2. bringing the QA process of SPs in accordance with the ESG;
3. enhance quality of SPs and increase their transparency and comparability, in order to enhance trust in the quality of SPs and make possible to formulate an informed judgment on the educational process offered by SPs;
4. promote modernisation of higher education through an on-line documentation of the characteristics and results of SPs.

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UDC 378.126

On Modelling Management Process in Engineering Schools

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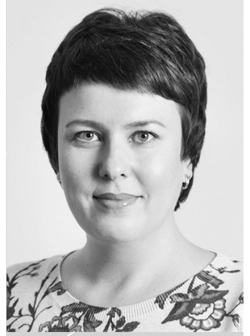

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The article considers an education process in an engineering school. Economic and mathematical approaches to education management modeling are suggested to build a new architecture of education process. The authors describe the application of Production Function Model to education process in a technical university. Special attention is paid to research management model and quality model for graduate training.

Key words: engineering university, educational process, the quality of education, simulation.

Education institution is an open system of interacting and controlled constituents (divisions, staff, etc.) with a particular strategy, mission, and limited resources. It is necessary to design structural and functional models to develop theoretical and applied aspects of management as well as to choose methods to forecast education processes in engineering schools.

While developing management models for basic processes in a higher education institution, the use of economic and mathematical methods has recently become an integral part of high technology. It is caused by the fact that most of Russian higher education institutions face such problems as weak marketing strategy, poor ad-justability of university organization structure to market conditions etc. These circumstances allow using the production function model for education processes of an engineering school [1; 2 et al.].

The analysis shows that basic products of higher education system are graduates (of different degrees and specialties) and scientific research (articles, monographs, dissertations, patents etc.). Production factors include staff (academic and non-academic), facilities (structures and constructions), and people entering the University. It can be expressed by the production function of the following form:

$$R = f\ (G, S, E, D) \qquad (1)$$

where R – product of education activity; G – number of graduates; S – staff; E – equipment; D – number of people entering the University.

To consider equation (1) as the production function, it should satisfy the efficiency feature, which means that at specified values of arguments, R should be on the curve of production capacity and reach the maximum in regards to other variables. Taking into account that there is a department aggregation in equation (1), the formula assumes that the resources are effectively distributed among the departments. It is obvious that this assumption is impossible in some cases. Thus, it is necessary to indicate a particular department with index i, which allows expressing the function for a University as follows:

$$R = \sum R_i = \sum f_i\ (G_i, S_i, E_i, D_i) \qquad (2)$$

To state the objectives of higher education is an important starting point of the analysis. It is natural to assume that the aim of a common competitive commercial entity is to maximize earnings. However, such comparison in terms of engineering higher institution is not sound enough. A part of higher education system is commercial in some countries, which makes earnings maximization be a possible goal of the University. On the other hand, universities are often regarded as non-profit and non-commercial organizations (in the USA and other countries), which gives them tax advantages to encourage education rather than commercial objectives achievement.

In particular, James E. [7] considered universities as organizations that with budget limitations tend to maximize some degree of benefits that depends on University image and a set of other variables of different values. The university image, in its turn, depends on basic academic factors, such as the number of graduates, research projects, etc., as well as on the quality of these "products" or factors. In this view, Universities are considered to be in competitive environment. They search for good students and funds for research, and their success depends on their image. Despite the approach be-ing developed for a university as a whole, it can be applied to separate faculties of engineering schools. Besides, the approach is reasonable to be used to analyze real system behavior and is determined by stimulation system and University funding. It is important to note that like all other organizations, technical universities try to survive, which is the best they can do under hard financial limitation. If in better conditions, a university has wider choice and can behave in the way described above. In this case, it is obvious that real choice is determined by the interaction of the production or objective function and financial limitation.

It should be specified that, as assumed in (1) and (2), the production function in the education system is similar to the production function of other goods and services characterized by a smooth threshold of substitution of production factors and output. However, the assumption is not fully applicable to the higher education system. Let us make some comments on it.

