JOURNAL ASSOCIATION FOR ENGINEERING EDUCATION OF RUSSIA

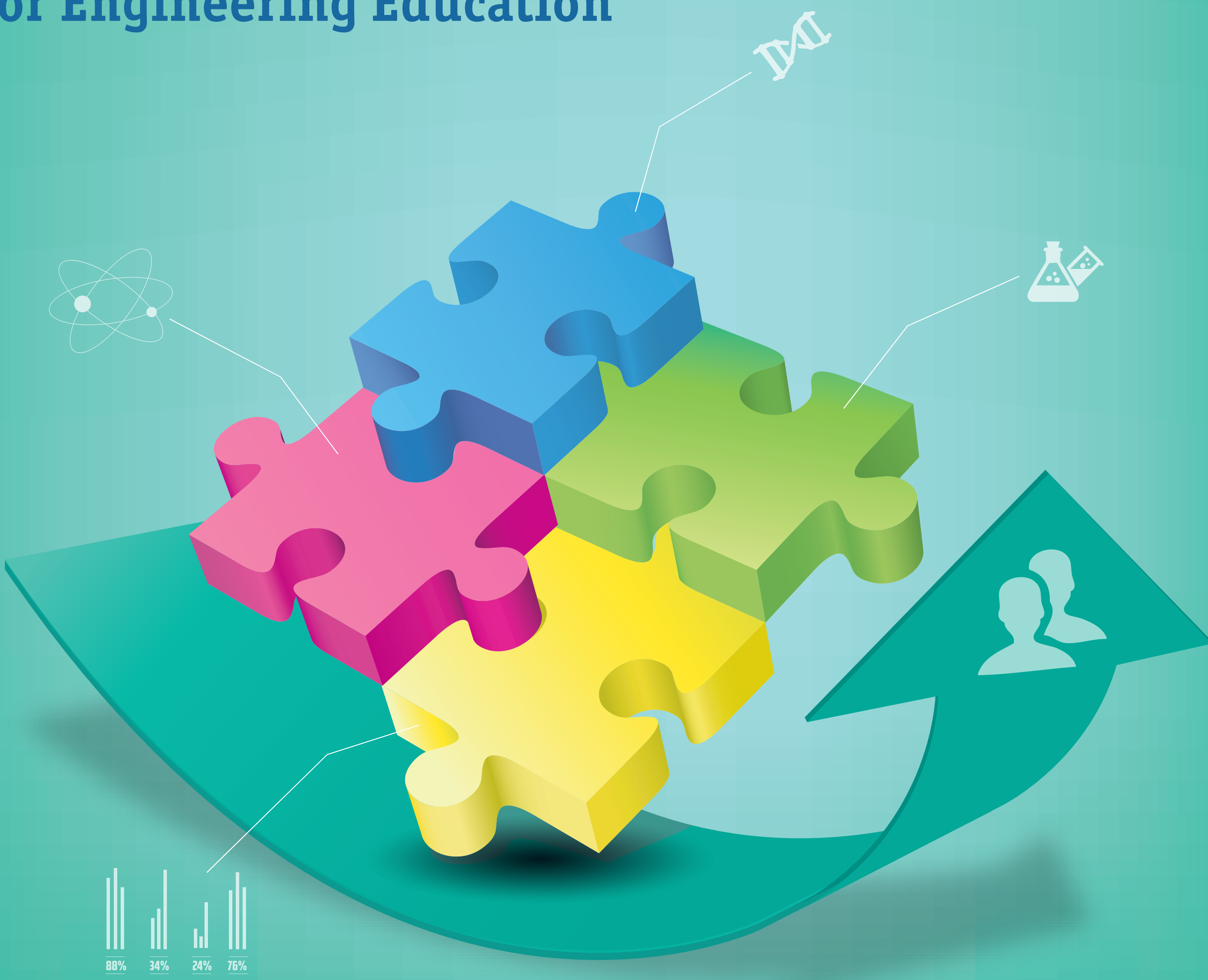
Общероссийская общественная организация
АИОР 1992

ENGINEERING EDUCATION

ISSN-1810-2883

14'2014

Interdisciplinary projects for Engineering Education



ENGINEERING EDUCATION
14'2014

Editorial board

Editor-in-Chief: Y.P. Pokholkov, President of the Association for Engineering Education of Russia, Head of Department of Organisation and Technology of Higher Professional Education of National Research Tomsk Polytechnic University, Professor.

Executive Secretary: B.L. Agranovich, Director of West-Siberian Regional Centre of Social and Information Technologies, Professor.

Editorial Board Members:

J. J. Perez	Full Professor of Physical Chemistry of the Department of Chemical Engineering of the Technical University of Catalonia of the School of Industrial Engineering of Barcelona
J. C. Quadrado	President of Lisbon Superior Engineering Institute
M.P. Fedorov	Scientific Supervisor of NRU Programme of Saint-Petersburg State Polytechnical University, Professor
G.A. Mesyats	Vice-President of the Russian Academy of Science, Director of RAS Lebedev Physical Institute (Moscow), RAS Full Member
S.A. Podlesny	Adviser to the Rector of Siberian Federal University, Professor
V.M. Prikhodko	Rector of Moscow State Automobile and Road Technical University, RAS Corresponding Member
D.V. Puzankov	Head of Department of Saint-Petersburg State Electrotechnical University "LETI", Professor
A.S. Sigov	President of Moscow State Technical University of Radio Engineering, Electronics and Automation, RAS Corresponding Member
Y.S. Karabasov	President of National Research Technological University "MISIS", Professor
N.V. Pustovoy	Rector of Novosibirsk State Technical University, Professor
I.B. Fedorov	President of Bauman Moscow State Technical University (National Research University), RAS Academician
P.S. Chubik	Rector of National Research Tomsk Polytechnic University, Professor
A.L. Shestakov	Rector of South Ural State University (National Research University), Professor

Dear readers,

The issues of interdisciplinarity (transdisciplinarity, multidisciplinarity) are always relevant and topical in scientific and educational field when searching for the ways hot to improve the effectiveness of different types of intellectual activity, like learning and teaching, basic and applied research or real engineering problems solving. First of all, we expect to get new synergetic effect or unexpected results at the intersection of disciplines (scientific fields). This approach results in emergence of new areas of research and training at the intersection of sciences. Today there are a lot of examples to prove that: biochemistry and biophysics, bionics and medical electronics, chemical cybernetics, system engineering and many others. However the benefits of implementing such interdisciplinary projects become aware after quite a long time, and that is unacceptable nowadays. Delay in benefits to appear mainly depends on the methods how interdisciplinary projects are organized and managed on the early stage. Involvement of experts in various fields to solve complex problems in any field of engineering activity does not assure such effects as novelty and synergy. By the form how project is organized it is often called an interdisciplinary one but in fact the final results of such projects represent just the sum of contributions to the cause made by experts in various fields. A striking example of such kind of projects is the curricula of engineering educational program. From the very beginning development of such program is based on recommendations or even mandatory requirements to the ratio and volume of various disciplines in different cycles of training: humanities, natural sciences, mathematics, sociology and economics, general engineering. Then each member of the project develops curricula of his/her discipline (course), and often prefers to use the previously developed programs. Among the best but unfortunately not so frequent cases, examples of the scope of the future specialist are included in the contents. And of course lack of such good cases leads to an abstract perception and poor understanding of these disciplines by future engineers. It results in approach with "little about everything and nothing about the main point". This way of training "motivates" to study only already motivated students. Of course, it helps to helps develop the students' ability, so to say, to work out "intellectual muscle", which will be helpful to the university graduate for engineering problems solving. But in order to get this he has to switch on his own from abstract mathematical theorems to mathematical modeling in engineering, technology and other practical issues. And if afterwards such abstract knowledge will be required within special disciplines, it is not easy to "extract" and apply them from memory even for a diligent student. And the picture becomes more depressing when talking about interaction of humanities, social and economic disciplines with special disciplines. The probability to achieve synergetic effect by introducing such program is extremely small. However some positive implications of such educational programs may still appear in new engineering solutions and developments, but it will take years while all these disparate courses are lined up in the head engineer in a comprehensive way, allowing him/her to solve complex (and may be multidisciplinary) problems.

It seems that positive changes could be made if outcome-based (competency based) approach is implemented when designing educational programs. However, the current high level of bureaucracy of the process, leads to the formal execution of the document, rather than to creating real conditions for synergetic effect, conditions for improving the quality of engineering training.

The same covers research and engineering interdisciplinary projects that should be laboratory and production base for future engineers training. As a rule, such projects arise spontaneously at engineering universities; this activity is not encouraged nor controlled by university management. In our opinion, one of the main and common obstacles to the development of Interdisciplinarity in engineering education is the lack of methodological tools for development and implementation of interdisciplinary projects.

Association for Engineering Education of Russia, following its main objective to improve engineering education, held an International Conference "Interdisciplinary Projects Management in Engineering Education: Planning and Executing" in Portugal in May 2014. The co-organizers of the conference were: International Federation of Engineering Education Societies (IFEES), Instituto Superior de Engenharia de Lisboa (ISEL), Instituto Superior de Engenharia do Porto (ISEP), Gubkin Russian State University of Oil and Gas, Don State Technical University (DSTU).

Representatives of 10 Russian universities, foreign experts in development and implementation of interdisciplinary projects from Denmark, Italy, USA and Portugal took part in the Conference. Participants learnt more about the methodology and international best practices of interdisciplinary projects management in engineering education. Within the conference, aimed at advancing skills of scientific and pedagogical staff and managers of engineering universities, participants completed practical tasks on the development of interdisciplinary projects in engineering education by themselves. At the "Round Table" participants together with the experts identified the main obstacles of developing and implementing interdisciplinary projects in engineering education and outlined ways how to meet the challenges.

The current issue of the journal "Engineering Education" is dedicated to the important and topical issue: "Interdisciplinary projects in engineering education." Some of the published papers were discussed at the conference and were noted as deserving attention of a wider academic community. Articles submitted to this issue may become the starting point for discussion of a wider topic in the engineering educational community – searching for the ways how to improve the quality of engineering education in Russian universities, and development and implementation of interdisciplinary projects as one of the major tools for success.

Sincerely,
Editor-in-Chief,
Prof. Yury Pokholkov

CONTENTS

UDC 378

Implementing Interdisciplinary Education through Virtual Environment for Design and Professional Tasks

Gubkin Russian State University of Oil and Gas

V.G. Martynov, V.S. Sheynbaum, P.V. Pyatibratov, S.A. Sardanashvili

Adherence to the standards of the worldwide "CDIO initiatives" guarantees the shift to the activity-based training and interdisciplinarity. The present article presents the experience in implementing virtual engineering environment in High Engineering School, which meets the requirements of activity-based training. The virtual engineering environment is regarded as a system of interconnected computer workstations for the team made up of different petroleum specialists and a set of digital models of objects and technological tools.

Key words: virtual environment of professional activities, interdisciplinary training, method case-study, a simulator for the specialist, CDIO.

