantly outrun the rates of formation of teaching staff; the potential of doctors and candidates of science rapidly grows old. Teachers have to work



simultaneously in several higher educational institutions. It does not allow having the time for their personal further and stable development;

3. Decrease in the number of graduates of basic education at the simultaneous growth in the number of positions for education in the higher educational institutions threatens with the decrease in the level of requirements towards the applicants and provokes the decrease in competitiveness;

4. Inconsistency in distribution of the population and inequality of the conditions for regional development;

5. Change in social structure of the society;

6. Uncertainty of the educational reform and instability of the plans for future development of the country and education.

Results

Active member of the Russian Academy of Education, psychologist E.V. Shipanova (2016) separates three main stages of formation of competence-based approach in education:

— first stage (1960-1970) is characterized by introducing category ‘competence’ into the scientific apparatus and creating preconditions for division of concepts ‘competence’ and ‘expertise’;

— second stage (1970-1990) is characterized by application of categories ‘competence’ and ‘expertise’ in theory and practice of learning a language, communication as well as analysis of professionalism among managerial specialists;

— third stage (early 1990s) – expertise as a scientific category in regard to education.

There is currently still no consensus regarding understanding of concept ‘competence-based approach in education’, which is necessary for ensuring integration of higher education into the sphere of the processes of general education in Europe and in the world (Hacrinova, 2016). A special attention, to our mind, should be paid to the English researcher P. Potter’s (2013) substantiation of the necessity of competence-based approach application with the following purposes:

✓ first, for teachers to be able to control individualized education programs, focused on development of the main competences of the students;

✓ second, for students to be able to exercise their specific talents, to observe their formation in the development process and to gain recognition for their talents and achievements;

✓ third, for teachers to be able to gain the recognition of their achievements at studying and estimate of their pedagogical activities;

✓ fourth, for those who are responsible for pedagogical diagnostics to be able to plan such researches which would stimulate their administration to search new ways of improving the education programs and education policy in general;

✓ fifth, in order to make possible to conduct effective policy in the sphere of labour resources, based on more elaborated procedures of professional training, employment and further professional growth of the specialists, as well as performance of such policy in the sphere of recruitment which would allow attracting worthy candidates for authoritative positions and rejecting those who do not suit them.

S.B. Adams (2009) characterizes general expertise of a person as a complex of cognitive, activity (behavioral) and passive (affective) components (Adams, 2009). Analyzing the concept of 'expertise' as a psychological trait he includes already not only cognitive (knowledge) and operational-technological (activity) components, but also motivational (emotional), ethical, social and behavioral components.

The 'Professional Education' dictionary provides the following definitions:

Expertise is the measure of compliance of knowledge, skill, experience of persons having a certain social and professional status with the real level of complexity of the tasks and problems which they perform and solve;

Competence is the range of powers, rights, and obligations of a certain authority or the range of problems where a certain officer has knowledge and experience.

Some scientists define expertise as a complicated synthesis of cognitive, objective and practical as well as personal types of specialist's experience.

For example, according to K. Mause (2013) expertise includes the following components:

- Cognitive and operational-technical;
- Motivational, ethical, social and behavioral;
- Results of education (knowledge and skills)
- System of value orientations.

Thus, one may state that professional expertise of future engineer is theoretical, practical and psychological kinds of his or her readiness to the professional activities, manifesting in his or her creative ability and universal (personal, professional, psychological) readiness to its effective implementation and achievement of the best results in the professional activities.

The approach of some researchers to the tripartite structures of readiness meaning the following three components is of a significant interest for our research (Starova & Zinov'ev, 2016):

- Physiological – the best state of all the main physiological body functions;
- Professional – the complex of the systematic special knowledge, skills and experience;
- Personal – all the peculiarities of the psychological processes, states and phenomena at the conscious level.

Summarizing the theoretical provisions suggested by various researchers one may conclude that the readiness as a complicated dynamical structure includes the following components:

- Motivational (motives, needs, professional mindsets, interests, values, ideals etc.);
- Orientational (the knowledge of the peculiarities of the activities and their requirements to the specialist);
- Operational (command of the methods and tricks as well as the culture of professional activities);



— Willing (self-control, self-mobilization to a certain kind of activities and overcoming the difficulties connected with them);

— Evaluative (self-evaluation of personal readiness).