1. Research and teaching activities are mutually supportive rather than inter-changeable: students are informed about the latest research results, post-graduate are directly involved in research projects of their scientific supervisors. Thus, the S increase within some limits can lead to simultaneous increase both in G and R (which is in contrast to the assumption mentioned above).

2. The ability for scientific and research work and its efficiency are unevenly distributed among faculty members and research groups. As a rule, most of the research output is produced by a limited number of faculty members who need, however, organizational support including their colleagues' help. Thus, the relation between S and R depends considerably on efficient functional distribution with focus either on research, teaching or administrative activities.

3. The output (production capacity) of the higher education and research system is quite sensitive to small changes in motivations for research activity. But the top-rank position of a department (for example, according to the British system of research evaluation) depends on efficient distribution of highly qualified faculty members in each discipline. Thus, despite universities attempts to improve their images by attracting the best researchers, the final output of the system does not increase significantly.

4. The efficiency and value of different teaching techniques and methods for different student groups have not been well studied yet, though there are a lot of opinions on this point. Some of them think that the main thing for students is just being in a university for 3-4 years, with teaching methods having no importance. Others argue that it is particular teaching methods and techniques (students' reports, interactive study, essays, discussions, traditional lectures et al.) that play the main part in education process. In this regard, what teachers do and how they do, as well as their "availability" for students, are very important.

5. The "product output" of the higher education system depends on "quality" of enrollees. It is obvious that universities should attract more prospective students with better training, since it would somewhat guarantee good future learning outcomes: such students will be successful even without intensive training support in the university. Other universities, however, have to choose another way. The students enrolled in such universities may have rather poor academic performance at the beginning. But due to intensive training and effective scientific supervision they achieve good learning outcomes at the end of the course. Thus, if measured properly, the added value of the latter training is much higher than that of the training in traditional universities choosing the best enrollees. This situation can be described by equations (1) and (2), if the student factor D is measured properly.

6. There is an important intertemporal aspect in the production function of the education system. It is implicitly present in (1) and (2), since we have not made any supposition about the relation between G (the number of graduates) and D (the number of enrollees of a particular year). It is necessary to take it into account, otherwise, one and the same variable will be both the production and factor and product itself. In a stable condition, if D is constant G should also be constant, as it was mentioned above. Then (1) means that with a given number D the number of graduates G can be increased due to the increase in production factors, especially staff. To reflect the intertemporal aspect with large gaps between input and output, we should use multi-periodical form of the production function.

These conclusions show that though the concept of the production function can be applied to the system of higher technical education, the particular features of the system require revising the traditional form.

Taking into account that the objective of an engineering school (J) is the increasing function of its basic output products: training and research, we get the following:

$$J = k\,(R;\,B) \qquad (3)$$

Besides, the real choice of a university depends on its financial limits. It has the following general form:

$$B = wS + E + c_1R + c_2G + H \qquad (4)$$

where B – budgetary costs consisting of personnel wS; w – the average salary including all social insurance, pension and other payments to the staff; E – equipment in monetary form; c_1R – research expenses R (c_1 – expenses per research unit); c_2G – expenses to train G graduates (c_2 – expenses per one student); H – extra expenses not mentioned above (for example, building heating and lighting, computer service and library expenses, administration et al.).

University's objective, then, is to maximize J (equation (3)) with production function (1). This task can be expressed as follows: to maximize the function

$$J = k\ (R;B) \quad \text{at} \quad R = f\ \ (G,\ S,\ E,\ D),$$

$$B = wS + E + c_1R + c_2G + H\,,$$

Practically, the model based on (1), (3) and (4) should be added with some limitations in capacity. For example, no matter how profitable it is to enroll more and more students, the amount of students is limited with the number of university buildings, rooms, staff, equipment, and other education factors. Thus, the model should have a limit in the form $D < D^*$, where D^* – maximum possible number of enrollees, which obviously limits the number of graduates G). The model shows the particular features of the education process of a technical university.