V.G. Martynov

V.S. Sheynbaum

P.V. Pyatibratov

S.A. Sardanashvili

The achievements of IT industry have drastically changed the way people handle all kinds of activities including educational process. New achievements continually contribute to this process. Traditionally, higher engineering education is regarded as a means of getting theoretical knowledge in university classrooms, laboratories, and libraries, while professional skills and experience are acquired by performing various practical activities and projects stated in the current curricula and by participating in internship programs which allow students to work at companies, particularly at Technology, Research and Development, Engineering and Administrative divisions. In Russia, student internship programs are usually initiated by the universities themselves, however, it is getting harder and harder to create effective internship opportunities for the growing numbers of students in the context of the market-driven economy and the absence of relevant statutory regulations for private companies. In Europe and the United States, the main responsibility for gaining experience and corresponding professional skills lies on the shoulders of students who usually try to find summer employment with the help of special university services.

Gubkin Russian State University of Oil and Gas (it is basically, Polytechnic University training of specialists for petroleum industries) is the first university to have started implementing virtual engineering environment which recreate workplace experience and project activities within the walls of the university [1]. This virtual environment is a system of computer workstation-

Fig. 1. High-tech Centers of Gubkin Russian State University of Oil and Gas (upper left – FDCC, upper right – control desk of FDCC, lower left – OGPTOC, lower right – Virtual Refinery).

simulators connected by high-speed network and imitated the operations of various specialists working in different subdivisions of the companies in the oil and gas sector: oil-production enterprise (oil field), refinery, underground storage facilities. In the case of oil field, workstations-simulators imitate the operations of such specialists as oilfield geologist, well-log analyst, well driller, production engineers, technician, power engineer, chemist engineer. Each of these simulators, on the one hand, allows imitating specialist's work, i.e. monitoring real technological complexes which are represented in virtual environment by corresponding digital models, however, on the other hand, the simulator provides the possibility to connect with the main server, use its data bases, interact with colleagues, team members and leaders. To be more precise, the simulators allow students to receive and transmit technical data, instructions, orders and etc. The situation center which is an analogue to the well-known spaceflight control center is a network core which connects all the laboratories equipped with the workstation-simulators.

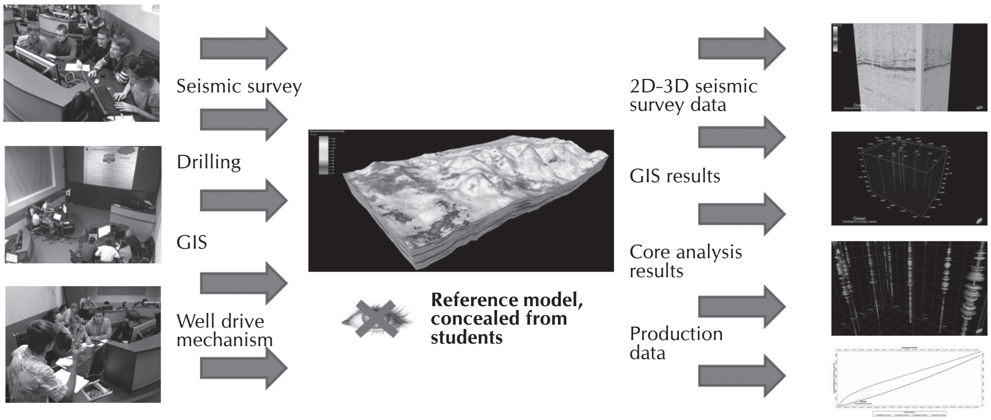
Today, there are three state-of-the-art situation centers at Gubkin Russian State University of Oil and Gas: Field Development Control Center (FDCC), Center for Monitoring and Control in Refinery Process (Virtual Refinery), Oil and Gas Production and Transport Operations Center (OGPTOC) (Fig.1).

These virtual environments and related technologies allow students to study in a number of innovative ways: on-line imitation of project activity (students work as specialists of the corresponding divisions of the project company in the laboratories equipped with simulation units); on-line imitation of production operation (students work as specialists of the oil and gas production company or refinery).

One of the key issues of virtual engineering environment design and implementation is the development of digital models of the study objects - oil-bearing formation, wells, downhole equipment, and etc. To address this issue, professional software products provided by worldwide companies Schlumberger,

ENGINEERING EDUCATION 14'2014

Fig.2. Performance Capabilities of Software Simulation Complex "Virtual Reservoir".



Roxar, Landmark, Honeywell, etc., potential employers of the university's graduates, are applied. To date, Gubkin Russian State University of Oil and Gas has set up cooperative relationships with the leading service companies which participate actively in developing and implementing simulator complexes imitated the processes of oil and gas field development, hydrocarbon transport and processing.

The most vivid example of such innovative solutions in developing computer simulations is the software simulation complex "Virtual Reservoir" developed in cooperation with Schlumberger. It is a rather complicated data entity which allows imitating reservoir response toward computational activity that corresponds to the real reservoir stimulations or realistic reservoir modelling carried out during oil and gas field exploration and development, i.e. seismic survey, core sample analysis, well logging and hydrocarbon production [2].

The proposed computer simulation complex is incorporated into the educational process through the interdisciplinary project intended for the Master and four-year students. The project has implications across disciplines and with learners having different background knowledge that enables to make up interdisciplinary students teams, each of which represents a certain company or organization aimed at effective hydrocarbon field development due to the optimal solutions in reservoir properties study, production well drilling and hydrocarbon recovery (Fig.2). The economic indicators of project implementation are automatically calculated in accordance with the cost of the arranged activities and the price of the extracting hydrocarbons.

This virtual engineering environment enables to implement the standards of the worldwide "CDIO initiative" which is based on the principle that the model of the entire product lifecycle, i.e. "Conceiving-Designing-Implementing-Operating", is the appropriate context for engineering education.

Thus, project activity simulation is introduced as key training courses throughout the curriculum, particularly in 7 and 8 semesters of the education calendar [3, 4]:

- Oil Field Development Modeling in Virtual Engineering Environment;
- Gas Field Development Modeling in Virtual Engineering Environment.

These training courses involve students with different background knowledge and in any major, which allows them to perform the roles of geophysicist, geologist, driller, reservoir engineer, production engineer and economist. It is essential that half of the whole class hours allocated within the curriculum are given over to these training courses aimed to address controversial issues and find appropriate solutions in a teamwork setting.

The main goal of the training courses in Oil and Gas Field Development is to give students experience and a feeling of participating in a big specialist team striving to find the solution for a complicated problem – selecting the most optimal field development scenario. The general concept of these courses is based on the corresponding reservoir engineering regulations and procedures which are under the legislation of the Russian Federation.

Involvement into the interdisciplinary project allows students, having different background knowledge, to explore the entire cycle of the technological operations included in the field development starting from well logging and reservoir modeling and ending with the calculation of development parameters and economic analysis (Fig.3).

At the end of the course students must defend their projects before the relevant evaluating committee under the same conditions and regulations which are established by the corresponding government bodies of the Russian Federation in relation to the defense of the reservoir management plan.

The proposed virtual environment is implemented by means of a "case-study" method within interdisciplinary setting.

Application of the "case-study" method in combination with the interdisciplinary approach within high engineering education is regarded by the authors of the article as a crucial and relevant task based on the following reasons:

- absence or inadequacy of the current conditions for introducing practice-oriented courses into the education programs offered at Russian universities;
- need to develop in future specialist, bachelor or master the ability to respond adequately to various standard and emergency situations;
- need to develop the ability to work in a team setting;
- need to provide a student with the deep understanding of his/her role in the technological process and responsibility that must be assumed for the decision being made.

The interdisciplinary training course "Oil Field Operations Management" designed for the first-year Master students pursuing degree in Geophysics and Petroleum Geology, Oil and Gas Field Development, Machinery and

Fig. 3. Full Cycle of Technological Operations Involved in Educational Process.

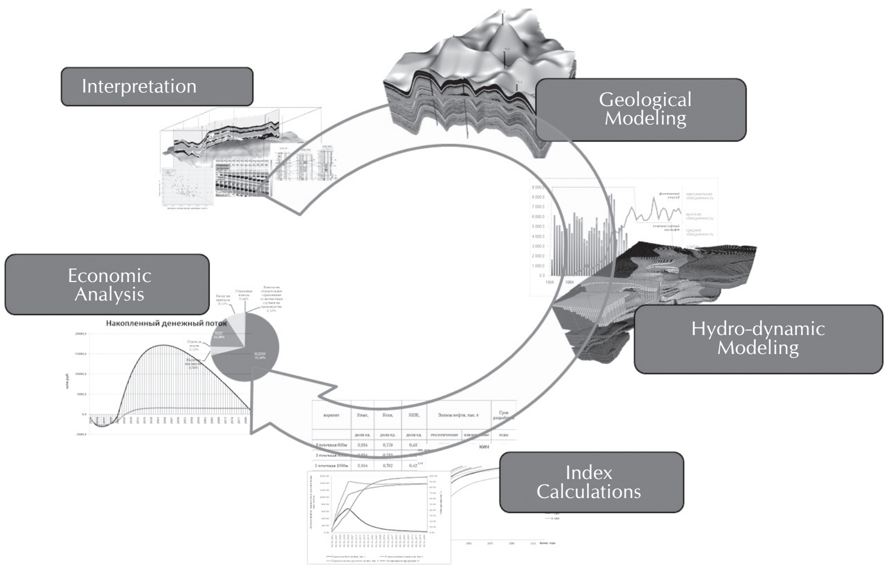


Fig. 4. Master Students Work as Staff-Members of Oil and Gas Production (FDCC).

Equipment, Economics and Managements is the best example of implementing "case-study' method in the learning process of Gubkin Russian State University of Oil and Gas [4].

The content of each class (case) contains the problems which can occur in the day-to-day realities of managing the oil field development and which can be solved not only by deep insight into the real setting, but also by making adequate and immediate decisions.

The fundamental aim of the proposed system of teaching is to provide students with the experience of team work when it is necessary to be able to analyze the problem from different perspectives, discuss the intermediate results and make the decisions within strict time constraints (4 classroom hours).

Depending on the engineering task, the student teams can be built up in the two following ways:

- 1 –based on the interdisciplinary principle, i.e. each team is comprised of 5 Master students having different background knowledge.
- 2 –based on the professional principle, i.e. each team is made up of the students in the same Master program.

Each of these ways defines the further class plan. The first variant allows imitating the operation of five competing oil production or service companies, which, in its turn, instills the sense of competition into the educational process. The second variant imitates the operation of different subdivisions of an oil production company, which helps to train teamwork skills in the corresponding divisions of the company (Fig.4).

Each team has one member designated as a team leader (company executive or head of the division) whose main task is to distribute the responsibilities according to the assigned task.

The content of each case contains the following sections: engineering situation outline; engineering situation analysis; presentation and discussion of the results; making one or several grounded decisions; evaluation of the obtained results (Fig. 5).

Each engineering or project task is set up in such a way that it is impossible for students to solve it working independently because of the differences in the initial data and the necessity to apply special software and interdisciplinary discussion.

