industry, is the formation of network education system. It will bring together the potential and competences of universities of different profiles under the aegis of the Tyumen State Oil and Gas University with involvement of research institutions and leading industrial enterprises distributed among different regions of the country. Figuratevely, we would call such form a "structured Network University"; it would provide solutions for top-priority issues, assure the development of industry and training of specialists ready to perform professional activity without additional adaptation period.

Each of the above-mentioned problems and solutions is a subject for development and specification. Tyumen State Oil and Gas University understands the problems today and is already implementing a scope of measures to provide the region with new generation of engineers. Elaboration of the whole Tyumen region's economic development strategy for professional education, which binds together the strategy to the south, the Khanty-Mansiisk Autonomous District, and the Yamal-Nenets Autonomous District, is necessary for the breakthrough. It is essential to decide: whom to train, what is the number of these people and who will be doing it. The challenges of the XXI century urgently require it.

REFERENCES

1. Verbatim record of board meeting of President's Council on Science and Education [Online resource] // kremlin.ru : official web-site of the President of the Russian Federation. – Moscow., 2015. – URL: http://www.kremlin.ru/events/president/news/45962, free. (date: 25.05.2015).
2. State program of the Russian Federation "Social-economic development of the Arctic zone of the Russian Federation for the period till 2020" [Online resource]: approved resolution of the Government of the Russian Federation on April 21. 2014 N 366. – Access from Database "Code".
3. R.M. Bembel Geosoliton: functional system of the Earth, concept of exploration and development of hydrocarbon deposits / R.M. Bembel, V.M. Megerya, S.R. Bembel. – Tyumen: Vector Buk, 2003. - 344 p.
4. M.V. Kovalchuk From the synthesis of science to the convergence of education // Educational policy. – 2010. – № 11-12. – P. 49-50.

UDC 378.14

Process Approach Application to Engineering and Education

Branch of National University of Science and Technology MISIS
V.P. Solov'ev, T.A. Pereskokova

V.P. Solov'ev

T.A. Pereskokova

"You can't solve a problem unless you first admit you have one"
Harvey McKay

The article is devoted to the implementation of process approach to any kind of professional activity as declared by the ISO 9000 Norm. The importance of evaluating process features: its productiveness, efficiency and adaptiveness, is emphasized. The article underlines practicality of the process approach introduction to educational activities for training competent engineers, who will base their own professional performance on this approach.

Key words: process approach, productiveness, efficiency and adaptiveness of processes, product quality, quality standards.

Any type of action involves certain work functions: steelmaker melts steel in an electric arc furnace, accountant calculates employees' wages, professor teaches students to solve differential equations, etc. How can we envisage realization of all these functions as a whole? Most likely, it should be envisaged as realization of various interconnected actions that are conducted consecutively or in parallel. Today these various actions are generally recognized as processes. One of the founders of modern quality management, E. Deming, stated "Any action can be seen as a technological process and, therefore, can be improved".

Modern management of organizations is based on quality management systems. Ideology of such systems focuses on 8 principles of quality management. The central (ground-breaking) principle is the process approach: **expected outcomes can be achieved more efficiently, if actions and corresponding resources are managed as processes** [1, p. 2-3].

What is meant by application of the process approach? Let's try to understand it by looking at the examples of educational and production activities. Production activity here is the foundry production, which provides main rough materials for automobile, aircraft, machine-tool and tractor production.

Foundry production requires a multifunction technological process. Batch preparation, alloy smelting, foundry sand and core sand mixtures' preparation, casting form and core molding, die casting, cast processing – all are parts of foundry final goods' production lifecycle. When using other methods for cast production: die or ceramic mold casting or consumable pattern casting, such multifunction remains. This brings up a question: "How to achieve required quality of a product in the context of such multifunction?" Overall technological process is divided into sub-processes. Organizational structure of production process (production units, departments, divisions, services) is built upon these sub-processes. Each structural division is responsible for its own sub-process. This is a typical functional organizational structure. What are the draw-backs of such structure?