Let us consider two examples: a management model for research and training process [5] and a quality model for engineering training [6].

It is important to note that the

management model for research and training process should be closely related to the education quality management system of the university. The education system comes to its stable functioning through successive changes of its constituents and assessment of environmental impact. This process presents a combination of activities of the system elements united by a common goal.

The modern university is being actively developed in response to new challenges to be overcome by means of new elements and more rational structures. The increase in information exchange and relations leads to growing scale of education systems, which makes them more complicated. There appear new levels, hierarchy, and self-organization, thus making the system dynamic in time.

Fig 1. shows the management model for research and training process in a university [5]. Economic parameters are identified in the basic blocks of the model to study the system's behavior temporally (1.2, 2.2, 3.2, 4.2). These parameters show the training cost, target profit, research and training process based on the target profit, economic efficiency and analysis of the economic performances [3; 4].

Quality of an engineer is of multidimensional character, it is the base to develop a quality management model for engineering training [6]. The quality of engineering training can be regarded as a vector $\vec{Q}(t)$. Then the requirements of the federal education standards and employers can be presented as the following inequation

$\vec{Q}(t) \geq \vec{Q}_{\min}(t)$, where $\vec{Q}_{\min}(t)$ – vector of minimal permissible parameters of engineering training quality.

As it was mentioned above, the quality of engineering training is closely connected with the quality of research and education process in a university ($\vec{q}(\tau)$) at $\tau < t$. Thus, it can be described with the following function:

where $\vec{F}(\tau, \vec{q}(\tau), \vec{Q}(\tau))$ – the function:

$$\vec{Q}(t) = \vec{Q}(t_0) + \int_{t_0}^{t} \vec{F}(\tau, \vec{q}(\tau), \vec{Q}(\tau))d\tau$$

that determines a training process and development of a future specialist in research and education environment of a university. The starting level, the time of enrollment, is identified with t_0.

Functions $\vec{Q}(t)$ and $\vec{q}(\tau)$ are a mathematical expression of the management model for engineering training quality shown in Fig. 2. Management $\vec{u}(\theta)$ is determined by the optimization task solution:

$$\vec{Q}(t, \vec{u}(\theta)) \to \max$$

In this aspect, management is regarded as a system of criteria focused on achieving maximal results in training process.

Thus, while modeling management process in an engineering school, it is necessary to take into consideration a number of sub-systems including:

- economic;
- organizational;
- methodological;
- innovative and education;
- technological, etc.

It should be concluded that the functioning of these sub-systems is ensured by the following processes:

- implementation of administration's responsibility (politics and strategy development, goal setting, paperwork management and analysis);
- resources management (staff responsibility, material support);
- changes, analysis, and improvement (monitoring of consumers and employers' satisfaction);
- education and information services (innovative training, school leavers enrollment, education, organizational and methodical activities);
- management of informational and technical resources, etc.