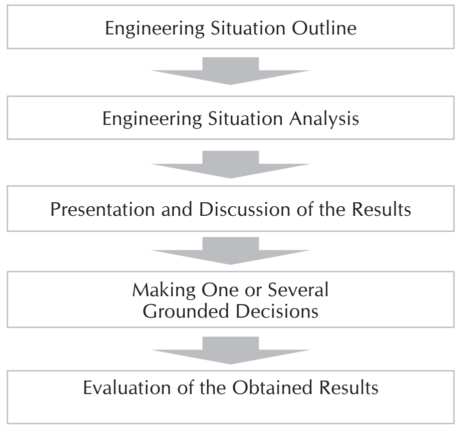
For example, the class is devoted to the analysis of a definite problem that has occurred in the oilfield, precisely, a rapid water encroachment. Each member of the team has equal access to all initial data and together they are trying to identify the reason for the occurred problem based on their knowledge, professional and teamwork skills.

Depending on the reason revealed, it is required to recommend the corresponding plan of actions aimed at enhancing production and improving lift efficiency. To elaborate the optimal plan of actions, students carry out the economic efficiency assessment. At the end of the lesson, student teams present their projects, defend their results and justify the decisions.

The result evaluation criteria applied to the students' projects include: relevance of made decisions, definite economic benefit from the proposed solution; team activity and commitment.

In conclusion, it can be stated that Gubkin Russian State University for Oil and Gas has developed and successfully implemented in the learning process an innovative teaching environment composed of a set of workstations, simulators and Situation Centers interconnected through the local network. This virtual environment allows students to simulate the work setting in order to enable them to experience those professional skills which would be required for future engineering activity, social interaction, team and independent work.

Fig. 5. Case Content.



ENGINEERING
EDUCATION
14'2014

REFERENCES

1. Vladimirov A. I. Specialist Training in Virtual Engineering Environment – Imperative of Our Time / A.I. Vladimirov, V. S. Sheynbaum // Higher Education Today. – 2007. – № 10. – P. 2–6.
2. Digital Reservoir in Education / V. G. Martynov, V. S. Sheynbaum, S. A. Sardanashvili, P. V. Pyatibratov // Oil Industry. – 2011. – № 6. – P. 124–126.
3. Oil Field Development Scenario in Virtual Engineering Environment / V. S. Sheynbaum, P. V. Pyatibratov, L. N. Nazarova, M. V. Kulapova, M. N. Dmitriev // Oil, Gas and Business. – 2008. – № 12. – P. 1–5.
4. Martynov V. G. Development of Innovative Teaching Technology Based on virtual Engineering Environment / V. G. Martynov, P. V. Pyatibratov, V. S. Sheynbaum // Higher Education Today. – 2012. – № 5. – P. 4–8.

Interdisciplinary projects for Engineering Education: Focusing the Gap Between Teaching Profile and Professional Skills

"Engineering Education Reserach" Interdep. Reasearch Unit
School of Engineering, Universita di Firenze, Italy
E. Guberti

E. Guberti

The continued globalization of manufacturing and service delivery has led to a concomitant globalization of the engineering profession. Engineers increasingly engage in international projects, including service on multinational teams at different points around the globe, collaborating on a common project through real-time, electronic communication. Effective collaboration requires not only the ability of participants to communicate in a common language, but also the assurance of a common level of technical understanding. Such issues are not trivial, given the global diversity of systems for educating engineers, for different goals in skills, for quality control of their education, and for regulating their professional practice. From the engineering education perspective, the accreditation and assessment of academic programmes is vital in order to maintain the quality and the status of engineering graduates, and hence the technical workforce. Results of a survey of the relevant literature and observations indicate that various accreditation models have been developed regionally, as well as internationally but most of these models seem to be non-uniform, too complex, non-transparent and, moreover, difficult in their application. This leads to confusion and growing concerns about the mutual recognition and global mobility of the engineering profession. As a result, there is an urgent need for a systematic and shared global model of engineering accreditation that can be used to assess global professional skills and attributes of engineering graduates. The aim of the current paper is double. While on the one hand it presents the added value of the EUR-ACE accreditation system as a European best practice example to encourage the mobility of engineering graduates, on the other one it presents a survey on the graduates' opinion on the level of training in the different technical and non-technical areas, comparing the teaching profile with the actual needs of the professional working environments. The survey was carried out in August 2012 by the International Relations Office of the School of Engineering (University of Florence) as preliminary activity to the EUR-ACE accreditation of two curricula.

Key words: Engineering Education, Interdisciplinary, employability, accreditation, transferrable skills.

1. THE EUR-ACE ACCREDITATION SYSTEM

At the very beginning of the EUR-ACE Accreditation System, a preliminary detailed survey of the standards used by the specialized engineering accreditation agencies throughout Europe revealed striking similarities behind different models. This made the compilation of a set of shared accreditation standards and procedures comparatively easy: the result was the first draft of the "EUR-ACE Framework Standards" [1]. Unlike the old national rules that prescribed inputs in term of subject areas and teaching loads, the EUR-ACE Framework follows the trend of the most recent Standards, and define and require "learning outcomes". This approach has several direct advantages: 1) it respects the many existing traditions and methods of engineering education in Europe; 2) it can accommodate developments and innovation in teaching methods and practices; 3) it encourages the sharing of good practice among the different traditions and methods; 4) it can accommodate the development of new branches of engineering; 5) it assures the quality levels in education of engineering profession.

Today the EUR-ACE is a Europe-based system, run by the European Network for Accreditation of Engineering Education (ENAEE), in which a common quality label (the EUR-ACE® label) is awarded to engineering educational programmes that satisfy a common basic set of standards (the already mentioned "EUR-ACE Framework Standards for the Accreditation of Engineering Programs" that were elaborated within the first EUR-ACE project and are accredited by an Agency fulfilling appropriate Quality Assurance (QA) prescriptions, in particular the "European Standards and Guidelines for Quality Assurance in Higher Education" (ESG) adopted in 2005 within the "Bologna Process" by the Bergen Ministerial Conference. By definition, the EUR-ACE® label ensures the suitability of the accredited programme as entry route to the engineering profession ("pre-professional accreditation"). EUR-ACE has been quoted as an example of good practice of QA in Higher Education in an official report by the European Commission and in an EU publication ("The EU contribution to the European Higher Education Area") issued on the occasion of the March 2010 "Bologna Anniversary Conference" [2].

EUR-ACE system, started in 2007, is a framework and accreditation system that provides a set of standards that identifies high quality engineering degree programmes in Europe and abroad. The EUR-ACE system incorporates the views and perspectives of the main stakeholders (students, higher education institutions, employers, professional organisations and accreditation agencies). Professions such as engineering, medicine, architecture and others carry out work which directly affects the lives of the public. In order to assure the public that these actions and decisions are carried out safely and ethically, graduates must possess specific competences. To ensure that engineering education programmes produce graduates who can demonstrate satisfactory achievement of these competences, they are subject to accreditation by their professional body or another accreditation agency which carries out programme-based accreditation. Engineering programmes that have been accredited by a EUR-ACE authorised agency can be awarded the EUR-ACE label. Among the main characteristics of the EUR-ACE label one can surely recall that it encompasses all engineering disciplines and profiles, is internationally recognised and facilitates both academic and professional mobility. Moreover, it gives international value and recognition to engineering qualifications, and is awarded to programmes which fulfil the programme outcome standards as specified in the EUR-ACE Framework Standards. Finally it respects the great diversity of engineering education within the European Higher Education Area and has created a quality system for accredited engineering degree programmes that share common objectives and outlooks [3].

2. THE EUR-ACE ACCREDITATION MODEL: SELF ASSESSMENT AND EXTERNAL EVALUATION

As above mentioned, the Bologna process has resulted in the EHEA in a common qualifications framework comprising the 1st (bachelor), 2nd (master) and 3rd (PhD) degree cycles. Components of the framework include the EQF (European Qualification Frameworks) qualifications and the ECTS credit system. European standards for internal and external quality assurance are proposed [4].

The EQF relies on stated learning outcomes that are rather general and applicable across all university education sectors. In order to effectively guide education design and accreditation processes for specific fields, more detailed learning outcomes need to be defined. As a result, "sectoral EQFs" emerged with the aim of developing the high-level EQF characteristics into detailed learning outcomes that should characterize specific professional degrees. In the field of engineering, the EUR-ACE framework standards [1] are taking this role. They include three main parts:

- Programme outcomes for accreditation.
- Criteria and requirements for programmes assessment and programme accreditation.
- Procedure for programme assessment and programme accreditation.

2.1. The EUR-ACE Programme Outcomes for Accreditation and Guidelines for Programme Assessment and Accreditation

The EUR-ACE programme outcomes describe the capabilities required of graduates from 1st and 2nd cycle engineering degree programmes. They are structured in six main categories, that is knowledge and understanding, engineering analysis, engineering design, investigations, engineering practice and transferable skills. The 2nd cycle version both adds progression with respect to the 1st cycle outcomes, and adds some additional outcomes, for example "Work and communicate effectively in national and international contexts".

The second part of the EUR-ACE framework standards includes the guidelines for programme assessment and accreditation which are subdivided into five main sections: Needs, objectives and outcomes, Educational process, Resources and partnerships, Assessment of the educational process and Management system. For each of these sections, criteria, requirements and related evidence that should be included in the accreditation documentation are identified.

2.2. EUR-ACE Procedure for Programme Assessment and Accreditation

The EUR-ACE accreditation process can be split in two different, but strictly correlated, phases: a self-assessment phase and, then, an external evaluation.

The self-assessment is implemented by a team according to the request of the accreditation model. The Team is selected inside the school and, often, is constituted by academic, technical and support staff, students. As a result of the self-assessment activity a report - denoted as self-assessment report - is written by the Team with details in accordance with the five main sections mentioned above. A particular attention is voted to the description of the skills regarding the professional figure of engineer. In this case, it is fundamental to distinguish the differences, in terms of skills, among the three different learning levels - bachelor, master and PhD.

The self-assessment report represents the starting point for the second phase of the accreditation process. On the basis of the content of such report and the performance of the learning

ENGINEERING EDUCATION 14'2014

path, an accreditation Team prepares a site visit at the University. This phase is also denoted as peer review. The site visit should include meetings with the university management, academic and support staff members, current and former students, and employers; visits to facilities (libraries, laboratories, etc.); and review of project work, final papers etc. In other words the goal of the site visit is to verify the compliance of the self-assessment activity and the contents of the report with the real situation. For this reason it is fundamental the meetings scheduled with different stakeholders during the site visit.

At the end of the site visit, feedback from the accreditation team is presented during the closing meeting. The accreditation team then writes a report, often denoted as accreditation report. The fulfilment of each individual quality requirement is assessed, using a scale with at least the following three levels: Acceptable; Acceptable with prescriptions; Unacceptable. The overall achievement of the requirements is also evaluated using a scale with at least three levels: Accredited without reservation; Accredited with prescriptions; Not accredited. The university has the opportunity to check the report for factual errors.

