Sustainable Technological Facilities in ESPC Educational Institutions as a Factor of Efficiency and Quality Improvement of Engineering Education

State University – Education-Science-Production Complex
M.A. Tarasova

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The article presents and proves scientific concept of sustainable technological facilities development in integrated scientific-educational institutions aimed at improving quality and efficiency of engineering education.

Key words: *educational system, rational technological resource base, system multilevel of monitoring, synergetic, educational service.*

Introduction

The foundation of high-quality engineering education is a profound academic training based on latest scientific and technical achievements. Implementation of this principle requires creation of training technological facilities. Technological facilities are an important constituent of scientific and educational potential of universities. It ensures both the possibility to conduct research and training work and its efficiency. These facilities can be definitely considered as the governing factor of quality assurance of the whole technical higher education [1].

The distinguishing feature of a contemporary development stage of higher professional education (HPE) is the increasing importance of practical training and, as a consequence, creation of a fundamentally new education-science-production complex (ESPC). Thus, universities purchase new equipment that would provide a required level of specialists' training, which increase cost value and reduces profit of educational service. This fact is also conditioned by constant cost increase of equipment.

There are two ways to reduce expenditures connected with equipment acquisition and maintenance and increase in education efficiency.

The first approach is associated with crucial changes in the university structure. Recently a steady trend has been observed in Russian higher education system- new forms of science – production integration are being developed: corporate universities, technoparks, incubators focused on new technologies, new technology centers, innovative-industrial complexes etc.

Sure achievement of "integration policy" is a synergetic effect of mutual support reflected in principally new intellectual products made in the frame of every subsystem of the whole chain "education – science – production" [2].

The second approach is connected with the system of university finance and economics management. To continue extending business efficiency of universities it is necessary to intensify factors causing

changes in IT, management and financial aspects of universities' business functions. In other words, university should develop its economic mechanism relying on economics and IT [3, 4].

However, both approaches are focused only on cutting the costs associated with buying equipment and its maintenance. Still they do not reflect the dependence of students' competence development quality on the use of training, scientific and industrial equipment.

Nowadays the process of equipment renovation in universities is of stochastic nature and is not supported by objective factors or scientifically based. Besides, there is not an index system to reflect the dependence of facilities expenditures on the quality of competences development at every training stage. Such system would solve the problem of inefficient facilities expenditures. Moreover, it would contribute to sound financial management of educational service and development of sustainable technological facilities of universities.

It makes most sense to develop the above mentioned index system for monitoring researches using the Quality Management System (QMS) of a university based on international quality standards ISO 9001 [5].

Educational service and learning outcomes as indices of monitoring technological facilities condition

In process of monitoring an index system of educational services and learning outcomes based on university's QMS is developed. The indices comprise all the stages of training: the first level (educational), the second one (scientific) and the third level (production), which makes the monitoring a systems multilevel one.

Structural components of educational service aiming at leaning outcomes achievement are:

- Educational program quality (structure and content);
- Curriculum and teaching process quality;
- Faculty quality;
- Teaching methods quality;
- Quality of resources:
  - Facilities (classes and labs, equipment, expendable material);
  - Informational and methodological support (textbooks, training aids, problem books, models, simulators etc.
- Scientific research quality, innovative technologies in the frame of ESPC, collaboration with research institutes, industrial enterprises and other universities.

The following things were developed to evaluate the quality of learning outcomes in the frame of university's QMS:

- Evaluation schemes;
- QMS that guarantees systematic achievements of learning outcomes [6].

At the same time the objectives of the researches are the following:

- to structure competencies distinguishing components of professional activity;
- to apply appropriate pedagogical technologies to develop the above mentioned components of competencies;
- to develop learning outcomes evaluation system to control quality of the developed competence components;

At the preparatory stage of the monitoring special attention should be paid to the status of educational programs and their international accreditation. Russia joined Bologna process, which makes it necessary for the national educational system to meet the international standard requirements. Therefore, it is useful to have the programs accredited in "Framework Standards for the accreditation of engineering study programs" of EUR-ACE [7]. Accreditation center of AEER has the right to award EUR-ACE quality label to the accredited programs [8].

