institutions and establishing certification centers. High-level professional competence-based training with the focus on international standards will make the Russian professional education more competitive on the international market of educational services.

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Modern Engineering Education in Conditions of "Information Explosion"

National Research Tomsk Polytechnic University
O.V. Rozhkova, N.V. Yakovenko
National Research Tomsk State University
N.Y. Galanova

Qualitative technological base is being upgraded and innovative technologies are being implemented in many countries of the world. The analysis of basic trends in education sphere proves that the strategy of e-learning is conditioned by the necessity of improving engineering education, educational process and inevitable globalization of education due to technological and communicational changes.

Key words: engineering education, pedagogics, training methods, "information explosion", generation Z, e-learning.

1. INTRODUCTION

One of the major challenges of modern life is to increase the quality of engineering education, mathematics, in particular, which tends to worsen in conditions of "information explosion". One of the solutions is to make easier the understanding of fundamentals of advanced mathematics, develop training methods, and use technologies of e-learning (TEL). The latter allows speeding up learning process by 10-15%, saving training time by 35-45%, increasing efficiency of academic activity of faculty staff by 30%, adjusting forms of educational materials to psychological features of Z generation, which would improve the quality of training.

2. NECESSITY TO IMPROVE ENGINEERING EDUCATION

In our digital epoch, mathematics has become a methodological base for almost all branches of science. Even biology and sociology are actively using mathematical methods. Thus, mathematics is necessary not only for physicists and engineers, as it used to be 40 years ago, but for all scientists and specialists. The "tip of the mathematical iceberg" is traditionally divided into three parts. The first part presents the essence of mathematics inherited from the ages from Antiquity to Medieval times. This part is studied at secondary school. The second part is advanced mathematics created during the last 400 years. It is studied at bachelor's, specialist's and master's degree engineering courses. The third part is divided into special disciplines the fundamentals of which are trained at departments of mathematics. These disciplines constitute a root system of a contemporary fast growing mathematical tree. There are no distinct boarders between the parts of the iceberg. In addition, the "University mathematics" course involves the basic ideas and facts of the elementary mathematics in more complicated forms. The "submerged part of the mathematical iceberg" involves separate facts, methods, and even theories that are already unnecessary, for whatever reason, or cannot be yet applied waiting for being developed in future. "Pure" and "applied" mathematics are even more relative classification [1]. In addition to inner demands and logics of mathematics development, there are external factors to increase mathematical knowledge and develop mathematical research; they are needs of natural science and technologies, and technical capacity to perform practical tasks. It is essential to increase the quality of education. The Russian education system

O.V. Rozhkova

N.V. Yakovenko

N.Y. Galanova

is rapidly changing, with introduction of new education standards. Instead of 5-year training courses, which are cancelled now, bachelor's and master's degree courses have been introduced, federal Universities have been established.

2.1. Loss of quality of mathematics education

Meanwhile, there is a tendency of education quality loss. The reason is "information explosion", which attacks the humankind this century. According to science theorists, knowledge doubled for 1750 years since the beginning of our era, the second doubling occurred in 1900, and the third one took place in 1950, that is for 50 years, with 8-10-fold increase for the recent 50 years. This tendency is increasing; the amount of knowledge in the world doubled by the end of the 20th century, and the information increased more than 30 times. In this regard, it is necessary to note that the "information explosion" makes it necessary for higher education system to apply the approach of "education without boarders" based on unlimited access to information, since limited access to information is practically impossible. Access to knowledge has become an inalienable right of every human being, which is ensured by the existing mass media infrastructure [2]. A strong information flow passes through people networks, organizations, and everyday life. There are numerous sources, from Internet to books, that constantly provide people with different kinds of information. Is an average student capable of perceiving it? Do modern students suffer from information overload? Can classroom training be efficient and informative in such a situation? Perhaps, there is no such problem at all. Only a couple percents of human brain potential are used. The information flows train human "grey cells". People have become smarter for the recent 100 years. Secondary school education programme has been significantly changed for the last 20 years. Some school subjects lag behind rapid development of science and technology. Such a school subject as "Computer Science" has become almost useless, since pupils know more about it than teachers of preretirement age. However, the question is if the main information source (news, advertisement and social nets) is able to develop a brain, or can only fill it forcing useful information out.

2.2 Basic forms of educational process

The variety of learning forms can be grouped in 3 basic types: classical or traditional that implies classroom academic activities (classes, lectures, supervision), distant learning that ensures learning without teacher-student direct contact, and a blended type that involves both type of teacher-student interaction- classroom activities and e-learning.