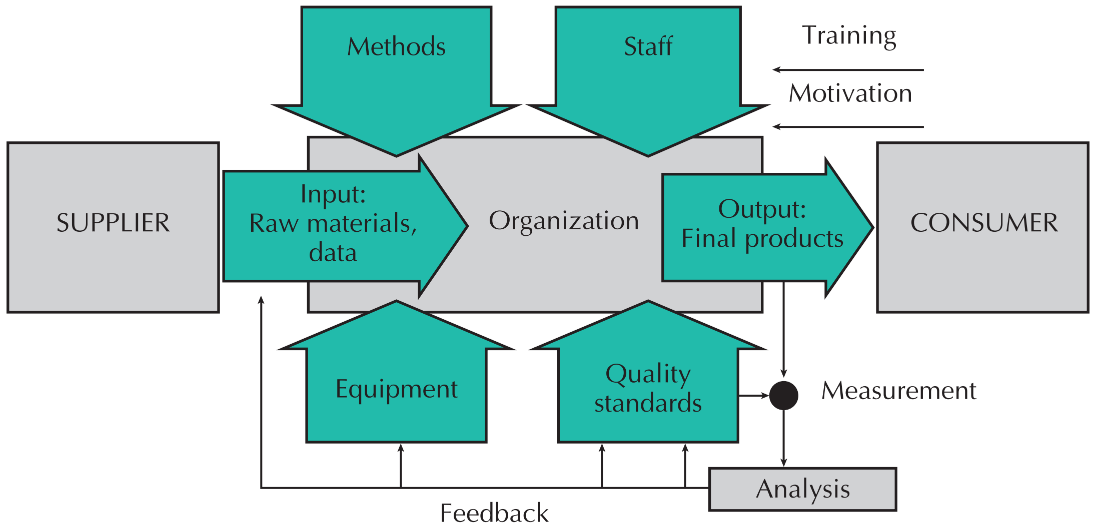
Let us provide a vivid example from the

personal experience. One of the authors happened to work at Leningrad Pipe-Rolling Plant after graduating university, first as a master, later as a head of smelting department. The main products of the plant were large-diameter cast-iron pipes for water pipe-line construction and underground tubing. Every now and then representatives of all departments, involved in production processes, joined at pipe and foundry units to review items rejected by the Quality Control Department. Each representative had a preset aim in mind: not to let QCD confirm that the damages occurred with the fault of his department, since it would have led to bonus shortcut for all the department staff. This was a typical functional approach (and we knew no other), when no one strived to identify real causes of faulty goods production and take further remedial of preventive actions.

But if all the departments involved in tubing (pipe) production worked on a single process (while remaining to be separate organizational structures) and had a common goal to achieve required quality of the products, then during the inspection of faulty goods we all would have looked for the cause of their appearance. And the occurring consequences of faulty production would have been split between all the participants of production process regardless of the "guilty ones". And this is the process approach. We are sure that the quality of produced goods would have been bettered constantly.

Now, let us turn to the educational process. Even within a single semester students are taught by different professors, each of whom follows a specific curriculum of the study course. But can we be sure that the contents of study courses correspond to one another; that all professors commit to the final outcome – graduates' mastership of competences needed for the professional performance? As a matter of fact, unfortunately, the majority of HEIs does not have that. Many professors (especially at the first years of study) are not extensively familiar with future profession

Fig. 1. Framework (model) of process performance



of graduates, do not know (and at times do not want to know) how the knowledge and skills, acquired by students while studying their course, should be applied later. This is a typical functional approach.

But what is the process approach? First, let us look into the process itself. In order to do so we need to address the ISO 9000–2011 Norm (Fundamentals and Vocabulary), concerning operations of Quality Management Systems of any organization [1, p. 9]. This norm defines process as a **"set of interrelated or interacting activities which transform inputs into outputs".**

Process can be presented in graphic form as shown on the Fig. 1, where Supplier – Organization – Consumer are all joined in one chain. This is how all the processes are executed: production process, service, data transfer, training and even nurturing.

We have required stock (raw materials) and data as inputs here, containing requirements towards final product, i.e. its quality requirements.

Technological process is performed using the provided equipment; it is conducted according to the developed technologies (methods); it engages the staff needed; it is organized and controlled in line with the internal quality standards.

