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Quality Assurance and Quality Enhancement in E-learning

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The article examines the issues, challenges and possible solutions related to quality assurance in e-learning applied in engineering education.

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E-learning (EL) is one of the fastest growing sectors in global educational environment. It is e-learning technology that is expected to change the teaching process itself. Such situation can be explained by the following reasons: development of post-industrial information society which is characterized by a wide spread of integrated processes based on the application of various information and communication technologies (ICT); free flow of information and knowledge; possibility not only to assure high education quality, but also to solve a number of social problems in order to provide the availability and transparency both of lifelong learning programs and education in general; constant teaching and learning quality enhancement. Of fundamental importance is a high degree of interactivity which makes it possible to provide information mobility, individual study path and timely updating of learning content. Therefore, quality assurance for e-learning technologies in engineering education is of vital importance. It should be noted that the requirements to engineering education content and teaching technologies are mainly defined by the external factors.

The main social and economic characteristics of post-industrial infor-mation society are substantially different from that of industrial one. This fact should be always considered in engineering education. Social and economic features are determined by such factors as economy globalization, sustainable development, high "living standards" and personal fulfillment [1]. A post-industrial society is a society in which an economic transition as occurred from a manufacturing based economy to a service based economy focused on individual demands. A great shift is observed in the principles of production organization and management – there are transnational corporations, e-enterprises and design-engineering offices which have no actual addresses and structures, but which actively apply information and communication technologies for integrating resources of the companies-partners scattered worldwide. A new type of production management occurs, i.e. product life cycle management based on continuous information support, as well as standardization of data submission through the application of CALS technologies. One of the technologies which are widely applied in science-intensive production is

Product Life Cycle Management (PLM). The integrated components of PLM are as follows: Product Data Management (PDM), Collaborative Product Development (CDP), Computer-aided Design (CAD), Computer-aided Engineering (CAE), and Manufacturing Process Management (MPM). The development of post-industrial economy is accompanied by the emergence of industry clusters which comprise interrelated high-tech enterprises, research and development companies, higher professional education institutions and innovative infrastructure. Implementing innovative technologies within high-tech production is the basic source of income. The products and services are becoming smarter and more knowledge based, which in its turn prompts high-tech production activity. Intellectual potential becomes a primary factor of production. There is the transition to the sixth technological mode which is characterized by nano-, bio- and ICT clusters. Thus, young engineers must become familiar with such professional environment which is inherent feature of post-industrial information society.

Global education trends are connected with the development of conceptually new system of open lifelong learning based on smart-technologies, cloud computing and social intelligence. Another fast growing technology is open education resources, i.e. digitized materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning and research [2]. Open education resources developed by different universities are integrated into numerous information systems which form global campus networks [2]. The flagship in development and implementation of open education resources is Massachusetts Institute of Technology (MIT). To develop special content available for a wide range of users, social intelligence based on the Internet technology and Web 2.0 and Web 3.0 platforms are widely applied. The previous in-class learning is substituted by a new one based on e-learning technologies. One can witness the emergence of electronic universities which provide information support of educational process. International consortium "Electronic University" has been established. Different repositories which contain digital learning materials are developed in compliance with the existing education standards.

Today, e-learning programs are offered almost by all universities in the USA and South Korea as its quality is considered to be even higher than that of traditional ones. The United States of America has taken the first place at the fastest growing market in education, while Europe comes in second [3]. Since 2003 a new learning strategy eBologna ("Electronic Bolonga") aimed at developing special electronic environment for Bologna process has been successfully implemented. The European Foundation for Quality in e-Learning (EFQUEL) comprising universities, corporations and national agencies has been legally established. One of the main initiatives of the foundation is a new certification and quality improvement scheme for e-Learning courses and programs in international Capacity Building (Open e-learning in Capacity Building Check) [4]. A vast international experience on e-learning quality assurance has been gained: e-learning accreditation guidelines and quality standards (for example, criteria and certification process initiated by EFQUEL).