According to the quality management principles, reflected in ISO 9000:2000 [9], monitoring researches cover all the subsystems of university education and allow specialists:

- to obtain objective cost estimate of educational service at each training stage (university expenditures);
- to evaluate the number of students having excellent and good knowledge, skills and competencies developed during the training process that involves training, scientific and pro-

duction facilities; then knowing the university's expenditures to determine the university's income;
- to analyze the components of educational service quality of each stage and determine the expenditure values for facilities improvement for each training stage.

Monitoring researches make it possible to evaluate each component of educational service, i.e. to expose weak and strong points of a training process. That is why a sound use of university's income for creating technological facilities based on the monitoring researches will definitely contribute to the increase of training process efficiency [10].

Thus, the monitoring researches allow developing a system of indices showing the connection between the investments in technological facilities for training process and the quality of students' competence development.

Synergetic effect

The educational system has some characteristics that make it possible to study it in terms of synergetics methodology as an open self-organizing non-linear system. This system can reach unstable state and have energy, information and substance sources and run offs [11, 12].

According to the self-organization theory one of the necessary conditions for a system to achieve a new qualitative state is to distinguish the leading component of the social development (in most cases it is technical or management innovation) and ensure its self-development.

It is very important for self-organization of the educational system that the educational services embrace all the subsystems of the university educational system [13]. Thus, the educational service of competence acquisition is offered at all stages of the educational process: in classes, training labs and industrial internships. This process involves faculty members, textbooks, training aids, training process management, program development and facilities.

The key principle of quality management is a process approach, that implies that a desired goal is achieved more effectively if all the corresponding activities and resources are regarded and managed as a process.

"Any activity in an organization should be regarded as a process, consequently, it should have well-defined inputs and outputs, resources, actions and interactions of all corresponding process components" [9].

While conducting monitoring it is suggested to consider the educational process at three levels. The input indices are the educational service of the preceding level and the output indices are the learning outcomes of the present level. The interaction between the educational levels is ensured by the educational program of a definite specialty.

The monitoring should be conducted from the prospective of synergetic approach. "We regard synergetic approach as a scientific knowledge method based on systems analysis of self-developing evolutionary system characterized by periods of prosperity and decline. It is possible to distinguish dynamic attractors there. The attractors are processes of information self-organization and generation of new rank parameters and bifurcation point. Fluctuations, i.e. "stochastic processes" are the leading factors of bifurcation" [14].

Monitoring of each level will allow introducing the management element in the training process. The management of every stage of the training process will be focused on the management of the whole educational process. Topologically correct organization of the subsystems leads to the maximum development of the system, which results in synergetic effect. "The whole united area becomes under the influence of new more intensive development process. The whole unit develops faster than its constituent parts. It is more useful and efficient to grow together, as it saves material, spiritual and other expenses" [12]. We suppose that the attractor is a qualitative new system state characterized by increasing quality of educational process.

Self-organization of a pedagogical subsystem will contribute to the dynamic equilibrium of economics, its sustainable development path determined by efficient use of university's resources.

However, while self-organization is an objective reason for activation of system development, organization is the way to regulate or to arrange initiatives of this or that forms. Self-organization can lead to negative results and needs to be corrected and supported by operating parameters.

That is why the aim of management is to create conditions for coordinated subsystems interaction that ensures functioning of the whole system, its safety and development and to ensure communicative links between the subsystems of an educational complex [15].

Thus, organizational innovation in the form of a systems pedagogical and economical multi-level monitoring aims to establish an index system reflecting the connections between technological facilities expenditure and the quality of learning outcomes and can lead the system to self-organization – a new qualitative state characterized as "sustainable technological facilities".

The monitoring researches can serve as a base for economic and mathematical model of sustainable technological facilities.

IT implementation will allow developing automated control system of educational process, which will increase efficiency of university educational system.

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