A complex multifunction process of an organization, for instance, the mentioned process of foundry die production, is divided into sub-processes and operations (Fig. 2). A process results in transformation of input stock (raw materials) into output product. Acquired quality of final goods is the basis for process evaluation. Application of this principle allows for a clear definition of internal "suppliers" and "consumers", determination of their interaction areas, vesting power in them according to the level of taken responsibility. IDEF0 (ICAM Definition for Function Modeling) is widely used for visualization of process modeling.

Fig. 2. Multifunction process diagram

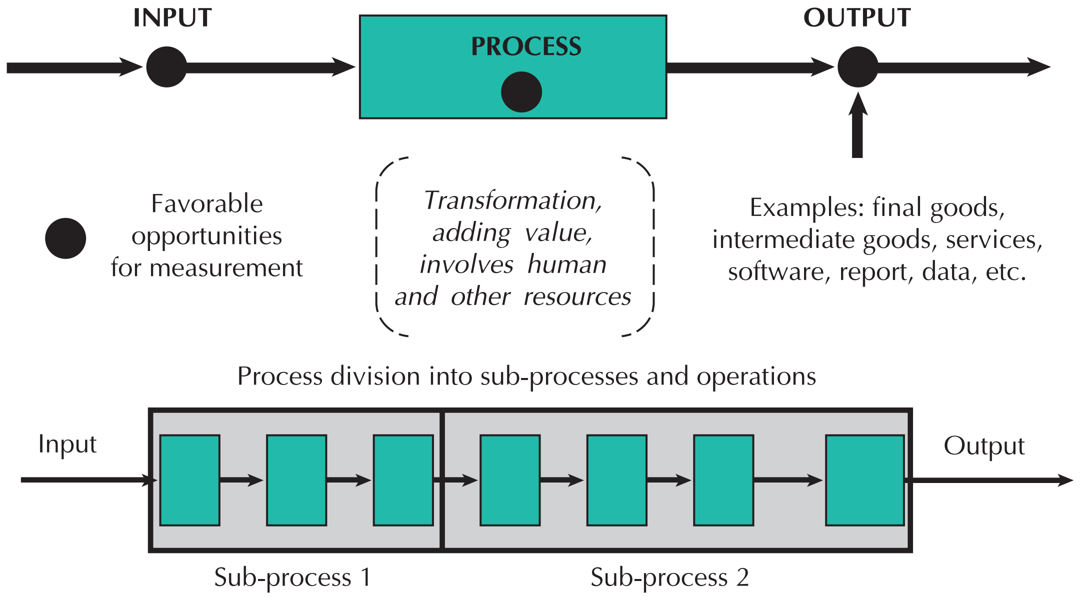
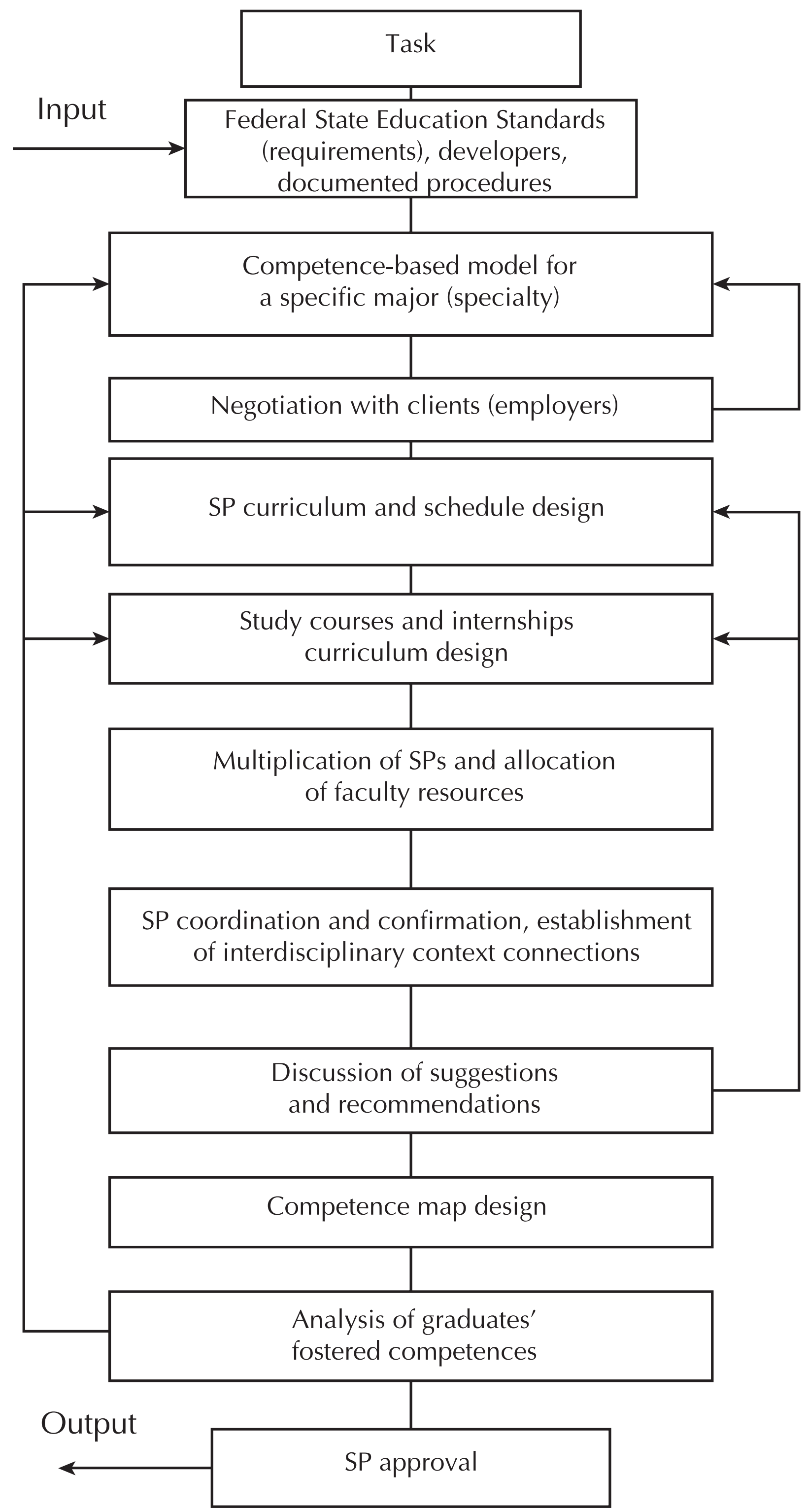


