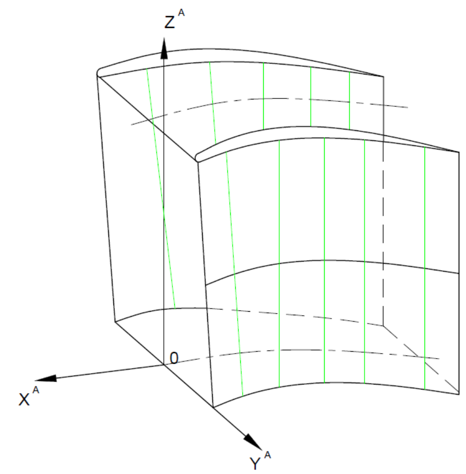
acquired skills are universal.

Conclusions

The discussed research enhances the development of undergraduate professional competences, furthers the cross-disciplinary communication in relation to modern education standards. The students are involved in research from the very first days which reveals their creativity potential. This also initiates the understanding of complex and multi-functional problems which future student-professionals will encounter in their life.

Fig. 12.



REFERENCES

1. Ivanov, G.S. Theoretical fundamentals of engineering geometry – Moscow: Mashinostronie, 1998. – 157 P.
2. Olkhovskii G.G. Energy gas turbine units. – Moscow: Energoavtoizdat, 1985. – 282 P.
3. Shlikhting G. Boundary-layer theory. – Moscow: Nauka, 1974. – 184 P.
4. Frolov S.A. Engineering geometry. Moscow: Mashinostronie, 1978. – 181 P.
5. Shnez Ja. I. Theory of gas turbine. – Moscow: Mashinostronie, 1979. – 202 P.
6. Deich M.E. Technical gas dynamics. – Moscow: Energy, 1974. – 115 p.
7. Standards of ESDD – Moscow: Standartinform, 2012. – 500 P.

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Methodology of Engineering and Technical Activity Analisys for Development of Academic Content Standards

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The author addresses the issue of methodology used within the institution to modify the learning outcomes of technical education. The paper represents the methodology for manufacturing process analysis conducted to develop academic content standards for engineering education of automotive profile. The content of structural elements in the analysis of manufacturing process has been substantiated. The methodology for representing production activity parameters in the form of education standards (competences) has been suggested.

Key words: professional education standard, graduate's competence, education standards (competences), methodology, vocational training.

Introduction

The methodology of engineering and technical activities analysis is an important issue today, as the universities need to determine the competences necessary for the graduates to correspond with the requirements of the regional industries.

In Institute of Transport, State University – Education-Science-Production Complex (SU ESPC), the strategic planning of educational process is aimed at supplying the demand of the automotive industry in professionally qualified human resources. Especially important is the main objective, namely, to develop professional competences relevant to the engineering and technical staff since the university graduates usually take these positions within the first two years of their professional activities.

Both technical and technological progress in automobile service and the emergence of new enterprises (authorized distributors of well-known automotive manufacturing plants) in Orel region have caused significant changes in the regional automotive industry. As a result, the automotive industry personnel and SU ESPC academic society understand the need for changes in higher professional education system and are ready for them.

Having analyzed the employers' satisfaction with the quality of higher professional education provided at Institute of Transport, SU ESPC, it is possible to state that some professional competences of graduates, who studied at the department of "Operation of Vehicles and Production Machines and Complexes", fail to correspond with the current requirements of the automotive industry. The disagreement between the industrial needs and the professional competences is caused by the fact that the traditional system of higher professional education is characterized by the lack of the dynamic response to the current technical and technological changes occurring in the industry. In Institute of Transport, this disagreement is supposed to be overcome by setting standards for learning outcomes. These standards are based on the systemic study of engineering and technical production activities. Thus, the development of master and bachelor degree programs at the department of "Operation of Vehicles and Production Machines and Complexes" is based on the analysis of the activities performed by the successfully developing automotive companies of Orel region. The professional competences determined as learning outcomes by the university standards are regarded as the information carriers of the industry requirements to the professional qualities of engineering and technical staff.

The systemic analysis of technical production activities as the basis for education standardization results from the needs of both industrial and educational spheres. It is important that the methodological knowledge within this system is regarded as practice-oriented and feasible, and providing the basis for efficient pedagogic activities.

Methodology for the production activities analysis

Learning outcomes of the higher education institution graduates are determined by a set of competences (education standards), which a student should master within the period of studying at university [1, 5, 8, etc.]. The education standards which imply the professional competence of the graduates are determined by the requirements of the engineering industry. Therefore, the analysis of production activities provides the basis to identify the standard outcome of the professional education.