The final accreditation decision is taken by an accreditation institution, and may be valid for up to six years with surveillance in the time. After that time, re-accreditation is required.

3. THE EXPERIENCE OF THE SCHOOL OF ENGINEERING IN FIRENZE (ITALY)

In February 2012, the School of Engineering in Firenze has decided to propose two curricula for International Accreditation using the EUR-ACE framework and namely:

- the undergraduate (G) course in Civil, Building/Construction and Env. Eng. (CEA).
- the postgraduate (PG) course in Engineering for preservation of the Env. (ITAT).

The Agency in charge for EUR-ACE in Italy is QUACING (http://www.quacing.it), an agency which has adapted the CRUI (Conference of Rectors of Italian Universities) national model to conformity to EUR-ACE standards. Experimentation on application of the CRUI/EUR-ACE Italian model has started in 2011. The model is highly structured and fulfils the fundamental requirements of most advanced models for quality evaluation and accreditation of university courses in the area of Engineering. The two courses proposed for international certification (CEA and ITAT) have defined the internal working groups and started examining critical issues associated with application of the CRUI/EUR-ACE quality model.

Among the critical issues, it was evident that a detailed decomposition of the learning outcomes/technical skills in the knowledge area of civil engineering was necessary (current models apply Dublin descriptors which are very general). Moreover, it was necessary to implement a survey on the graduates' opinion on the level of training in the different technical and non-technical areas, comparing the teaching profile with the actual needs of the professional working environment. As CEA is a new course, reflecting however a layout generated in 2001 (Bologna agreement- DM509IT) and revised in 2008 (DM270IT), the fundamental skills were inherited by these courses. They were reformulated as EUR-ACE learning objectives, and have been mapped against the Dublin descriptors which have been used up to now). The teaching/learning profile was the same (with different levels in specific areas) for Civil and Environmental engineering (Tab. 1) and a specific set was defined for Building/Construction Engineering (Tab. 2). The survey was run on the graduates from 2008 to 2012, and involved overall 143 students: 75 1st cycle engineering degree, and 68 2nd cycle engineering degree. The survey was designed to avoid overlapping with questions which are already present in the ALMA Laurea

ENGINEERING
EDUCATION
14'2014

questionnaire. The survey was focused on motivation and correspondence between learning profile and required working technical/professional skills.

The main results of the survey for Environmental Engineer (both G and PG) are reported in Fig. 1 and 2. Fig. 1 shows the results of the survey in terms of learning profile, while Fig. 2 shows the difference between the learning profile and the required professional skills (as perceived by the respondents). Similar results are reported in Fig. 3 and Fig. 4 in case of Building/Construction Engineering (again both G and PG). As general comment the learning profile finds a good correspondence with the professional skills, with special reference to the average (G + PG). The fact that some skills have a difference score close to -1 (Capability of running simulations and/or experiments and result assessment; Development of team work attitude; etc.) should be considered a normal outcome, with special reference to the undergraduate learning profile.

Moreover the survey inquired about the reasons for starting the specific university studies (G/PG) and the potential reasons for looking for a different job opportunity. The responses were quite different for the two levels (G/PG); for the two cathegories (Starting University studies/Changing Job); and for the three areas considered (Civ/Edi/Env). The survey also inquired about difficulties encountered in the first impact with the work environment after University studies. Both these surveys are still in progress since data gathering and interpretation is still on the way.

4. CONCLUSION

As our society is facing many grand-challenges and threats, such as the current economic crisis, environ-

Table 1. Learning outcomes: Civil / Environmental Engineering.

1	Scientific fundamentals (Mathematics/Physics/Chemistry)
2	Civil/Structural Engineering (Geotechnics/Structural Mechanics/Theory of structures)
3	Hydraulic Engineering (Fluid Mechanics/Hydrology/Sanitary Engineering)
4	Land Representation Engineering (GIS, Topography)
5	General-purpose SW (Operating systems/spreadsheets/scientific simulation)
6	Specific SW (CAD/specific SW packages such as FE, thermodynamics/heat transfer,...)
7	Materials Engineering
8	Electrical Engineering (plants, electric machines and power electronics)
9	Energy Engineering (Thermodynamics/Heat Transfer)
10	Capability of data gathering (experimental research, field data surveys, including data validation and reduction by statistical methods)
11	Attitude to project work (project organization, civil/environmental engineering)
12	Attitude to group working (teamworking/project study groups)
13	Capability of writing technical reports
14	Fundamentals of economics evaluation and finance tools
15	Professional expertise in quality, safety and environment
16	Interdisciplinary engineering skills (different from Civil/Environmental)
17	Capability of lifelong learning (self-organisation)
18	Principles of Ethics in engineering practice (seminars, part of specific courses)
19	Language skills and capability of working in an international panorama
20	Capability of assessing the environmental performance of a process or of a product (environmental synthesis)
21	Capability of data and information retrieval (from scientific/technical/standards literature;...)
22	Capability of running simulations and/or experiments and result assessment
23	Hydraulic construction works

ENGINEERING EDUCATION
14'2014

mental sustainability, climate change and demographic ageing, these are obviously having different impacts on Higher Education. Therefore Higher Education Institutions should, or better have to contribute to identify the ways out. Universities play a key role and should be involved in providing a cutting edge and effective platform for communication and collaboration among all stakeholders in engineering education that share the same interest. Experience has proven the importance of cooperation in the European and trans-European policy context of the Lifelong Learning Programme and TEMPUS and it is precisely this activity that should be promoted in the future. The key theme is now the necessity of collaboration in engineering education in the future and more precisely, how this must contribute to creating and promoting creative and competitive education in the engineering sector and how future engineers should be assured with the necessary skill requirements and subsequently an employment. The methodology to adopt is welcoming contributions and inputs from all actors in engineering education, from students, researchers, teachers, professionals and industry, since the basis of collaboration

Table 2. Learning outcomes: Building/Construction Engineering

1	Scientific fundamentals (Mathematics/Physics/Chemistry)
2	Civil/Structural Engineering (Geotechnics/Structural mechanics/Theory of structures)
3	Building design (Technical architecture and Architectural detailing, Architectural Design and Composition)
4	Construction management, safety and quality assessment
5	General-purpose SW (Operating systems/spreadsheets/scientific simulation tools such as Matlab)
6	Specific SW (CAD/specific SW packages such as FE, thermodynamics/heat transfer,...)
7	Materials engineering
8	Construction control and management
9	Urban analysis and urban planning
10	Capability of gathering data (experimental research, field data surveys including data validation and reduction with statistical methods)
11	Development of project work attitude (project management, civil/environmental engineering)
12	Development of team work attitude
13	Capability of writing technical reports
14	Energy and fluid distribution systems engineering for buildings
15	Professional expertise in quality, safety and environment
16	Interdisciplinary engineering skills (different from Civil/Environmental)
17	Capability of lifelong learning (self-organization)
18	Principles of Ethics in engineering practice (seminars, part of specific courses)
19	Language skills and capability of working in an international panorama
20	Capability to evaluate the performance of the building and its components
21	Capability of data and information retrieval (from scientific/technical/standards literature;...)
22	Capability of running simulations and/or experiments and result assessment
23	Environmental Sanitary Engineering
24	Graphical Information Systems (GIS)
25	Hydraulic engineering (Fluid Mechanics/Hydrology)
26	Land expertise (Topography)
27	Electrical engineering
28	Energy engineering (Thermodynamics/Heat Transfer)

ENGINEERING
EDUCATION
14'2014

is to include and not to exclude.

In this context the School of Engineering in Firenze has decided to propose two curricula for International Accreditation using the EUR-ACE framework. As a preliminary step a self-evaluation of the actual curricula was performed, and the paper showed a part of the obtained results. On the one hand it has been shown how it is possible to plan and run a survey investigating correspondence between teaching profile and professional skills. The other hand results of the survey are promising and confirm a satisfactory teaching profile under the several design constraints. They will be used for tuning the teaching profile and adjusting it to the professional skills, moreover it is necessary to present and discuss the outcomes with professional associations, industrial and "political" stakeholders.

Fig. 1. Learning Profile (1 = very bad, 4 = very good).

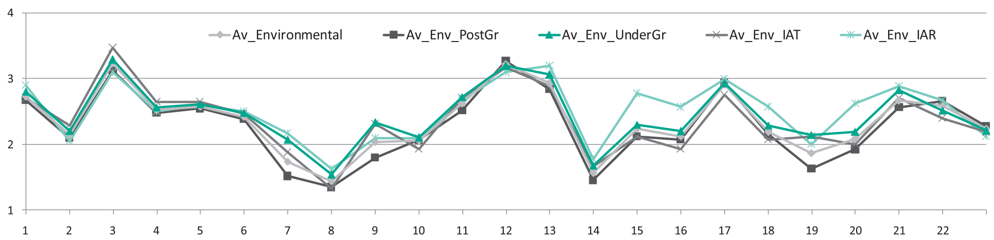


Fig. 2. Difference Learning Profile – Professional skills.

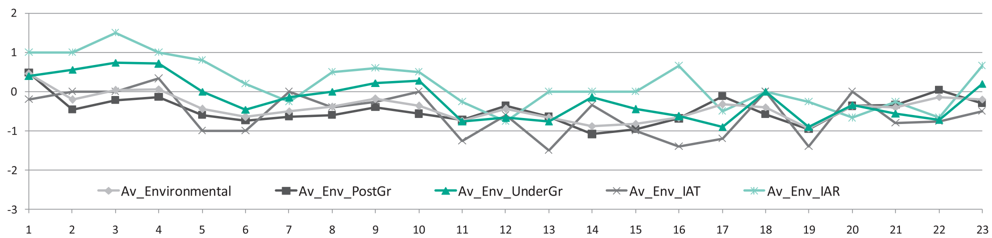


Fig. 3. Learning Profile (1 = very bad, 4 = very good).

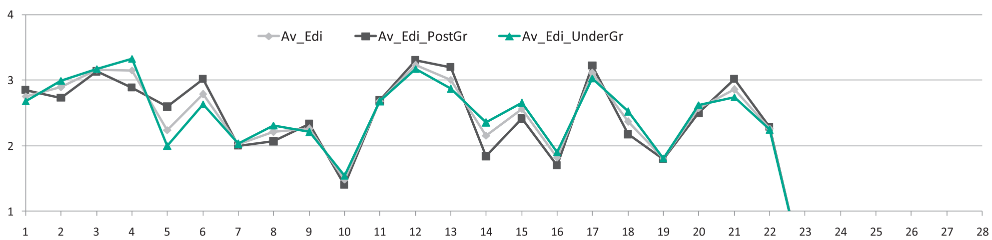
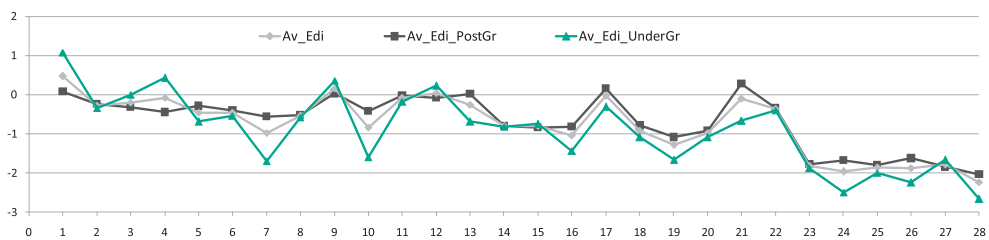


Fig. 4. Difference Learning Profile – Professional skills.