Fig. 3. Flow block diagram of SP design



It is a vivid "language" for understanding the essence of a process [2, p. 160-166]. Presenting a process in the form of a flow block diagram permits to "see" it vividly with all the possible intersections [3, p. 5-7].

This visualization tool is convenient for any process participants' training in the form of business games. Operational division of a process allows for determination of control points during the process performance.

It is worth mentioning that final outcomes hinge on the level of staff qualification and motivation. Process approach in QMS is considered to be the fundamental "pole" of the quality ideology that has to be encompassed by all personnel of an organization.

An example of a flow block diagram application for development of a study programs (SP) for engineers' training will be introduced further (Fig. 3). But first of all, the content of an SP will be agreed as follows:

- Competence-based model for training graduates of a particular major (specialty);
- Curriculum in Study Program;
- Curriculums in study courses;
- Curriculums in internships;
- Study schedule;
- Guidelines, recommendations on organization of a study process common for all majors or for a particular major.

When creating a competence-based educational model, besides competences specified by the Federal State Education Standards, HEI includes requirements of employers and the HEI itself, inter alia the requirements of professional standards on corresponding majors. It is reasonable to mark a specific block in an engineering training model – a block of tooling (instrumental) competences, i.e. skills that allow using tools and equipment, conducting measurements and presenting results, applying IT, etc.