All the components integrally exist in the single structure of a specialist's readiness to the professional activities, their level of development and completeness is the indicator of a high level of a specialist's readiness, which is ensured by his or her vigorous activity in achievement of a goal, mobility of inner conditions, peculiarities of various psychical processes, integral manifestation of congenital and acquired mechanisms and the culture of behavior, communication and the activities during the entire process of his or her professional training in the higher educational institution (Lambert, Terenzini & Lattuca, 2007).

The United Nations General Assembly announced 2005-2014 the decade of education for sustainable development – i.e. the period aimed at forecasting and forming the knowledge, skills, relations, the activities style of people and communities, personal traits and competences which will provide the improvement in the quality of life. Social procurement for preparation of scientific staff is one of the paramount tasks of higher education. That's why for formation of a researcher's personality it is necessary to define the content of research competence of future specialist.

According to the analysis of many literature sources, the today's education should be proactive and be focused on identification of personality through acquisition of life and professional experience nominally structured as competences.

In pedagogics, perceiving the competences as the basic components of potential expertise which can be demonstrated by a graduate, has obtained concurrence. The most relevant seem to be the ideas of Yu.V. Panfilov, Yu.B. Tsvetkov & A.I. Belikov (2016) who understand competence as a certain norm of professional training of an officer, while the formed expertise – as a result of this training.

Engineer is a complicated concept uniting in its conceptual meaning the results of pedagogical and engineering training. That's why considering research competence of future engineers we deem it to be reasonable to apply to the experience of defining a certain competence both engineers and teachers.

According to the requirements to competences of the engineering programs graduates suggested by H. Choi & B. Shields (2015) and adapted to the requirements of the WA Graduate Attributes and Professional Competencies, the content of each competence is represented in accordance with the levels of educational training. The educational level of bachelor complies with such 'descriptive' characteristics of research competence as conducting a complex engineering research including the search of the necessary information, experiment, analysis and interpretation of the data with the application of the basic and special knowledge and modern methods for achievement of required results.

At the same time the scientists suggest forming the skills of research activities of future teachers by introducing such special courses as 'The Bases of Scientific and Research Activities', 'Scientific Bases of Research Organization'

which will allow revealing the methodology, structure, scientific apparatus, and methods of pedagogical research (Resta & Laferrière, 2007).

Drawing on the fact that the knowledge of the scientific research methods and command of the methods of their successful implementation are important conditions for organization of productive research activities, we consider necessary to base the structure of research competence on such components as command of theoretical and experimental methods of research and the methods of organization of the research process.

The culture of an individual scientific research organization depends on the level of command of the methods of research activities. There is no consensus on the classification of the research methods (Loyalka et al., 2014).

All the scientific research methods are traditionally divided into the empirical methods – those which are perceived by sensory receptors, and theoretical. Also the scientific research methods particularly theoretical methods divide the methods of scientific cognition (dialectical method, method of revelation and solution of contradictions, generation of hypotheses) and the methods of theoretical research (analysis, synthesis, comparison, abstraction and specification). Empirical methods of research are also divided into two groups. So, C. Baillie, J.A. Bowden & J.H. Meyer (2013) separate working and partial methods of empirical research (search of literature, documents and results of the activities, observation, survey, the method of expert analysis and testing) and complex general methods based on application of one or some partial methods (monitoring, studying and generalization of experience, research process and experiment). E.V. Habaeva & M.S. Hozjainova (2016) considering methodology as a theory of activities, suggest classifying both groups of the research methods as the action methods and operation methods. In other words the classification of scientific research methods according to E. V. Habayeva, M. S. Hozjainova is the following:

1) Theoretical methods:

- Cognitive action methods: revealing and solving contradictions, setting the problem, generation of hypothesis and so on;
- Operation methods: analysis, synthesis, comparison, abstraction, specification and so on;

2) Empirical methods:

- Cognitive action methods: investigation, monitoring, experiment and so on;
- Operation methods: observation, measurement, surveys, testing and so on.

In our opinion, the structure of research competence should imply gradual acquisition by the students of certain general methods of scientific cognition. For preparation of the engineers qualified as ‘bachelors’ we divided all the content of research competence into four levels of digestion in accordance with the degree of complexity and in such sequence where the digestion of the previous level is an important precondition for digestion of the next one. Such succession of content in the educational process can be achieved by introducing the elements of studying the methodology of research activities during the entire process of education from the first to the fourth course.

The first level of research competence according to our structure is elementary, containing such components as mastering theoretical methods of



scientific research (induction, deduction, analysis and synthesis) and mastering the method of studying psychological and pedagogical, scientific and methodical literature and archive materials. The last component will imply mastering the skills of bibliography compilation, precis-writing, note-taking, annotating and quoting. These are exactly the components of educational and exploratory activities which are necessary for the first year students to obtain primary experience of research activities.