Majority of Russian universities have been falling behind in e-learning technologies, however, essential changes can be seen. First of all, the development of legal groundwork for e-learning programs has been launched. A new Federal Law "On Education in the Russian Federation" includes the following articles: "On implementation of Educational Programs based on E-learning and Distance Learning Technologies", "Network Educational Programs". This law regulates the implementation process of e-learning in higher education (availability of learning and information environment which includes electronic information resources, electronic learning resources, integrated information technologies and corresponding learning tools). Nominative legal acts aimed at regulating e-learning application in higher education are being developed. Special at-tention is paid to electronic learning resources, i.e. e-learning courses, e-learning training simulator and laboratory course, e-learning programs, e-learning assessment tools, e-library resources, remote databases and knowledge bases, etc.). The engineering training is mainly based on the application of so-called hybrid (mixed) learning technology which unites traditional and e-learning approaches. However, this fact does not eliminate the necessity of developing adequate learning and information environment.

The analysis of worldwide and Russian trends in higher professional education has revealed that university learning and information environment should be created considering the following principles (Table 1).

A number of Russian universities (Moscow State Technical University n.a. N.E. Bauman, Moscow Power Engineering Institute) gained considerable experience in e-learning implementation. For example, Moscow State Technical University n.a. N.E. Bauman has introduced interactive training methods into education process to increase the efficiency of ICT application [5]. Students are taught to fulfill engineering tasks at all stages of product life cycle based on the innovative educational framework developed by Massachusetts Institute of Technology in cooperation with scientists, faculty members and industry representatives. The framework is designated to provide students with engineering fundamentals set in the context of "Conceiving — Designing — Implementing — Operating" [6]. Besides, students are involved in learning content development that contributes to shaping required competencies and skills. Some universities apply Siemens PLM Software, i.e. leading worldwide supplier of PLM-technologies [7].

Laboratory classes are of vital importance in engineering education. In this regard, a great deal of work has been done in Siberian Federal University where faculty members developed automated remote-access laboratory practicum based on net multi-user on-line access to the lab equipment through a single network access point – automated and virtual portal of laboratory practicum. Such type of laboratory practicum is based on the concept proposed by Krasnoyarsk State Technical University [8]. On the basis of this concept, computer measurement tools National Instruments and gained experience, a number of software packages and unified flow diagram of automated remote-access laboratory practicum have been developed (Fig. 1). Portal design in terms of functional components (special network laboratories, departments and common use centers, remote access software packages, etc.) provides the possibility to adapt its virtual space to the assigned task.

It has become obvious that developing remote-access software packages implies not only such challenge as selection of appropriate software technology but also development of multi-component software guidelines. These problems should be solved with the systemic approach which allows integrating all components into the unified information and science learning environment.

The development of training e-enterprises as a part of information and science learning environment is also of current interest. Such e-enterprises are designed by integrating administrative and technical resources of various university units (e-enterprise flow diagram developed by Siberian Federal University is given in Fig. 2). These e-enterprises are oriented to train such engineers who are capable of working in

Table 1. Principles of University Learning and Information Environment Management

Principle	Description	Result
1. Fundamentality of educa-tion due to in-depth study of Mathematics and Physics	Fundamental and systemic approaches in learning mathematical aspects of infor-mation technologies and physical effects in engineering	Solving engineering problems based on synthesis method
2. Consistency in Information Technology application	Development of a conceptual sustainabil-ity-driven curriculum covering all neces-sary material concerning ICT application with a progressive sequence	In-depth and system-ic knowledge in ICT within engineering topics
3. Relevance and priority-oriented	The content of the curriculum should be aligned with the priority areas in science and engineering and based on the recent achievements in the relevant subject areas in order to provide knowledge acquisition ahead schedule	Correspondence of learning environment with the re-quirements of econ-omy, labor market and professional community
4. Availability of network technologies in production process design	Collective method application in ICT-based technical production	Knowledge and skills in E-design offices and Industrial Virtual Enterprise
5. Multilinguality	In-depth learning of foreign languages, es-pecially English language (fluency)	Participation in inter-national projects. Ex-port of educational services
6. Orientation on international standards	Orientation on the international standards which provide storage of process and ob-ject models corresponding to different stages of product life cycle in a formalized manner	Development of com-petitive technical products in network economy
7. Economic efficiency	Consideration of basic economic parame-ters in learning environment development	Learning environment economic efficiency and circulation
8. Multifunctionality and adaptability	Convertibility of learning environment in accordance with the current objectives and individual peculiarities of a student	Teaching quality increase and education cost reduc-tion
9. Practical orientation	Application of math modeling and simula-tors in lab classes. Development of e-learning resources in compliance with em-ployer's requirements	Knowledge and skills in engineering prob-lem solving. Model-ing of true-to-life production processes
10. Modularity and person-centered learning	Development of module-based curriculum which allows students to choose individual study paths	Learning environment flexibility, orientation on students' peculiari-ties, needs of econo-my, labor market and professional commu-nity
11. Marketability	Development of information and learning environment based on the best national and foreign experience	World competitive in-formation and learn-ing environment