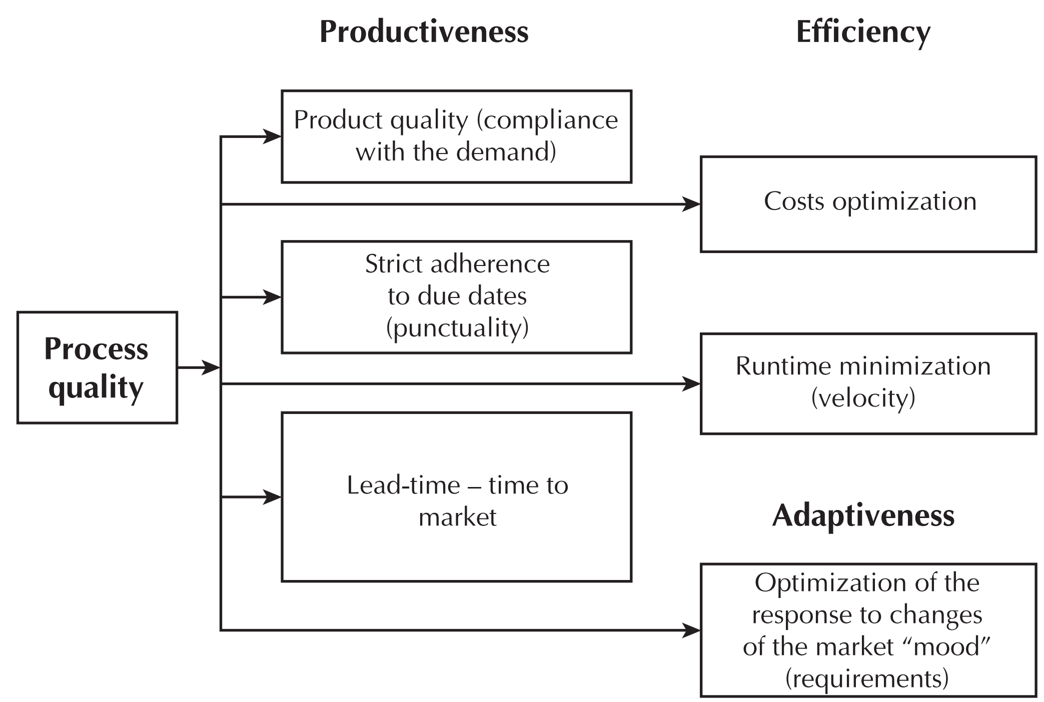
Thus, a flow block diagram presents the whole process of input-output transformation as a finalized SP. In fact, SP design process is conducted in line with a set procedure that documents performers of each operation and due dates, provides necessary document forms and procedures for coordination and confirmation. Teaching materials are developed for conducting educational process on each study course. They normally include:

- Course work programs;
- Synopsis of lectures;
- Supportive notes (student's workbook);
- Presentation;
- Classwork scenario;
- Lab case-studies;
- Workshop textbooks;
- Guidelines for studying the discipline;
- Diagnostic tests;
- Questions for assessing knowledge, skills and fostered competences.

Each professor develops teaching materials for his/her own study course. Future engineer's study curriculum includes more than 40 disciplines. Therefore, there will be 40 disciplinary sub-processes of an integrated curriculum for specialist's training. The scope of process approach application to educational activities is disclosed below.

Any process is assessed-based on three features, as shown on Fig. 4. **Process productiveness** defines achievement of set goals; most commonly those are the requirements of a client, determined by an agreement; and for the education those are the requirements of the Federal State Education Standards. It is definitely a key indicator of the performed process. **Process efficiency** concerns rational utilization of planned resources (material, financial, information, human) for the achievement of a set goal. **Process adaptiveness (flexibility)** plays an important role in the market economy relations, since there is a constant process of product and production improvement in the context of high competitiveness. In education it is also

Fig. 4. Features of any technological process



necessary at times to introduce changes that should correspond to the innovations in educational contents and teaching methods.

Unfortunately, many national articles and speeches assess processes (and many other things) using a widespread and familiar term "efficiency" without specifying the distinction between assessing achievement of goals and used resources. Such approach complicates determination of possible mismatches that occur during process performance, as well as causes troubles in taking necessary remedial of preventive actions.

Most Russian enterprises and organizations exploit functional management, when managers do not have the full authority to make decisions on their level of management.

These organizations remind an armful of sheaf, where each sheaf is a functional division. This is exactly the way an educational process can be pictured; where each discipline and its provider are the sheaf that is separate from any other discipline.