REFERENCES

1. EUR-ACE Framework Standards for the Accreditation of engineering Programmes: [Electronic resource] : approv. by the ENAEE Administrative Council on 5 Nov. 2008 // ENAEE : the offic. website. – [S. l.], cop. ENAEE, 2012. – 14 p. – URL: http://www.enaee.eu/wp-content/uploads/2012/01/EUR-ACE_Framework-Standards_2008-11-0511.pdf, free. – Tit. from the tit. screen (usage date: 24.05.2014).
2. The EU Contribution to the European Higher Education Area / Europ. Commiss. – Luxembourg, 2010. – 27 p.
3. Re-engineering Engineering Education in Europe / ed. by C. Borri and F. Maffioli. – Firenze, 2007. – 190 p.
4. The European Qualification Framework for Lifelong Learning (EQF) / Europ. Commis.; Education and Culture DG. – Luxemburg, 2008. – 15 p. http://www.ond.vlaanderen.be/hogeronderwijs/bologna/news/EQF_EN.pdf, free. – Tit. from the screen (usage date: 23.05.2014).
5. Augusti G. The EUR-ACE Accreditation System of Engineering Education: Origins and Current Status [Electronic resource] // Inquiries into European Higher Education in Civil Engineering / EUCEET; Lifelong Learning-ERASMUS thematic network project. – Bucharest, 2010. – Vol. 9. – P. 265–277. – URL: http://www.euceet.eu/publications/files/EUCEETvolume9.zip, free. – Tit. from the tit. screen (usage date: 23.05.2014).
6. Augusti G. EUR-ACE 14+: Empowering the European System for the Accreditation of Engineering Programmes [Electronic resource] / G. Augusti, E. Guberti // Global Engineering Recognition, Sustainability and Mobility : proc. of the SEFI annu. conf. 2011, Lisbon, Portugal, Sept. 27–30, 2011. – Lisbon, 2011. – P. 369–373. – URL: http://www.sefi.be/wp-content/papers2011/T8/70.pdf, free. – Tit. from the screen (usage date: 21.05.2014).
7. Borri C. Crucial Milestone for EUGENE: from vision to action [Electronic resource] / C. Borri, E. Guberti, F. Maffioli // Ibid. – P. 734–739. – URL: http://www.sefi.be/wp-content/papers2011/T14/59.pdf, free. – Tit. from the tit. screen (usage date: 21.05.2014).
8. Borri C, Guberti E, The EU Lifelong Learning Programme (LLP) for the Competitiveness of European Engineering Education on the Global Scale, Proc. of the ICA2011 (Washington Accord and ABET Imperatives), Chennai, 18-19 May 2011. Нужна ссылка на электронную версию (если есть) + страницы
9. Standards and Guidelines for Quality Assurance in the European Higher Education Area [Electronic resource] / ENQA. – 3rd ed. – Helsinki, 2009. – 41 p. – URL: http://www.enqa.eu/wp-content/uploads/2013/06/ESG_3edition-2.pdf, free. – Tit. from the tit. screen (usage date: 21.05.2014).

Natural Science and Humanities Concepts in Interdisciplinary Projects: Bridge the Gap between Humanists and Scientists

Senior Researcher/Rocha Cabral Research Institute, Lisbon, Portugal

Maria Burguete

M. Burguete

All earnest and honest human quests for knowledge are efforts to understand Nature, which includes both human and nonhuman systems, the objects of study in science. Thus, broadly speaking, all these quests are in the science domain. The methods and tools may be different; for example, the literary people use mainly their bodily sensors and their brain as the information processor, while natural scientists may use, in addition, measuring instruments and computers. Yet, all these activities could be viewed in a unified perspective: they are scientific developments at varying stages of maturity and have a lot to learn from each other.

In fact, in the last 400 years or so since Galileo, modern "science"(consisting mainly by nonhuman systems) has progressed rapidly because of three factors: Scientists pick the simple systems to study; they make a lot of simplifications; they use external detectors and information processors (computers). Partly due to the great successes of these studies, these days, the word "science" is inexplicitly identified with the "science of simple systems", while the "science of complex systems" to which all human-dependent knowledge belongs is often neglected.

However, in the field of human-related disciplines, it is only recently, with the advent of modern science and experiences gathered in the study of statistical physics, complex systems and other disciplines, that we know how these disciplines can be studied scientifically. Science Matters (SciMat) is the new discipline that treats all human-related matters as part of science. SciMat is about all human-dependent knowledge, wherein, humans (the material system of Homo sapiens are studied scientifically from the perspective of complex systems using unifying principles that can be found in different paradigms such as fractals and chaos. SciMat's definition of science: Science is human's pursuit of knowledge about all things in Nature, which include all (human and nonhuman) systems, without bringing in God or any supernatural.

There seems to be a consensus on the fact that sciences and humanities are indispensable in generating knowledge about the dynamic changes that transform our societies. They form the basis of the Horizon 2020 Societal Challenges Pillar and their integration with other sciences will broaden our understanding of innovation, driven not only by technological advances,

ENGINEERING
EDUCATION
14'2014

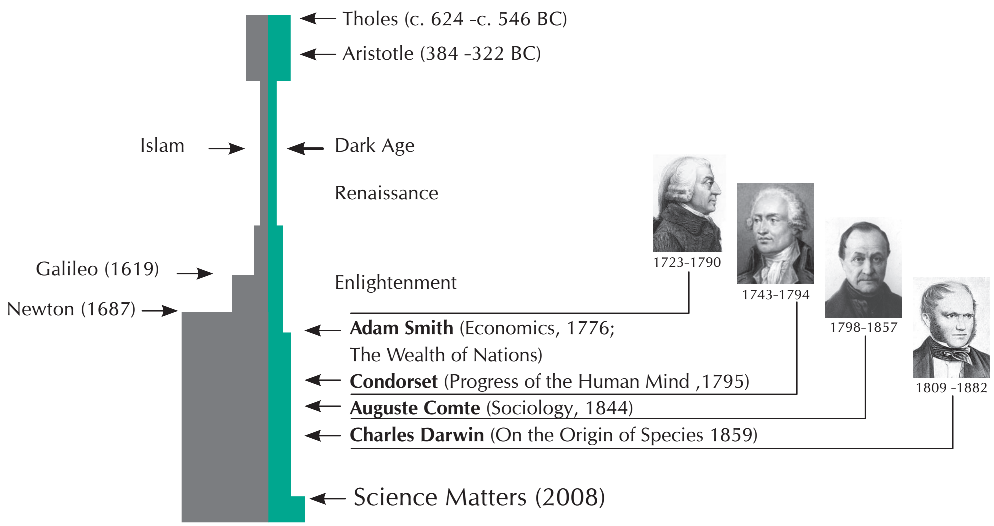
but also by societal expectations, values and demands. Now, according to the SciMat Project the aim of SciMat is to bridge this gap by unifying all the fields producing a new landscape of knowledge: the "Knowscape", which involves a human-dependent part (human matters and artificial systems) plus a human-independent part. SciMat includes: Humanities, Social Sciences, Natural Science and Medical Sciences, all-in-one discipline called SciMat since 2008 according to the principle: "Science is to understand Nature", humans included because everything is made up of atoms. Science Matters (SciMat) is an attitude (or concept), like the case in any new discipline when it first emerges. The attitude of SciMat is just one sentence: "Science is to understand Nature". To make this possible knowledge must struggle for a unified perspective.

Key words: Natural Sciences, Humanities, Interdisciplinarity, Knowledge, Science Matters.

INTRODUCTION

All earnest and honest human quests for knowledge are efforts to understand Nature, which includes both human and nonhuman systems, the objects of study in science. Thus, broadly speaking, all these quests are in the science domain. The methods and tools may be different; for example, the literary people use mainly their bodily sensors and their brain as the information processor, while natural scientists may use, in addition, measuring instruments and computers. Yet, all these activities could be viewed in a unified perspective: they are scientific developments at varying stages of maturity and have a lot to learn from each other. In fact, in the last 400 years or so since Galileo, modern "science" (Fig. 1) (consisting mainly by nonhuman systems) has progressed rapidly because of three factors: Scientists pick the simple systems to study; they make a lot of simplifications; they use external

Fig. 1. A brief history of science in the last 2600 years since Thales. The left (right) column corresponds to simple (complex) systems; the column width represents roughly how much the development activity was during different time periods.



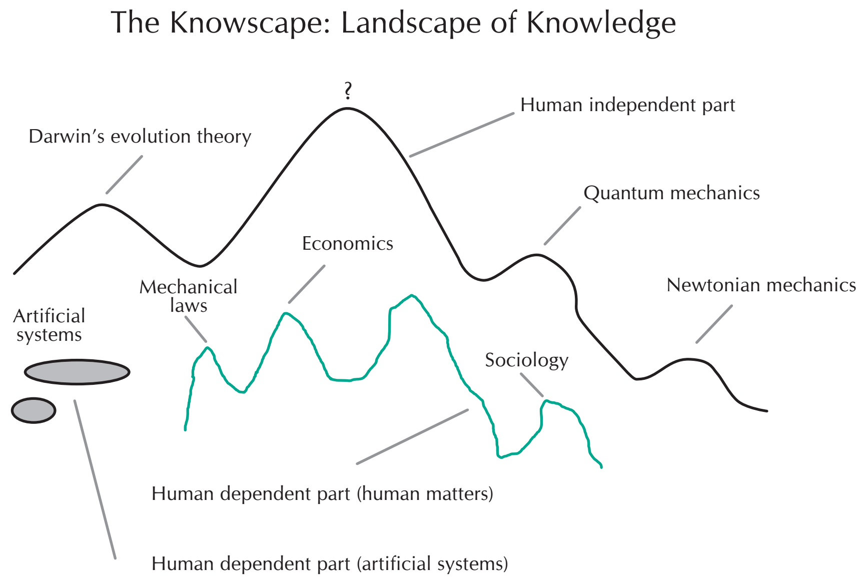
detectors and information processors (computers). Partly due to the great successes of these studies, these days, the word "science" is inexplicitly identified with the "science of simple systems", while the "science of complex systems" to which all human-dependent knowledge belongs is often neglected.