There are two model types, which are regarded efficient in terms of standardization and thus necessary to be developed. They are the model of specialist's activities and the model of graduate's learning outcomes. It is noteworthy that the foundation of graduate's learning outcomes model rests on the model of specialist's activities. It is important to identify and develop both models as they are characterized by two different objectives. The objective of the specialist's activities model is to represent fully and consistently all activity types, as well as the whole range of industrial production goals and problems solved by the personnel in charge. However, the specialist's activities model fail to be implemented into the competency-oriented educational process as it does not suggest any education standards amplified for pedagogics, i.e. graduate's competences. In its turn, the model of graduate's learning outcomes brings the data contained in the model of the specialist's activities into education standards, with all necessary educational and personality development characteristics being specified.

Automotive manufacturing operations performed by engineering and technical staff are varied and complicated. As a result, the attempt to identify operation components seems to be a great challenge. However, practice-oriented approach to this task allows finding the efficient solution: the aim of the manufacturing operations analysis is to identify the bulk of competences necessary for the graduate to cope successfully with future work responsibilities.

The manufacturing operation analysis is the source of information essential to develop education standards, i.e. competences, for a certain specialty. The necessary amount of information and its reliability are provided by the scheme of the manufacturing operation analysis.

In technical industrial engineering, one can identify three major aspects of professional activities: professional, moral and ethical, and social [9, 11]. Education standards oriented at learning outcomes comprise all three aspects and represent them as graduate's competences. In the course of the manufacturing operation analysis, each aspect is considered separately. However, only three aspects in combination ensure the efficient manufacturing operations. Therefore, considering the aspects separately is just a method to develop a complete academic content standard.

The elements in the analysis of social and professional environment

Manufacturing operations in technical sector are performed in a certain social and professional environment. Therefore, some particularities of manufacturing operations may be identified through the analysis of social and professional environment of the companies. The social and professional environment within the sector of technical industrial engineering can be considered at two levels: macro-social and micro-social [2, 4]. Macro-social level of professional activities comprises the factors which are characteristic for the regional manufacturing. These factors are geographic, ecological, demographic, and sociocultural ones. Higher education institution graduates are employed at the enterprises of one business profile (in compliance with the graduates' specialty) but these enterprises may be of varied types. For instance, the graduates of Operation of Vehicles and Production Machines and Complexes department, Institute of Transport, SU ESPC, are employed at the automotive companies of Orel region. However, the companies differ. According to the data on the demand for human resources at the geographical market, the graduates may be employed not only at service stations, but also at logistics companies, automotive companies which sell cars and repair parts, and filling stations.

In the manufacturing process analysis, it is important to study the elements, which reflect the micro-social level of the social and professional environment. In contrast to the macro-social level, which is under the influence of the regional particularities, the micro-social level implies the company's characteristics. The analysis at the micro-social level includes the following elements: technical, technological, organizational, and socio-psychological [7]. These aspects being taken into account, the manufacturing operations analysis represents the complete range of particularities characteristic for automotive companies. It is important to note that different automotive companies are characterized by different elements of the micro-social level. For example, technical and technological aspects are the most relevant for service stations. For automotive companies selling cars and repair parts, economic and socio-psychological aspects are the most significant since one of the most important employee's abilities is to influence the buyer's choice. It is possible to conclude that the starting point for development of the professional activities model is identifying sociocultural elements characteristic for these activities. One should take into account that the objectivity of information obtained at this stage results in adequacy of competences (education standards) developed on the basis of these data. Taking into account all analysis aspects, the professional activities might be represented as a core model. The core is an operational component of the professional activities while the surrounding layers are macro-social and micro-social levels. Each element specified is a complex object with a particular structure. Thus, the core structure includes the components as follows: types of manufacturing operations, employee's responsibilities, types of manufacturing tasks to be solved by the employee. Considering the whole structure, it is possible to identify the elements of particular professional and social environment, which will be used as a basis to develop academic content standards.

If to consider the components of different elements within the model of professional activities, one can identify significant correlations. Developing the macro-social element of the model, it is possible to recognize the particularities of professional activities, which are characteristic for the region. These data make the core of the model, i.e. the types of professional activities. These types allow determining the functions fulfilled by the employee. As a result, it is possible to represent the model of professional activities in detail.

Many technical and technological changes regularly occur in the automotive industry which is intensively developing. What is important, the structure of the manufacturing operation model can be modified in response to these changes. It is noteworthy that the structure

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allows considering the impact, which a modification has on the other elements. This makes it possible to modify, specify, and update the academic content standards.

Manufacturing process environment: the stages of analysis

To develop education standards, one should identify the bulk of competences necessary for the graduates. The analysis of manufacturing process environment includes several consecutive stages. To get the data relevant to the analysis objectives, it is important to determine the order of stages for the procedure to be consistent. This can be provided if the stages of the analysis correspond to each other: the statement formulated at a certain stage should appear in evidence of the conclusion made at the previous stage and condition the statement of the following stage.