And the main issue of management, especially quality management, is to transform these separate secluded structures into an integrated whole in the context of overall technological process performance. In the functional approach each unit is an entity that runs its own activities, but in the process approach units are used only for the convenience of planning and resource accounting [4, p. 218-220].

When transiting to the process approach it is necessary to allocate the process "owner", who will be endowed the required rights. A process "team" is created regardless of staff's official positions. Process owner should manage the chain of product lifecycle processes from market

analyses to product's realization to the consumer. Interaction of processes may lead to the development of a multifunction process structure in an organization, which would permit to eliminate existing functional barriers of the management structure.

One of the authors, an expert of Russian Government Quality Award, had a chance to see the productiveness of the process approach (they called it project approach) used by metallurgical company "Severstal" when working on the construction of a complex for automotive sheets galvanization. The project team included heads of several production units and technical services, which, at the same time, were not released from their continuing duties. The person in charge (process owner), who joined all the participants for project's execution, was a young and active economist, who had graduated the National University of Science and Technology MISiS only 5 years prior to the time. A clear evidence of the project's success is the "Severgal" operating complex for HDG steel production.

In education the process approach is used, first of all, for making logical connections between the content of study disciplines. Each professor marks which blocks (study units) of preceding or parallel disciplines he/she uses in his/her course [5, p. 86-93]. Tab. 1 provides an example of finding connections between disciplines of a curriculum.

The developed matrixes will "show" application of knowledge and skills of disciplines from the whole period of study. Thus, tab. 2 provides an example of implementation of "Calculus" contents to other disciplines of a certain major's curriculum. A sum of all references on each study course (horizontal bars) indicates application of specific Math topics in a particular discipline. Whereas, a sum of references in columns (vertical bars) indicates application of Math contents in various disciplines, i.e. its significance.

In such case each professor knows, what his/her colleagues are expecting of him/her. Everyone is tied in a single process of students' training.

The result is the basis for managing mathematical, physical, chemical and other cycles of study disciplines of a major

Table 1. Matrix of interdisciplinary connections of study disciplines

Study units (blocks) of a preceding (parallel) discipline	Study units (blocks) of the analyzed discipline						Sum of ferences
	1	2	3	4	5	....	
1	x			x			
2			x				
3		x		x			
4	x				x		
5		x			x		
....							

Table 2. Consolidated matrix of discipline's content application

Subsequent (parallel) disciplines of curriculum	Study units (blocks) of preceding discipline (Calculus)						Sum of references
	1	2	3	4	5	....	
Physics	x		x		x		
Applied Mechanics			x		x		
Materials Science		x					
Physical Chemistry			x		x		
Thermal Physics		x			x		
Organization of Experiment			x				
Sum of references							

(specialty), by controlling the volume of fundamental knowledge application and reinforcement in other study courses. All these is necessary for assuring the quality of future graduates' training (the quality of education).

Planned curriculum of each discipline can be presented in general terms as a process map (Tab. 3).

A real process map would indicate names of the faculty involved, names of disciplines, list of fostered competences, guidance materials, performance dates. It creates a vivid system of actions that can be easily controlled, and paves the way to strive for the set goal.

When involved in the study process, learners should be bound up in it; they should feel all the operations of the process, its aims and outcomes. This will lead to the improvement education quality and cultivate process approach ideology in future specialist's mind.

Process approach together with team work is the life style of the cutting-edge organizations of the XXI century. It is the phenomenon of process thinking, i.e. such view of life that transforms the whole visible world into processes [6, p. 169-171].

Famous Japanese expert on quality, Kaoru Ishikawa, noted: "The ideal state of quality control occurs when inspection is no longer necessary".