"Science" with the so-called scientific method dated only from 1867 and emerged as a separated field of knowledge from humanities. Therefore, the aim of SciMat is to bridge this gap by unifying all the fields producing a new landscape of knowledge: the "Knowscape" (Fig. 2), which involves a human-dependent part (involves the study of humanities, social sciences and medical sciences mainly neurosciences and genetics) plus a human-independent part (involves the study of non-human biologic and inanimate systems – usually called as "natural sciences"). SciMat includes: Humanities, Social Sciences and Natural Science all-in-one discipline called SciMat since 2008 according to the principle: "Science is to understand Nature", humans included because everything is made up of atoms. Science Matters (SciMat) is an attitude (or concept), like the case in any new discipline when it first emerges.

In the field of human-related disciplines, it is only recently, with the advent of modern science and experiences gathered in the study of statistical physics, complex systems and other disciplines, that we know how these disciplines can be studied scientifically. To bridge the gap, Science Matters (SciMat) is the new discipline that treats all human-related matters as part of science. Science Matters links up humanities and "science" completely while active walk, fractal and chaos, respectively, does that partially. Humanities and "science" share the same root, growing up like two branches of the same plant (Fig. 3).

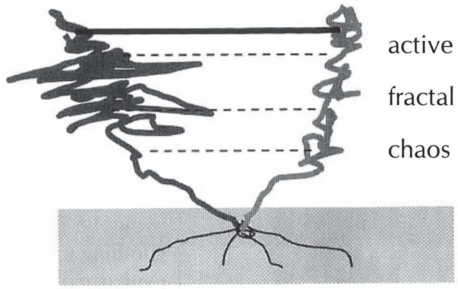
SciMat is about all human-dependent knowledge, wherein, humans (the material system of Homo sapiens are studied scientifically from the perspective of complex systems

Fig. 2. Knowscape.



ENGINEERING
EDUCATION
14'2014

Fig. 3.



using unifying principles that can be found in different paradigms such as fractals, chaos and "active walk". A fractal is a self-similar object, possessing quite often a fractional dimension; fractals are everywhere, ranging from the morphology of three leaves, rock formations and human blood vessels to the stock market indices and the structure of galaxies [Warnecken, 1993; Barrow, 1995; Lam, 2004]. Chaos is the phenomenon observed in some nonlinear systems and as examples there are, human heartbeats and planetary motion in the solar system. The concept is also found applicable in psychology, life sciences and literature [Robertson & Combs, 1995]. A review of chaos for general readers is available [Yorke & Grebogi, 1996]. Active Walk (AW) is a major principle that Nature uses in self-organization; it is a generic origin of complexity in the real world [Zhou et al., 2008]. Active Walk is a paradigm introduced by [Lam, 2006] in 1992, to handle complex systems; in a AW, a particle (the walker) changes a deformable potential – the landscape – as it walks: its next step is influenced by the changed landscape. Active walk has been applied successfully to a number of complex systems coming from natural and social sciences. Examples include pattern formation in physical, chemical and biological systems such as surface-reaction induced filaments and retinal neurons, formation of fractal surfaces and human history [Lam, 2002; 2006; 2008]. All three principles are now an integral part of complex-system science, which is becoming important in the understanding of business, governments and the media, among other things. In any scientific study there are three approaches or levels: empirical, phenomenological and bottom-up - that one can adopt to go further [Lam, 2002]. These three approaches in the cases of physics and arts are sketched in Fig. 4. Empirical studies always happen first. Phenomenological studies are done without knowing the mechanism underlying a phenomenon; they are very powerful and sometimes undervalued. Fundamental understanding of a phenomenon is reached through the bottom-up studies in which the mechanism will reveal itself and become understood.

SciMat's definition of science: Science is human's pursuit of knowledge about all things in Nature, including all (human and nonhuman) systems, without bringing in God or any supernatural (Fig. 5).

So we can design a "Science Room" where we can see the difference between the conventional view of science and SciMat view (Fig. 6).

By grouping humanities and social science together under one umbrella, human-related science, one can

ENGINEERING
EDUCATION
14'2014

Fig. 4.

Three Levels of Study in Humanities

In any scientific study, after

- observing and collecting data and,
- analyzing data

In arts, done mostly by artists, writers, musicians, movie directors and actors, ...

See, e.g., J. Lehrer Froust was a neuroscientist (2007)

There are three approaches to go further:

Approach	Gas	Arts
Empirical	gas law	done by some artists, art critics and historians; physicist-fractals
Phenomenological	Navier-Stokes equation	done by some historians / philosophers; evolution theory (Darwin's time)
Bottom-up	molecular picture (called "microscopic" method in physics)	biology-evolution theory (genes), cognitive science (neuro) physics - statistical analysis, ...

Jonh Barrow, The Artful Universe (1995): Physics Meets Art and Literature. Dec. 2002

Fig. 5.

God in the Philosophy Box

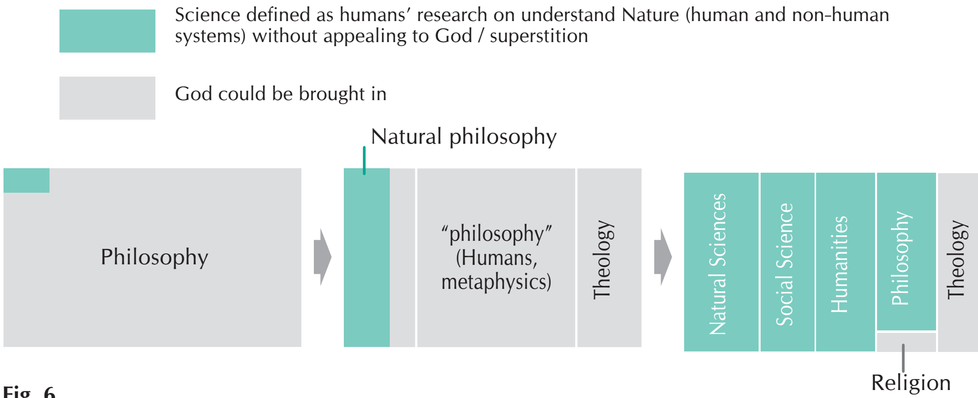
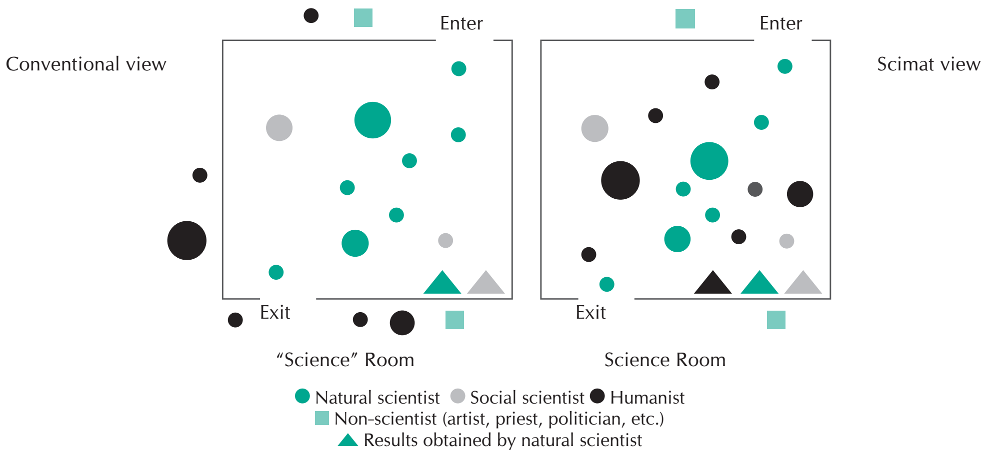


Fig. 6.

The Science Room



understand a new and more logically the connection between the constituent disciplines (Table1.1). For the sake of convenience and with full respect for life an interesting phenomenon in Nature with yet an unknown origin, let us call a human being a "body" (there are several basic facts about such a body [Lam, 2002]( ).

Keeping these facts and table 1.1 in mind is important and advantageous when a human-related study is being undertaken. It allows you to pick up the right tools and the right approximations (that is, simplifying the problem by ignoring some irrelevant factors) to do the research. And it allows you to borrow or to be inspired by some successful experience from other areas of study such as physics or chemistry (wherein, same classification like that in Table 1.1 is used).

There seems to be a consensus on the fact that sciences and humanities are indispensable in generating knowledge about the dynamic changes that transform our societies. They form the basis of the Horizon 2020 Societal Challenges Pillar and their integration with other sciences will broaden our understanding of innovation, driven not only by technological advances, but also by societal expectations, values and demands. Now, according to the SciMat Project there is a six steps Science Matters Program being the first three already performed. The Science Matters Program, started by Maria Burguete and Lui Lam in 2007, is the latest international effort to revive the Aristotle tradition of a unified knowledge, and is the "only game in town":

1. Established the biennial international SciMat conference series
2. Establish an International Science Matters Committee with 17 prestigious members from all around the world, Robin Warren, Nobel of Medicine 2005 included 3. Establish a new book series, Science Matters Series Books published by World Scientific

Table 1. Classification of the human system in a focused study according to the number of bodies involved, with examples and major relevant disciplines.

	One-body	Few-body	Many-body
Example	a Greek male, a Tang Dynasty female, Einstein, Barbara Streisand, Hark Tsui, you, me	Romeo and Juliet, husband and wife, husband and wife living with mother-in-low? A person with two loves, small-size family, the Beatles	Large physics class, tribe, city, country, Roman Empire, society, stock market, IBM
Discipline	Art, music, performing arts, language, literature, psychology, history (biography) , neuroscience, genetics, medicinal science, law	Psychology, literature, performing arts, history, (family) law	Anthropology, (mass) psychology, philosophy, literature, culture, religion, history, business management, economics, education, environmental science, law, social welfare, sociology, women's study, law

[1] Each body is macroscopic from 40-200 cm long; it is a classical particle, so quantum mechanics is irrelevant to those bodies; each body in their daily life moves very slowly compared to light, so no need for Einstein's special relativity theory; the mass of each body is so small (compared with that of the Planet, say), that Einstein's general theory of relativity can be forgotten too; each body consists of layers and layers of structures (molecules, cells, organs, etc); and many internal states (memory, thought, mood, etc);all bodies derived from the same ancestor, say African Eve, around ten thousand years ago and according to Darwin's evolution theory, human body and human nature, take a long time to evolve and thus are practically unchanged over the last 6000 years or so – the period in which human history is recorded; each body is an open system, so the second law of thermodynamics does not apply here since the law is for closed systems and equilibrium states only; each body is under the influence of external fields, the most important of which is the society to which the body happens to belong.

Publisher until 2017 assuring the first five volumes of the collection 4. Establish SciMat centers worldwide 5. Set up an International SciMat Society 6. Publish an International SciMat Journal.

To make this possible knowledge must struggle for a unified perspective. To make the world better it is important to raise the scientific level of the humanities. We believe that Enlightenment (1688-1789) fails to established humanities as a science because: human matters are complex systems and also not deterministic systems like in Newtonian mechanics and the tool of probabilistic science was not yet there. To ensure this happen, the two crucial steps are:

1) The establishment of a large number of SciMat Centers around the world.

2) To write up of a SciMat general-education textbook for university students of all majors.