Fig. 1. Management model for research and education process of a University

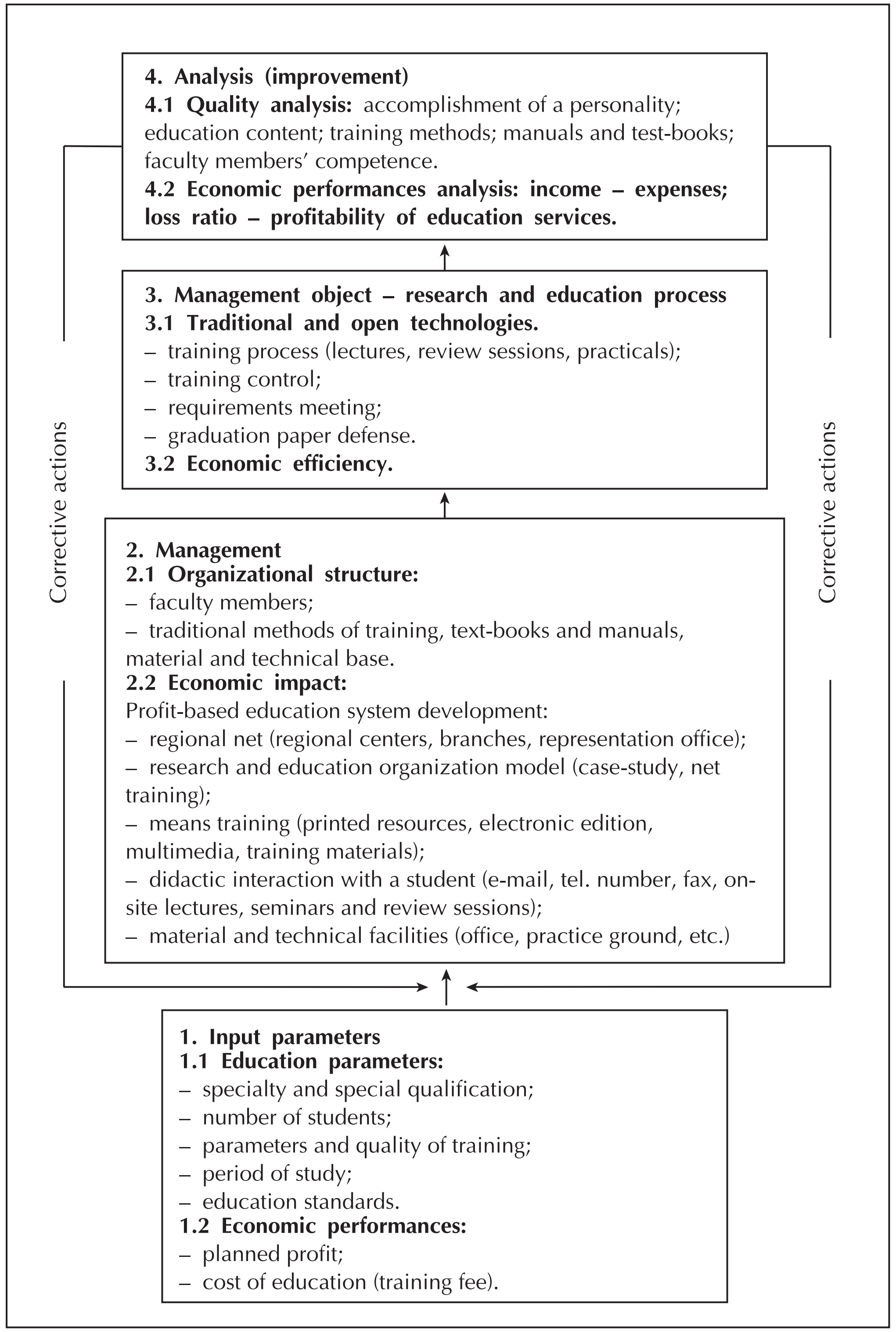
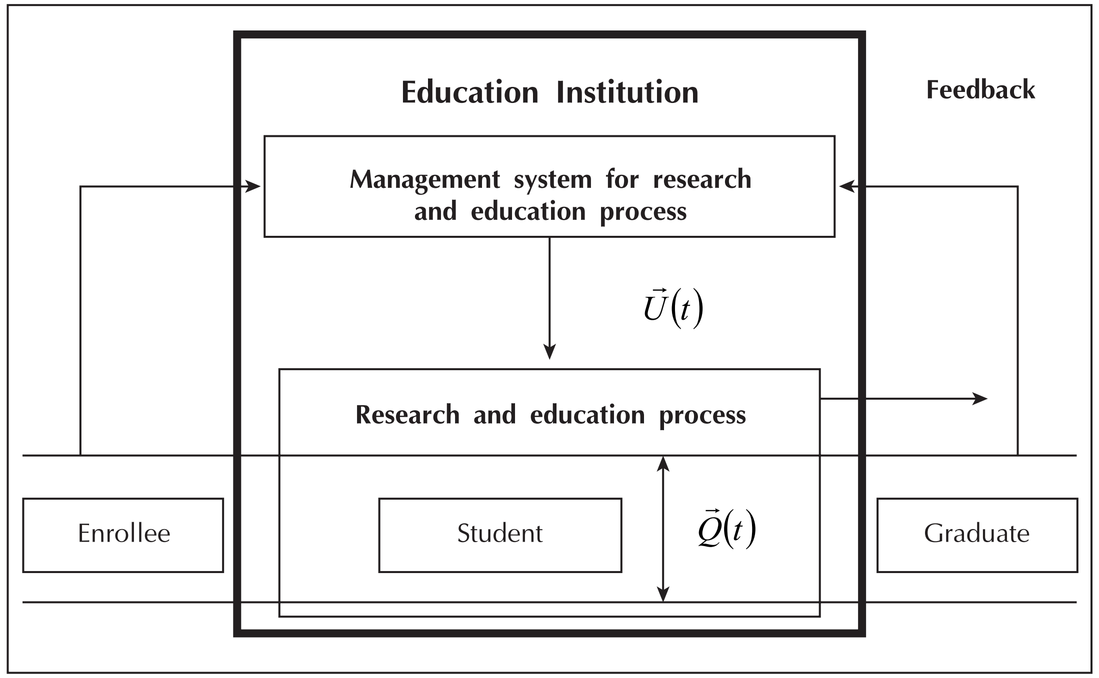