QMS certification of an organization, first of all, evaluates the ability of its processes to guarantee required quality of the produced goods or services. Assessment of the level of management of technological and operation processes is the basic criteria for national quality contests, including the

Table 3. Terms as a process map

Discipline ___________________________

Process Input	Students with knowledge and skills, acquired while studying preceding or parallel disciplines
Process Output	Students with acquired knowledge and skills on this discipline (fostered disciplinary competences according to the course work program)
Process Suppliers	Professors of preceding or parallel disciplines
Process Consumers	Students, professors of subsequent of parallel disciplines, department administration, dean's office
Process Owner	Professor of this discipline
Process Aim	Fostering students' knowledge, skills, attitudes (fostering competences, including soft skills), students' nurturing (their "growth")
Administrative Actions	Faculty requirements (guidelines), orders of head of the department, dean, methodic council decisions
Resources	Professor's competency, guidance materials, lecture halls and labs, information support, educational environment
Assessment Criteria for Process Productiveness	Level of acquired knowledge, skills, attitudes of students (competence assessment); time for discipline learning
Methods and Means for Process Monitoring	Diagnostic and control activities, homework assignments, individual consultations

Russian Government Award instituted in 1996.

High competitiveness of many Russian and foreign organizations using process approach as a basis of their performance proved that implementation of the process approach is highly practical and beneficial.

REFERENCES

1. Quality Management Systems. Fundamentals and Vocabulary. ISO 9000:2005, http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=42180
2. Quality Management at University / edited by Chuchalin A.I., Pokholkov Yu.P. – Tomsk: TPU, 2004. –251 p.
3. Adler Yu.P. A process in the microscope / Yu.P. Adler, S.Ye. Shepetove // Quality Management Methods. – 2002. – Iss. 7. – P. 4-8.
4. Kruglov M.G. Quality Management as It Is / M.G. Kruglov, G.M. Shishkov. – Moscow: EKSMO, 2006. – 540 p.
5. Solovyev V.P. Education for Innovative Economy / V.P. Solovyev, Yu.A. Krupin, T.A. Pereskokova. – Staryi Oskol: TNT, 2014. –272 p.
6. Adler Yu.P. Repeating the Unrepeatable / Yu.P. Adler. – Moscow: Standards and Quality, 2007. - 239 p.

UDC 378:332.1

Engineering Education Development Paths for Innovation-Based Regional Economy

Volgograd State Technical University
I.L. Gonik, Ye.V. Stegachov, O.V. Yurova, A.V. Tekin

The article justifies the importance of engineering education development for the innovation-based market economy both on regional scale and for the economic system as a whole. A set of actions for formation of a holistic engineering education environment in regions is systemized, encompassing the practices of Volgograd State Technical University (VSTU).

Key words: universities, engineering education, interaction quality, competency-based approach, development trends, economics.

I.L. Gonik

Ye.V. Stegachov

O.V. Yurova

A.V. Tekin

Besides the phase-out of imports and retrenchment policy (in the face of external sanctions enforcement), the optimization of structure of state budget revenue sources (decrease of the income fraction of oil and gas export), and other, modern development trends of the Russian economy also intend commitment to development and commercialization of innovations as a result of R&D stimulation.

It goes without saying that from the position of national security and particularly economic security of the country, the key role is played by "engineering" (i.e. technical and technological) innovations that are expected to be developed by graduates of technical universities. Therewith, in this particular case we are speaking not only about future professionals of the military-industrial complex, but about other important societal spheres that involve theoretical and applied engineering knowledge, skills and attitudes. Competence-based educational concept is put into practice for successful acquisition of such knowledge, skills and attitudes.

Thus, for instance, the framework of national and economic security of Russia includes not only the issues of developing advanced types of various armaments, but also the issues of industry, production, quality assurance and availability of different types of food supplies and other fast moving consumer goods, quality and availability of medical and educational services, peacekeeping issues and many others. Nowadays, it is hard to imagine these and other societal spheres without scientific, technical and technological inventions, which, in their turn, arise from engineering activity and directly depend on the quality of engineers' mastership of soft and professional competences.

The importance of improving quality of engineering education for the economy of a country and assurance of its economic security, competitiveness, and focus on innovation development has been brought up repeatedly by modern practitioners and theoreticians of all the technical, financial, economic and socio-managerial scientific areas; by governmental officials from different branches and tiers of authority; as well as by representatives of various relevant associations and unions:

For instance, when bringing to light the practices of industrialized and economically developed countries, Pirumov A.R. argues in detail that "engineering is the basis of innovative economy". In leading European countries training of young highly qualified professionals for high-tech industries is set as a key objective for the nearest future…" [1].

Akatiev V.A. and Volkova L.V. state that "nowadays, in the context of sanctions