The first stage is understanding of and argumentation for necessity of correspondence between the graduate's professional competences and the efficiency of activities performed by the company staff of the same qualification. The second stage is setting the aim of the manufacturing operation analysis. If the aim of the manufacturing operation analysis is to design the graduate's competence model, the development of education standards (i.e. competence content) is the objective of the second order [8]. It is important to note that in virtual university environment the manufacturing process analysis can be initiated by the administration order to develop the graduate's competence model for a certain specialty; however, this does not exclude the first stage when the importance of this task is realized. Under these circumstances the first stage seems to be vague but it still exists. To get the efficient results, all analysis stages should be passed through: it can be done in the direct order (towards the analysis aim) or in the reverse order (restoring the whole context of the analysis). Therefore, under the circumstances described above, the first stage should be restored even if the analysis started with the second stage.

The aim of the manufacturing operation analysis, i.e. identification of the graduate's competences corresponding to the demand of the regional human resources market, is determined by the industry, on the one hand, and the higher education institution, on the other hand. These two options are not exclusive but mutually supportive. The goals of the two social spheres are different: while the industry needs efficient human resources, the institution aims at improving educational process. The global aim, namely, identification of competences, is achieved only through collaboration between the institution and the companies-partners.

The third stage of the analysis is to set the pedagogical problem, which is to be solved through the analysis. The pedagogical issue of education standards should be appropriately considered. Thus, the aim of the manufacturing operation analysis, i.e. identification of the graduate's competences, identifies the pedagogical problem connected with the forms of competences' representation. Moreover, the form of representation should be appropriate as an instrument of feedback connection between the institution and the enterprise. Therefore, it is necessary for the education standards to contain complete and consistent information on the industrial requirements for the professional education. It is a well-known fact that the adequate representation of manufacturing process requires its formalization [12]. Formalization implies that the phenomenon being analyzed is split into structural elements. In the course of the manufacturing operation analysis, the responsibilities of the employee are formalized and represented as the graduate's competences. Consequently, the formalized description of professional responsibilities provides us with all particularities and details which should be taken into account. Another supportive argument for this procedure is competences themselves being relatively constant and well-defined.

The fifth analysis stage is the choice of the object. Manufacturing process as the analysis object is a complex integrating work objects, tools and instruments, technologies, production relations. The complexity of the analysis object ensures the analysis sustainability. As the object is complex, analysis methods should be complex as well to obtain the data necessary for the development of academic content standards. The analysis is conducted at different levels and provides complete understanding of the object. Moreover, the analysis complexity in ensured through considering the object from interdisciplinary perspective, which integrates the following disciplines: the economics of business enterprise, technical tools and their application, enterprise management, psychological and social aspects of work, etc. Multi-level analysis implies considering each element of the manufacturing process in terms of its content and function, which the element performs within professional and social environment. This helps to identify personal qualities of an employee as a specialist and as a member of social fabric.

Thus, multi-level analysis makes it possible to regard the object, namely, professional activities of technical profile, from different perspectives, which provides the data sufficient to develop academic content standards. Multi-level analysis allows identifying particular states of the object, which reflect various aspects of the unity [9]. The particular levels provide the researcher with complete and consistent information on the requirements for the specialist qualification which ensures professional success. Moreover, multi-level analysis makes it possible to group education standards reflecting the graduate's learning outcomes. It seems reasonable for the number of education standards (competences) groups to be equal to the number of aspects considered. It makes the standards well-structured and consistent as well as prevents amorphousness in the description of the standard components.

Engineering and technical activities make up a complex object [12]. As a result, the levels are distinguished conventionally. Therefore, there are no strict criteria which allow referring the particular element of production activity to the particular level of analysis. The principle of completeness in the description of the object implies identifying the complex of parameters which characterize the professional activity. To fulfil the pedagogical function, namely, to develop the professional education standard, it is enough to provide the complete description of the corresponding competences. It is noteworthy that completeness of description can never be absolute but only sufficient for representation of feasible activities performed by the specialist. More important, the aspiration to complete representation of all parameters of the object may cause the lack of emphasis on the major aim of the analysis, i.e. academic content standard. It is the empirical process of analysis that can ensure the optimal completeness in the description of the object parameters and consequently the optimality of academic content standards.

The empirical analysis is an essential condition to develop hand-on education standards (competences) of technical profile. The complexity of manufacturing process requires the empirical research of its parameters. However, the empirical character of the analysis does not eliminate the importance of the theoretical basis. The empirical approach to manufacturing process analysis is chosen to prevent an opposite approach – a priori one. A priori choice of manufacturing process characteristics inevitably results in the lack of accuracy, which weakens the relevance of education standards to the feasible professional qualities demanded by the industry. As a result, empirical approach to manufacturing process analysis verifies academic content standards in terms of their completeness and reliability. Most important, the empirical analysis ensures operability of education standards and consequently the efficiency of educational process at higher educational institution.