The importance of fundamental mathematics can hardly be overestimated. Mathematics is not only special method of nature study, but also, as Lobachevski stated, "a language used by exact sciences". Mathematics is an important tool to study other disciplines. Thus, mathematics is in demand not only for engineering education, but also for economics, humanity science etc.

The main weak point of the traditional educational form is human factor. New information technologies (NIT) allow solving many problems relating to learning process. A student can revise the material required for study (including educational content at secondary school). If students miss classes, they can obtain the missing information in electronic form, video, etc. A student can apply mathematical skills in such professional activities as mathematical analysis and modeling, theoretical and experimental research [3].

There is a recent trend to reduce academic hours for mathematics with increase in hours for student's independent work. The importance of mathematics in development of professional competencies also tends to increase. Classroom hours are decreased without reducing educational mathematical content, since a highly-qualified teacher can easily explain the material and organize students' independent work more effectively.

In the frame of distant learning, the stumbling point is ineffective control of students' knowledge. Besides, there are quite a number of engineering subjects implying laboratory work. No matter how perfect laboratory simulators may be developed, they cannot fully substitute real laboratory work of students. However, distant learning has its advantages. While the traditional learning requires alertness to perceive information at once, the distant learning allows revising and repeating learning material several times until it is understood by a student.

Apart from traditional methods, a modern teacher's set of techniques contains the following activities: teaching on line, multimedia and IT application use of computer models and virtual platforms. Besides, a teacher should be well educated to realize the interrelations between different subjects of a curriculum. Education also implies profound knowledge of the subject, which ensures free professional communication with students.

3. PROBLEM SOLUTION

3.1. Pedagogics is one of the way to increase education quality

Deming cycle is a well-known model used to control and continually improve any processes in different spheres of life. It is also known as PDCA, which stands for Plan – Do– Check – Action or Adjust.

Teaching is one of the ways to learn. The aim of education is learning but not teaching. Pedagogics is one of the ways to achieve this aim [4]. Pedagogics is a science studying patterns of social experience transfer from older generation to younger one. The object of pedagogics is goal-oriented activities of society and teachers that condition personality development. For example, one of these activities is education, which is a purposeful process of teaching and training performed in favour of a person, society and state. The subject of pedagogics is a goal-oriented educational process. Pedagogical science studies principles, patterns, trends, and prospects of education process development. It develops theory and techniques of pedagogical management. It also improves the education content, and offers new forms, methods and tools of the educational activity. Basing on the definitions mentioned above, it can be concluded that pedagogics is a science relating to teaching, training and education of children and adults. The aim of pedagogics is to identify patterns of personality development and choose the most adequate methods that would facilitate such development [5].

3.2. Effective application of informational resources and consideration of psychological and physical characteristics of the contemporary young generation

Experts state that the growth of knowledge is being exponential [6], which could be overcome by effective use of informational resources (IR). However, it is necessary to ensure the conditions for realizing personality's potential and taking into account social traditions and values. Contemporary Russia needs intellectual capital, creative people capable of processing and providing information needed for a society, organization or person [7].

Traditional education ensures linear character of knowledge accumulation approximately until the age of 35 with further possible decrease in knowledge due to forgetting. The contemporary rate of information perception is expected to result in 60%-information-gap between graduates' knowledge and knowledge to be perceived by the 30's of the current century. The predicted information gap can be even more because of the so-called generation Z entering Universities soon. They grew in Internet and can hardly be able to perceive information presented in a traditional academic form, which can lead to loss of interest in learning [8]. Generation Z (known also as Generation M, Net Generation, and Internet Generation) is the generational cohort following the Millennials, approximately those who

were born from the mid-1990s to mid-2000s. Generation Z are predominantly the children of Generation X, but they also have parents who are Millennials. The technologies that used to be regarded as "cutting edge" and "future" have become everyday reality for them. It makes the basic difference between the two generations.

3.3. Training methods improvement

The decrease in education quality often results not only from information overload and slow learning but also from poor teaching methods. Science progress implies new research and achievements as well as promotion and facilitation of the results obtained by previous generations of scientists. The aim is to make the understanding of fundamental mathematics easier. Progress in pedagogics and training methods might lead to studying advanced mathematics as early as the alphabet. [9].

3.4. Effective use of e-learning technology

Another way of education improvement is active application of modern training tools and technology. First of all, it is e-learning technology (ELT) that enhances learning by 10-15%, saves time by 35-45%, increases efficiency of academic activity of faculty staff by 30%, and complies with psychological and physical peculiarities of the Generation Z [10].

The increase in e-courses and online courses made it necessary for educational institutions to rearrange educational process and professional requirements for faculty staff with regard to e-learning. It is reasonable to apply a complex approach to education enhancement by optimal combination of traditional training forms with innovative educational methods.