Fig. 2. Quality model for engineering training [3]



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UDC 744 (571.56)(092)+929

Yakutsk State Academic Olympiad in Technical Drawing – 50 years

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The article is devoted to the current teaching problems in technical drawing in the schools of Sakha Republic (SR) (Yakutia), involving the 50-year background experience in organizing and conducting olympiads in technical drawing. The pedagogical achievements of the technical drawing teachers and olympiad winners have been described.

Key words: technical drawing, graphics problem-tasks, school, individual approach, out-of-class activities, Olympiad in technical drawing.

Since 1962-1963 school olympiads in technical drawing were organized and conducted under the supervision of N.S. Nikolaev in the Sakha Republic. The 50th Olympiad Anniversary was conducted in 2015.

The idea of conducting school olympiads in technical drawing started up in the 60s of the last century to improve the school teaching quality of technical drawing, as well as advancing teaching and learning standards in this subject.

What are the advantages of olympiads? It is a well-known fact that school-teaching should not be restricted only to in-class learning. Extracurricular activities are introduced to reinforce and increase student knowledge and skills obtained during classroom activities. Such activities reveal such aspects as student orientation, personality qualities, creativity ability and versatile interests. Extracurricular activities should be diversified, and, only in this case, a teacher would be able to win both recognition and authority. An interesting extracurricular activity is the olympiad, the target of which, is to identify and develop student interests and abilities and evaluate class and out-of-school activity results in this or that subject for an academic year. Another important aspect includes pedagogical issues. For example, initiating friendly ties and establishing business relations with different schools, regions, districts and republics. In the days of olympiads students do not only compete, but also help each other and intercommunicate.

Olympiads are both a popular type of student assessment and achievement and a tool in advancing the role and significance of this or that subject. New and new student groups are becoming involved in the subject after such competitions. Experienced technical drawing teachers (Yakutia) have proved conclusively that the fruitful efforts of olympiads flourish only under conditions of systematic out-of-school activities or become the starting point in their development. Excluding these factors could convert olympiads into simple go-to meetings without any benefit or results.

Every teacher knows that children strive for autonomy- a desire to try themselves in revealing their own creativity and to explore everything on their own which is typical for their age. However, this inherent motivation can not always be acceded within the framework of academic classes, while olympiads enhance more possibilities and broad options. Often students more distinctively and clearly reveal their individuality, demonstrate their personal characteristic traits and their own way of thinking when competing. Observing how