The second level of research competence is operational, as the operation methods prevail in it. The components of mastering theoretical methods of scientific research are the methods of comparison, classification, abstraction and specification. The main methods of empirical scientific research are monitoring and measurements as well as a complex method of revealing contradictions on the basis of the studied best practices (Ovcharenkov, 2016). We added the third component to the operational level which can be related to the methods of organizing the research, exactly drawing up a research methodology. There we class the element of setting a problem, singling out the subject and object of research, defining the objective and tasks of the research, generating the hypotheses. The second year students should be already able to analyze, correlate and compare, classify the phenomena and categories, substantiate the problem theoretically, setting the goal and tasks of the research.

Also the students should acquire the experience of conducting laboratory observations and measurement of quantitative characteristics of certain objects (Innovative technologies, 2016).

The third level of the research competence by its content covers the following components: theoretical methods of scientific research (analogy, modeling, formalization, idealization, and generalization), practical methods of scientific research (testing, polling, surveying, expert evaluation method), and also the major part of scientific research design. I.e. it implies the skills of compilation of the research methodological apparatus and the experiment program. That's why we deem it to be reasonable to call the third level of research competence the design level.

The fourth level is technological; it consists of four elements such as generation of logical structure of the theoretical research, application of correlation analysis and description of the data obtained. The fourth year students due to the acquisition of the scientific research method should be completely ready for conducting independent research both in their profile and pedagogical area (Crawley, Brodeur & Soderholm, 2008).

Gradual acquisition of research competence implies its growth by the stage levels in accordance with the correspondent courses.

By the model it is meant the artificial object which in the simplified form reflects the structure, peculiarities and relations between the elements of the investigated object as defined in a pedagogical dictionary. We suggest the level-based structure of the content of the future engineers' research competence according to which gradual load of professional training is imposed to the students by the methods and methodology of scientific research.

Discussion and Conclusions

We have represented the model of research competence of future educational engineers, the structure of which includes the following components: knowledge of

theoretical research methods, empirical research methods, the methods of the research process organization. The described components are suggested to be introduced gradually into the content of professional training. The corresponding levels of inclusion of the research competence elements into the content of the engineer education are suggested to be identified as elementary, operational, design and technological levels. The research competence level structure suggested by us implies development of authors special course aimed at implementation of gradual methods for acquisition of research competence by the future engineers in the process of professional training.

Ensuring formation of future engineer's readiness to professional activities requires significant organizational, technological, methodical changes in the educational process of the higher educational institutions the authority of which is defined by the readiness of its graduates to the professional activities.

1. The new paradigm of education in training of future engineering specialists should ensure reconsideration of the former training experience taking into account such brand new approaches to its substantiation as:
2. Understanding of necessity in substantiation of the methodology of engineering specialists' professional competence formation in the process of their training in the higher educational institutions;
3. Search of adequate theoretical bases for research by pedagogics, psychology, educational philosophy, sociology, informatics and legal study of the pedagogical phenomena which are connected with the engineering specialists' professional competence formation in the process of their training in the higher educational institutions;
4. Understanding of necessity in engineering specialists' professional competence formation both in the process of study and in the process of extracurricular activities;
5. Studying, systematization, and creative application of positive national and world experience in the training of future engineering specialists in the higher educational institutions;
6. Change in the stereotypes of perception of engineering specialist's personality and awareness of the necessity in formation of his or her personality and the main kinds of competences;
7. Innovative concept of the place, role, task and function of modern engineering specialist in the system of social, industrial and interpersonal relations in the country economic management;
8. Understanding the necessity in a brand new direction of educational researches regarding the training of future engineering specialists to the professional activities.

Recommendations and Perspectives of the Research

The system analysis of the problem of competence-based approach in education, clarification of the content of such concepts as 'competence', 'expertise' and 'competence-based approach' show that the problem is manifold, complicated and requires interdisciplinary solution. Though, the competence-based approach in education contributes to focused formation of the main kinds of the higher educational institutions students' competences.



One of the main indicators of the future engineering specialist's professional competence is the established professional way of thinking, which represents his or her intellectual ability to solve professional problems and the content of which is directly connected with the solution of professional tasks at production site, and it is the direction of further researching.

Disclosure statement

No potential conflict of interest was reported by the authors.

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