Methodology of representing production activities in terms of education standards

The important stage of education standardization is transformation of production activity parameters into education competences. The parameters of production activity represented as education competences are to reflect the manufacturing process without any distortion. On the one hand, any parameter of production activity represented as a competence should be recognizable for the employee of the relevant industry. Therefore, the use of any pedagogical or psychological terms in the description of the competence content is unappropriate, even if the terms express the idea of the competence to full extend. Under these circumstances, the competence content should be described in the terms typical for the social and professional environment of a given industry [7]. On the other hand, each competence represents the education standard and its content should not be reduced in purpose to simplify wording. Each professional competence as a learning outcome reflects a particular parameter of the production activity. It is obvious that each education standard should be self-contained. Therefore, the competences should be independent of each other: the competence should never contain any elements of the other competence, in other words, they should not be overlapping. However, it is important to ensure interconnection and complementarity of competences [8]. This thesis is supported by the principle of completeness in education stastandardization, which indicates that the competences, each representing the total learning outcome, should be interconnected as the parts of the whole. The unity of competences within one structural group are unilevel and homogenious characteristics of a particular professional education parameter [8]. It is obvious that the list of competences reflecting production activity parameters should be tested for the completeness of representation. It is stated that the list of graduate's competences may be modified and updated. However, the competences added to the list are not to double the content of other competences. For the experts who estimate the list completeness, it is important to consider that the list of competences represent only the most significant parameters of future production activity. This is the reason why the completeness of the list is supposed to be sufficient but not absolute. It seems to be reasonable to add the competences which were supported by no less than 75% of experts (on the basis of the probability rate of consistent coincidences). This will ensure that the connection between the lists of competences regarded as essential by the experts is significant and positive. The competences beyond the list are considered by the experts as minor. The number of competences at any level can never be limited or set in advance. Every time when the academic content standard is developed for a particular specialty, the number of competences is set by experiment since each profile of production activity is characterized by specific features.

Conclusion The author's experience in the development and implementation of principle bachelor and master degree programs for "Operation of Vehicles and Production Machines and Complexes" at SU ESPC (Orel) proves the efficiency of the methodology suggested for development of academic content standards of technical profile. The major advantage of the methodology is orientation at learning outcomes of professional education one the basis of the industrial demand for professional competences of engineering and technical staff.

REFERENCES

1. Panina T.S. A New Model of Professional Education for Innovative Economy / T.S. Panina, N. Pavelyeva, S. A. Dochkin // Professionalnoye obrazovanie. Stolitsa. – 2010. – № 1. – P. 37-39.
2. Sazonova Z.S. Integration of education, science, and manufacture as a methodological basis for modern engineering education: PhD dissertation: 13.00.01 / Sazonova Zoya Sergeevna. – Kazan, 2008. – 440 p.
3. Serov V.G. Topicality of professional education for small enterprises // Topical issues of modern science: collected papers. – Novosibirsk: SIB PRINT, 2010. – P. 87–92.
4. Solodovnikova O.M. Shaping competences for elite technical specialists\ Ed. O.M. Solodovnikova,O.V. Zamyatina, P.I. Mozgaleva, M.V. Lichaeva. – 2013. – № 11. – P. 65-71.
5. V.I. Education standard: the experience of systematic research: monograph / V.I, Baydenko. – Novgorod: Yaroslav-the-Wise NovSU, 1999. – 440 p.
6. Bordovskaya N.V. Time challenge and new models of developing education environment // Chelovek i Obrazovanie. – 2013. – № 2 (35). – P. 4-11.
7. Elagina L.V. Developing professional activities culture of future specialist through competency-based approach: methodology, theory, practice: PhD thesis / Elagina Ludmila Vasilyevna. – Chelyabinsk, 2009. – 59 p.
8. Lubimova O.V. The fundementals of education standardization: monograph / O.V. Lubimova, O.F. Shikhova. – Izhevsk: ISTU Publishing House, 2009. – 184 p.
9. Ivanov N.I. Philosophical issues of engineering: theoretical and methodological aspects / N.I. Ivanov. – Tver: TSTU, 1995. – 100 p.
10. Belonovskaya I.D. Developing engineering competence of a specialist at university complex: PhD thesis / Belonovskaya Izabella Davidovna. – Orendurg, 2006. – 42 p.
11. Russian employee: education, profession, qualification: monograph / Edited by V.Ye. Gimpelson, R.I. Kapelyushnikov: National research university "High school of economics", 2011. – 574 p.
12. Gorokhov V.G. Sciences: the history and theory (the history of science in philosophical perspective) / V.G. Gorophov. – M.: Logos, 2012. – 512 p.