To finish, I would like to say a word in terminology: In SciMat, the word Science is used to mean all kinds of scholarly enquiry, including those from Sociology, Art Studies as well as Physical Sciences, while Science in the narrow sense adopted by others is written with quotes, "Science".

REFERENCES

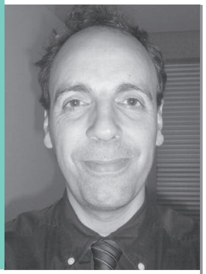
1. Barrow J. D. The Artful Universe: The Cosmic Source of Human Creativity / J. D. Barrow. – Boston [etc.], 1995. – 288 p.
2. Lam L. Histophysics: a new discipline // Mod. Phys. Lett. B. – 2002. – Vol. 16, № 30. –1163–1176стр.
3. Lam L. A Science-and-Art Interstellar Message: The Self-Similar Sierpinski Gasket // Leonardo. – 2004. – Vol. 37, № 1. – 37–38 pp.
4. Lam L. Active Walks: the First Twelve Years (Part 2) // Int. J. bifurcation and chaos. – 2006. – Vol. 16, № 02. –239–268 pp.
5. Lam L. Human History: a science matter // Science matters: humanities as complex systems / M. Burguete, L. Lam, eds. – Singapore, 2008. – 234–254 pp.
6. Chaos theory in Psychology and the Life Sciences / R. Robertson, A. Combs, eds. – Mahwah, NJ, 1995. – 416 p.
7. Warnecken H.-J. The Fractal Company: a Revolution in Corporate Culture / H.-J. Warnecken. – N.Y., 1993. – 228 p.
8. The Impact of Chaos in Science and Society / J. A. Yorke, C. Grebogi, eds. – Tokyo [etc.], 1996. – XIV, 401 p.
9. Zhou T. Towards the Understanding of Human Dynamics / T. Zhou [et al.] // Science Matters: Humanities as Complex Systems / M Burguete, L. Lam, eds. – Singapore, 2008. –207–233 p.

Interdisciplinarity in Engineering education: Trends and Concepts

Fulbrighters Portugal, Vice-President

Nicolas Lori

Interdisciplinarity in engineering is a topic whose potential is not always matched by actual success. A perspective is presented here on when interdisciplinarity is capable of being helpful to success. Different examples of interdisciplinarity are presented in fields like neuroscience, films, computer games, gene development, and power grids. The role of interdisciplinary complexity in defining both the wealth of a nation and the value of universitary education are also discussed.



N. Lori

Key words: interdisciplinarity, engineering, universitary education, wealth, complexity.

INTERDISCIPLINARITY ISSUES

The topic of interdisciplinarity is one that any university must address in order to be successful in a world where technological integration is a major source of technological development. But there are correct and incorrect approaches to intedisciplinarity. What interdisciplinarity should not be is: i) a group of people each an expert on everything; ii) putting people from different expertise in the same place and hoping interdisciplinary stuff happens; iii) creating the tools for everything that is needed in all fields. What interdisciplinarity should be is: i) establishment of communications that enable idea-filtering; ii) idea-filtering creating information that is useful; iii) allowing that useful information to become institutional knowledge, which for Eric Beinhocker in his Origin of Wealth book is the true wealth of any institution [1].

Interdisciplinarity correctly done can thus be a source of wealth. A university interested in exploring the major advantages of interdisciplinarity should do the following: i) degrees based on topics rather than fields, e.g. a degree on solar panel construction rather than a course on mechanical engineering which can be applied to a lot of things but cannot make anything with it; ii) have language classes integrated within the degrees based on what are the countries with the most job offerings for that degree; iii) built the degree based on what employers are saying they are needing right now, and forecasting the job offerings of the future.

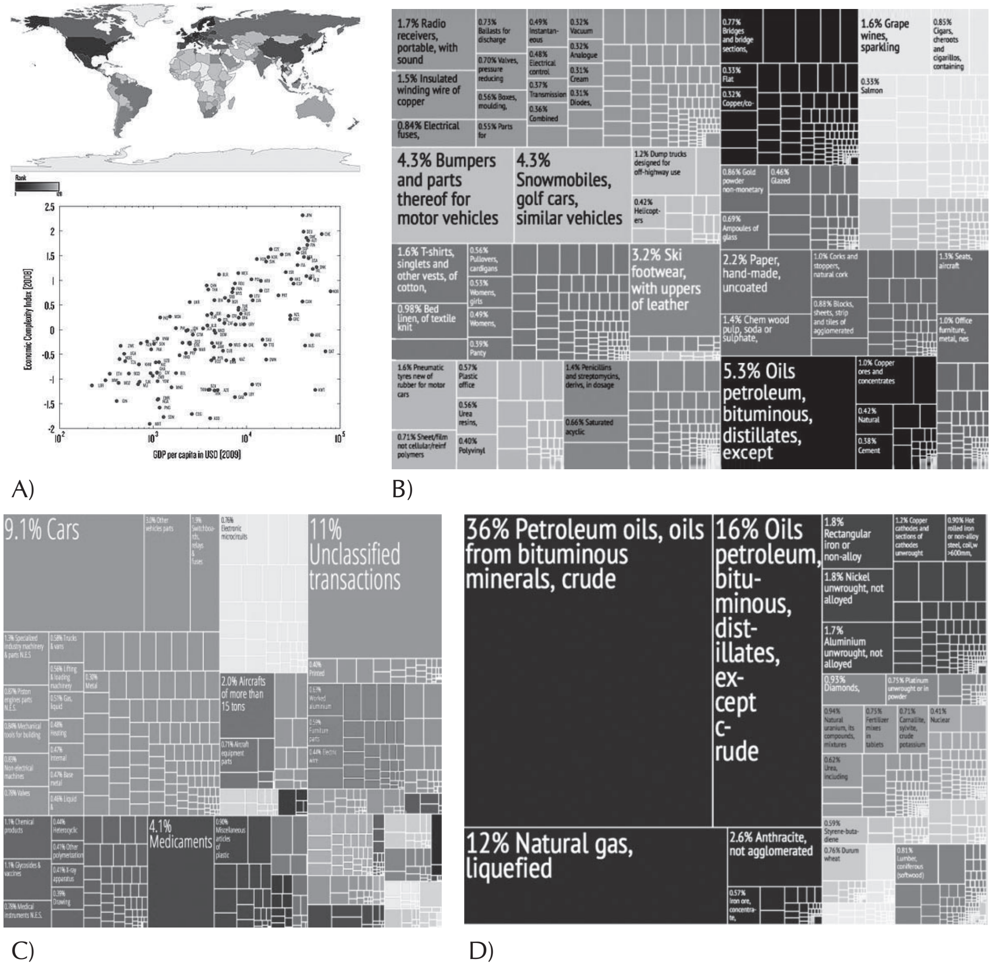
In the perspective of complexity economics proposed by Eric Beinhocker [1], wealth is useful information institutionally implemented, meaning information that can be used to build things by that institution (an institution can be as small as a single person). Information is directly related to entropy, in that entropy equals the total amount of information in a system. In complexity economics, the economical environment is represented as a system of interacting atoms, except that now the atoms can make elaborate decisions. In a system of freely moving interacting atoms, like in a liquid, the atoms undergo Brownian motions which can be approximated by random walks. Random walks in Chaitin's Meta Math! [2] are described as general purpose tools which can describe Darwinian evolution. Likewise in complexity economics, the

ENGINEERING
EDUCATION
14'2014

Fig. 1. Differences Between Standard Economics and the Complexity Economics.

	Traditional economics	Economy as Complex Adaptive System
Dynamics	Economies are closed, static, linear systems in equilibrium	Economies are open, dynamic, non-linear systems far from equilibrium
Agents (human behaviour)	Spock-like. Only use rational deduction. Have perfect information and infinite computational power. No errors, biases and hence no learning needed.	More like Bart Simpson. Mix deductive/inductive decision-making, i.e., rules of thumb. Imperfect information and finite computing power. Makes mistakes, learns and adapts over time.
Networks / institutions	Assumes people only interact indirectly through market mechanisms. Information is adequately conveyed by prices and quantity.	Explicitly accounts for network structure of interactions and institutions.
Linergence	Macro patterns are the linear adding up of micro behaviours. Agents are homogenous and representative.	Macro patterns emerge non-linearly from micro behaviours and interactions.
Evolution	Contains no endogenous mechanism for creating novelty, or growth in order and complexity.	Evolutionary process creates novelty and growing order and complexity over time.

Fig. 2. The economic complexity index (ECI) [3, 4] is a measure defined at the Harvard-MIT Observatory of Economic Complexity) of the production characteristics of large economic systems, usually whole countries. A) Global ECI levels. B) ECI components for Portugal; C) ECI components for Germany; D) ECI components for Russia.



economical systems evolve in a landscape of all possible economical systems. Evolution is an all-purpose formula for innovation, a formula that, through its special brand of trial and error, creates new designs and solves difficult problems. Evolution can perform its tricks not just in the "substrate" of DNA, but in any system that has the right information-processing and information-storage characteristics, e.g. the business plan of a company.

Evolution's simple recipe of "differentiate, select, and amplify" is a type of computer program. It can do its order-creating work in realms ranging from computer software to the mind, to human culture, and to the economy [2].

But a more complex economy is likely to require changes in social interaction. In the work by Oishi and Kesebit [5] it is analyzed what is the optimal social networking depending on the surrounding economical conditions. Let's say we have a population of 1,000 people with 10 friends each and no "random" friends. That is, everyone's friends are drawn only from a strictly defined social circle [family and neighbors]. In that case, the average degree of separation is 50; in other words, on average it will take 50 hops to get from one randomly selected person to another. But if we now say that 25% of everyone's friends are random [not family or neighbors], that is, drawn from outside their normal social circle, then the average degree of separation drops dramatically to 3.6.

In an extreme narrow [deep ties] social network, there are no random friends. In a extreme broad [weak ties] all the friends are "random". The obtained results [5] indicate that narrow [deep ties] are only economically favorable in low mobility high crisis probability situations, and on low residential mobility low median income situations; for all other situations brad [weak ties] are better.