ENGINEERING EDUCATION 12'2013

multidisciplinary teams and moving the profession forward.

Major issues affecting e-learning in Russia are as follows:

- absence of e-learning development strategy which is required to enhance forward-looking engineering education;
- insufficient investment quotes;
- insufficient e-learning methodology;
- low competence of faculty members in e-learning technologies;
- ill-defined e-learning quality assessment policy;
- unconformity in the existing university quality systems and e-learning peculiarities;
- absence of strategy in e-learning quality problem solution.

E-learning pedagogies must incorporate new learning environment, teacher-student interactive behavior patterns, up-to-date approaches to outcomes assessment, etc. Faculty members should have deep knowledge not only in corresponding subject areas, but also e-learning technologies and tools.

When introducing e-learning into teaching process, special attention must be given to education quality. The factors which can influence e-learning quality can be divided into two groups: external and internal [10]. The external factors are those which are outside of e-learning process (political, social, demographic, and economic). The internal factors occur within university and have direct influence on e-learning process (university e-learning policy and strategy, quality of information and learning environment, level of student-teacher competency in IT and etc.).

To provide high quality of e-learning within engineering training, it is necessary to assure the quality at every stage of educational process and implementation of effective quality system. In accordance with National State Standard (P53625-2009 (ISO/MEK 19796-1:2005), life cycle processes as applied to e-learning are

Fig. 1. Unified Flow Diagram of Automated Remote-Access Laboratory Practicum based on National Instruments technologies

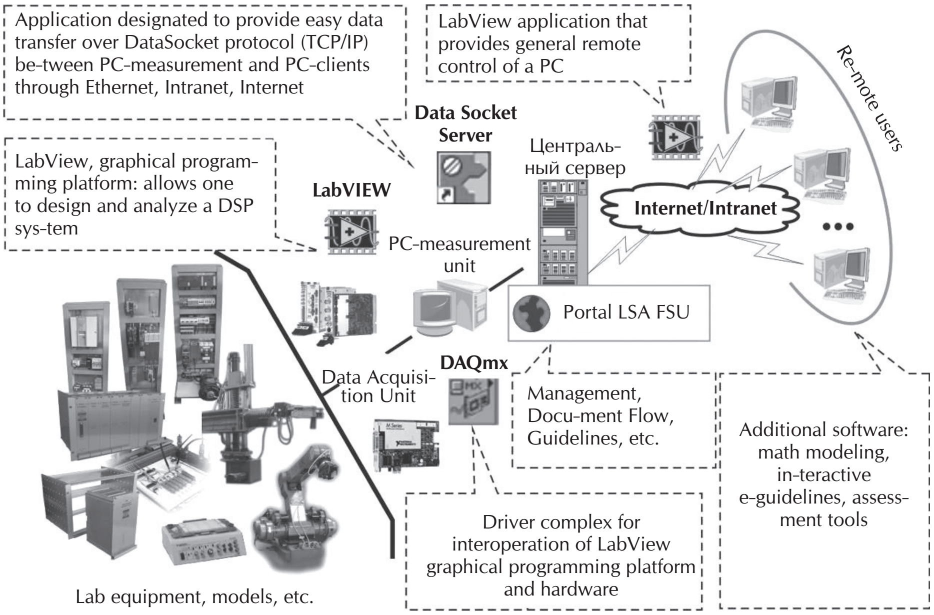
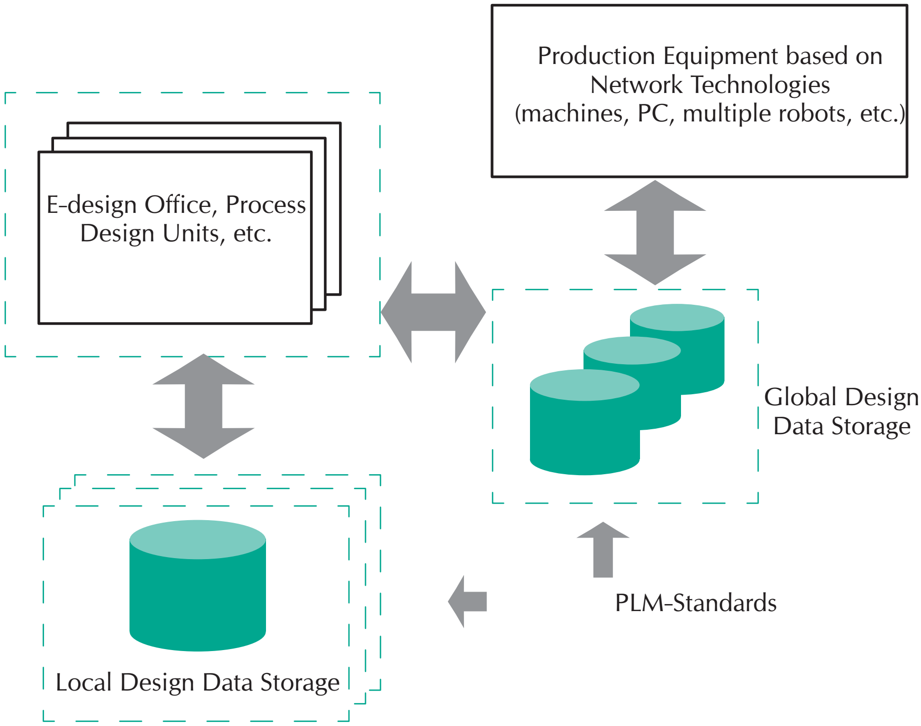