However, e-learning makes the education system face new challenges. How to focus and keep students' attention through the Net? How to involve students and provide a feedback?

3.5. Effective use of "educational technologies"

UNESCO defines educational technologies as a systematic approach to educational process with regard to human and technical resources, and their interaction aimed at education and learning outcomes enhancement.

An educational technology is a detailed model of all stages of educational activity that implies comfortable conditions both for students and teachers. The educational technology implements the idea of total manageability of educational process.

The efficiency of educational process depends significantly on an adequate choice and professional implementation of particular educational technologies, which are traditionally called modes of instruction and training methods. Educational technologies should be regarded as systematic and consistent implementation of educational process planned beforehand, a set of techniques and tools that ensure effective process management.

Innovation means something new. Thus, innovation in the education system implies changes in aims, content, methods and technologies, forms and management of the education system. It should involve all aspects of educational activity: management and assessment systems, curricula and education programmes, instruction and training materials, and teaching-learning activities.

Currently, there are the following innovative trends in Russian higher education system:

- Multi-level education system is being developed in many Russian Universities. The advantages of such a system are wider choice of training periods and specialties for students. It facilitates the ability of gradates for further education and professional development.
- The universities are using more and more informational technologies, and are intensively using Internet by providing distant learning and introducing e-courses, e-modules, e-textbooks, and other educational content through educational networks and platforms.
- All higher education institutions in Russia are being integrated with the leading Russian and international Universities, which results in university complexes.
- Russian Universities are becoming self-financing.
- The higher professional education standards are being changed to meet the international standards. It has led to the experimental stage to approbate new curricula, education standards, educational technologies, and management structures.

3.6. Effective educational framework

The educational framework involves both traditional forms of instruction and "systematic use of new computer technologies". The first academic years of University study are to create a solid foundation for further development of professional and special skills and competencies. Educational equipment has been lately significantly upgraded. The application of new informational and multimedia facilities contributes to better visibility of instructed material, diversity of educational activities, which improves the learning outcomes. It allows students to develop systemic thinking, problem solving, and information processing skills.

A modern graduate of a technical university should be a highly-qualified professional. These social requirements make it necessary to pay special attention to engineering training. A competitive graduate can quickly get adapted to new working conditions and equipment, perform set tasks and solve non-standard problems. To ensure such an education level it is required to apply efficient educational approaches.

3.6.1. Application of electronic lecture notes

Currently, many teachers are using electronic lecture notes (lecture presentations) for more effective presentation of instruction material. Electronic lecture notes are a roadmap to present educational content in a clear and comprehensible way. New informational technologies allow controlling the presentation quality while delivering a lecture, and using different ways of material presentation (application of videos, figures, drafts, and all kinds of electronic support). It increases the quality of the presented material. According to numerous research studies, up to 80% of the information received from the outside world is processed by the visual pathway. Thus, visibility and attractive presentation of instruction material, as well as combination of the visual presentation with lecture reading, allow focusing students' attention and having emotional impact on the audience, facilitating learning progress.

Electronic lecture notes (lecture presentations) combine the advantages of multimedia and traditional lecture delivering. Actually, it is a modern tool to control the educational process in a class regardless the number of students. A lecturer usually uses several styles of material delivery: descriptive, narrative and explanatory for students to remember the material better. The use of electronic lecture notes multiplies the efficiency of this method.

While developing electronic lecture motes, it is necessary to take into account the following requirements: a slide should contain maximum information but be visual; fonts and numbers should be readable; the number of slides should be from 25 to 60; the presentation should support but not copy the lecturer's report, otherwise, students' attention is distracted. The structure of the presentation can be as follows: lecture theme, objectives, topics to be covered, topic delivery, and references.

The application of multimedia equipment makes it necessary for a lecturer to keep with new informational technologies. The design of a lecture-presentation should be as modern as the design of internet web-sites. Thus, it takes a lecturer more time to design electronic lecture notes than hand-written lecture notes but it is worth it [11].

3.6.2. Increasing student motivation for learning

Engineering education is considered

a key factor of social and economical development in Russia. Rapid development of informational and communicational technologies led to changes in content of engineering work, which, in its turn, caused changes in requirements for graduates training as well as development of new approaches to assessment of professional competencies.

Let us consider motifs of learning activity in higher school.

The first motivation level. Doing sums, making equations, writing essays do not attract students. They tend to escape such kind of activities. Simple formal content and easy tasks are more preferable for students. Fulfilling these tasks ensures passing exams and relative success without much effort. Professionally related personal qualities are not manifested, their professional significance is difficult to identify. The motif can be defined as "I have to". It is often related to the external aspect of learning and focused on formal success and achievement of assessed results.

The second motivation level. Students pay more attention to the subjects that seem to be more important and interesting. They are active and self-sustained in the classes they are interested in. They can set learning objectives, acquire and develop new knowledge and skills deliberately. Learning and professional activities bring them pleasure, they are often involved in additional courses, non-academic and social activities. This level is characterized not only by personally important motifs but also by understanding social significance of such activity.

The third motivation level. Cognitive activity and need for personal development are the typical characteristics of the level. There is a rapid progress in personal and professional development, which makes a strong motif for learning. Students can see their professional prospects related to field of study. This level is characterized by persistence in achieving objectives and active cognitive activity. Projects, essays, course papers are often original. Such students study subjects deeply and independently.

According to research studies, most students are at the first motivation level. It is also proved by the fact that one of the predominant motifs to study at university is to "get a diploma". It implies formal attitude to study and search for the easiest or even illegal ways to pass exams. The motivation level does not change during a university course, which is a problem. Second-year students start to study subjects related to their future jobs, which should increase students' interest in study [12]. Success in professional activity should lead to success in study thus increasing motivation to learning.

3.6.3. Development of MOODLE courses

Tomsk Polytechnic University has been lately introducing the third (a combined) educational form and developing electronic textbooks, modules and courses at different educational platforms. One of such platforms is MOODLE (Modular Object Oriented Dynamic Learning Environment). A lot of educational materials and e-courses have been set up on this platform for students to use them in their learning process [13]. The advantages of the Moodle courses are the possibility to present different kinds of educational resources such as lectures, tasks for practical and laboratory works, presentations, reference links to additional information sources. It also provides a wide range of test forms, a news forum and "question-answer" tutorial instruction, etc.

Each subject course contains an electronic content, theoretical, practical and testing blocks, and references. The following methodology materials have been developed: course programme, instruction for students, academic calendar (or a schedule showing a training and testing form, terms for task performing for each topic), teacher's book containing instruction and recommendation relating to the whole course and to some units in particular). Such courses should not be overloaded with information. It should contain maximum information in minimum educational material, which is a very difficult task for a course developer).

Those students who use the elements of distant learning have better learning outcomes, are more active and successful with individual tasks. It is explained by that fact that they can adjust the learning process to their needs by using new technologies.

Training tests set up in these courses usually contain several standard tasks, with one algorithm, but varied parameters. These tests help students improve their competencies independently. They allow students to identify gaps in their knowledge and induce them to improve their learning outcomes.

Educational tests in theoretical mathematics should be aimed at training to apply theoretical notions in different situations, to determine relations between these notions and facts but not to learn by heart mathematical notions and theorems. An instructor can give examples of the most important notions by developing a test. A student, in this case, takes an active part, since he/she has to deal with the task on his/her own but not to repeat teacher' words and actions.

Home-task tests differ from common home tasks. They are more variable (each student is given an individual set of tasks that can be immediately self- checked). There can be no time limit, if a student writes down a test task, then does it in a copybook, and then loads the answer. It makes students more disciplined. Such tasks can sometimes fully substitute traditional home tasks. In addition, students have the opportunity to improve test results, by doing it several times, until they achieve the desired scours.

Thus, testing is an effective addition to the traditional educational techniques. Testing allows students to assess their mathematical knowledge, train some particular material, and understand theoretical notions and difficult aspects of practical tasks. Students can spend even more time doing mathematics, but, as students say, it is more interesting to do tests. Moreover, the Internet makes it possible for students to choose comfortable time for this kind of learning. In some cases, it is possible to save time by loading only final result without detailed notes [14].

4. CONCLUSION

The computer engineering system described above is an efficient tool to organize educational process. There are two forms of mathematics courses for full-time students: a traditional form and a combined one. The latter is a traditional form (lectures, practical classes, and seminars), supported by an electronic course.

While analyzing basic trends in education, it is obvious that the demand for better engineering education and more effective educational process, as well as inevitable education globalization, determine the modern strategies of e-learning in the world.

In terms of pedagogics, the use of IT technologies facilitates students' personal development and makes them feel comfortable in the information society. It also facilitates development of communicative skills, decision making, experimental and research skills, information culture, and data processing competencies [15].

E-learning is being more and more actively used and integrated in the traditional education system all over the world. It is becoming one of the basic components of every leading University, which makes it even more popular among potential users of education services. We should face this reality and keep up with the times by effectively introducing e-learning, taking new advantages, and assessing possible risks.

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LEARNING PROCESS

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