Fig. 2. (Net) E-enterprise Flow Diagram



as follows: needs analysis–structure analysis–concept/project–development/implementation–training–assessment/optimization. Apart from Federal Education Standards and Professional Standards, effective university quality system can be based on European standards and guidelines for internal quality assurance within higher education institutions ENQA [10] and e-learning quality standards. According to ENQA standards and guidelines, university quality system comprises three subsystems: quality assurance, quality monitoring and management.

Quality assurance subsystem based on hybrid technology should include:

- learning quality assurance policy;
- educational program requirements and standards;
- facilities requirements for the departments involved in implementing degree programs;
- information and learning environment requirements;
- courseware requirements;
- requirements for program constituencies;
- requirements for educational services suppliers;
- local nominative acts for education quality assurance.

E-learning quality to a significant extent defines competitive advantage of higher professional institution.

Therefore, interaction of universities with various organizations focusing on quality assurance in e-learning is of vital importance, they are as follows:

- The Agency for Higher Education Quality Assurance and Career Development.
- The European Association of Distance Teaching Universities (EADTU).
- The European Foundation for Quality e-Learning – EFQUEL (provides accreditation and quality improvement scheme for E-

Learning programs and institutions promotes and implements e-learning technologies, develops inter-university e-libraries, etc.).

- Association "Education in Information Society".

One of the mechanisms of e-learning quality assurance is an integrated review of e-learning resources, which should include the following stages: content analysis (relevance, correspondence with educational program, presence of multimedia resources and interactivity, monitoring, etc.), software audit (software implementation, functional parameters, interface indicators, observance of international standards, etc.), design and ergonomics examination (spatial layout of the information, quality of multimedia components, easy navigation, etc.).

Possible criteria of e-learning quality assessment:

- education quality (training "in-demand" specialists);
- quality of university information and learning environment components;
- meeting the requirements of the parties concerned;
- international accreditation of educational program;
- efficiency of applied software tools;
- quality of nominative acts for e-learning regulation.

The following conclusions can be drawn from the present study:

1. E-learning should be regarded as one of the guaranties of engineering education quality assurance.
2. E-learning quality policy should be based on standardization and certification. A special infrastructure which involves voluntary certification has been already established.
3. Universities must develop further training courses aimed at upgrading faculty qualification in e-learning technologies.
4. There is a vital necessity to train e-learning experts, establish departments and academic units focused on developing e-learning resources.

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