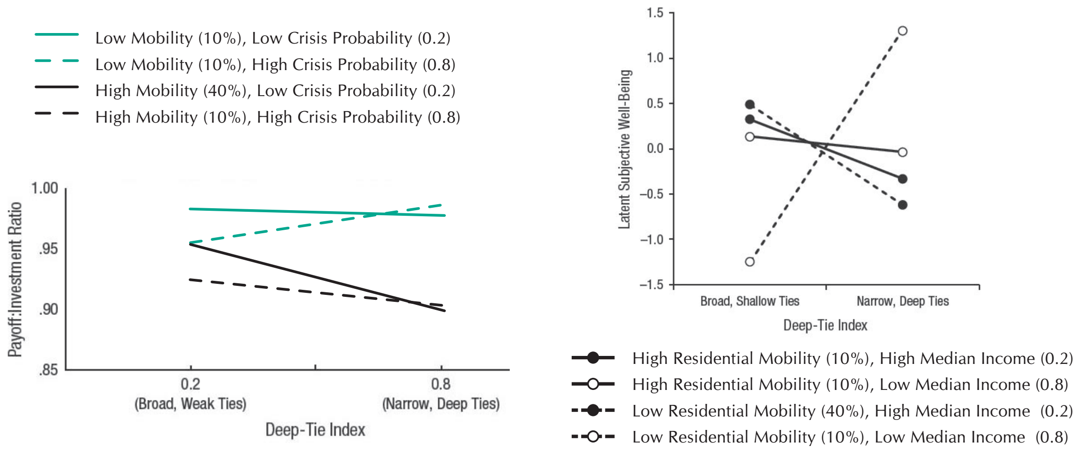
INTERDISCIPLINARITY EXAMPLES

As interdisciplinary examples, we will consider: i) Neuroscience; ii) Films & Games; iii) Gene Development; iiii) Contemporary National Grid. Each of these topics involves several presently-existing courses, but each of the examples only uses a part of those courses, so a possibility for a university would be to focus on the topic, so that someone with a degree in the topic could coordinate (and/or implement) the interactions between people with presently existing degrees.

DISCUSSION

We address the correct and incorrect approaches to interdisciplinarity in engineering. The reason for the correctness of an interdisciplinary approach is directly related to its capacity to address the major difficulty of interdisciplinar-

Fig. 3. Oishi and Kesebit's [5] results on what is the optimal social networking.



ENGINEERING
EDUCATION
14'2014

ity, the impossibility of being up-to-date in all the disciplines. It is hard enough keeping up-to-date in one discipline, keeping up-to-date with all the disciplines that interact in an interdisciplinary way is virtually impossible. That has always been the drawback of interdisciplinary approaches to engineering education, no matter how well prepared a student is by the university, without the permanent professor-induced and colleague-induced pressure to perform, the student loses contact with the relevant literature in a short amount of time. If that is relevant for standard degrees, it is even more so for interdisciplinary degrees.

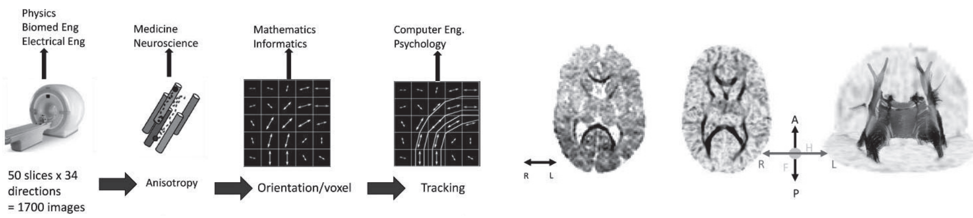
The remedy we propose is that the interdisciplinary degree focuses in production topics, meaning that the student has an interdisciplinary education focused around the generation of a certain type of product. The focus is not the area of knowledge, but the area of production. Focusing on the production is likely to increase the usefulness of the student in the job market, and if a certain form of production disappears, what appears after is likely to be an evolution of previously existing forms of production. So, all the ex-student will be asked to do after finishing the degree is to keep up with the evolution in the production techniques associated to the student's area of expertise.

Table 1. Relation Between Topcs and Presently Existing Universitary Courses.

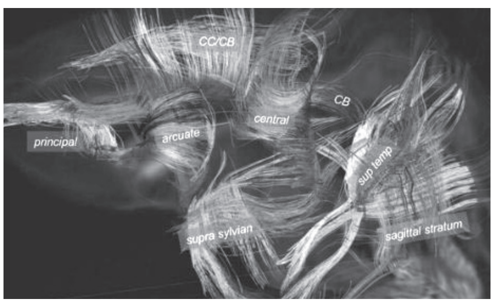
Topics	Presently Existing Courses
Neuroscience	Genetic Eng., Social Sciences, Biomedical Eng., Psychology, Physics
Films & Games	Marketing, Computer Eng., Literature, Management, Publicity
Gene Development	Bioinfomatics, Genetic Eng, Biomedical Eng., Physic, Computer Eng.
Contemporary Power Grid	Electrical Eng., Mechanical Eng., Informatics, Transportation Eng.

Figure 4. Examples of Interdisciplinary Areas.

DIFFUSION MRI DATA PROCESSING IN NEUROSCIENE



DIFFUSION SPECTRUM IMAGING (DSI) RESULT [6] USING DIFFUSION MRI



DIFFERENT BRAIN CONNECTION RESULTS (E.G., DSI ON THE RIGHT) USING THE HUMAN CONNECTOME CONCEPT [7]

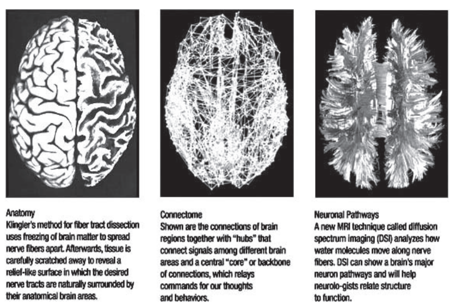
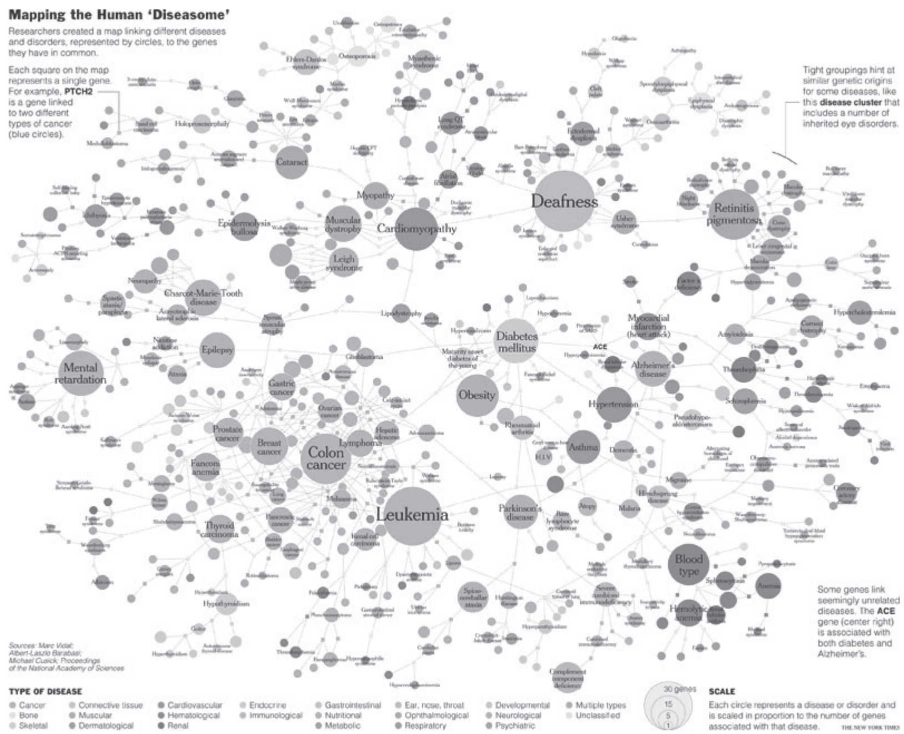
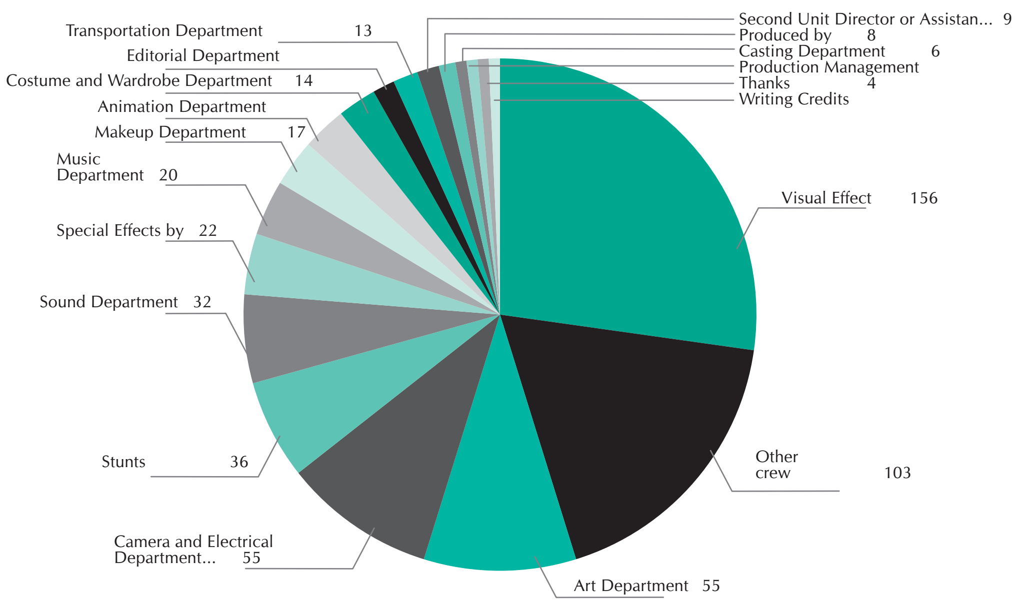


Fig. 4. Examples of Interdisciplinary Areas.

MAP OF GENETIC RELATION BETWEEN DISEASES, THE DISEASOME [8]



DISTRIBUTION ACROSS EXPERTISE AREAS FOR AN AVERAGE
FILM PRODUCTION BETWEEN 1994 AND 2013 (550 PEOPLE)



ENGINEERING EDUCATION 14'2014

SUGGESTED READING

1. Damasio A. R. Looking for Spinoza: joy, sorrow, and the feeling brain / A. R. Damasio. – Orlando, Fla, 2003. – 365 p.
2. Organizational trust: a reader / R. M. Kramer, ed. – N. Y., 2006. – 496 p.
3. Panikkar R. The silence of God: The answer of the Buddha / R. Panikkar. – Maryknoll, N.Y., 1989. – 294 p.
4. Levine P. Waking the tiger: healing trauma / P. Levine, and A. Frederick. – Berkeley, Ca., 1997. – 274 p.
5. Cognitive and neural foundations of religious belief / D. Kapogiannis [et al.] // PNAS. – 2009. - Vol. 106, № 12. – P. 4876–4881.
6. Unequal chances: family background and economic success / ed. by S. Bowles, H. Gintis, and Osborne Groves M. – N. Y. ; Princeton, NJ, 2005. – 310 p.
7. Penn D. C. On the lack of evidence that chimpanzees possess anything remotely resembling a 'theory of mind' / D. C. Penn, and D. J. Povinelli // Philos. Trans. of the R. Soc. B : Biol. Sci. – 2007. – Vol. 362, № 1480. – P. 731–744.
8. Lori N. F. Matter and selfhood in Kant's physics: a contemporary reappraisal / N. .F Lori, P. Jesus. // Relations of the Self / E. B. Pires, B. Nonnenmacher, and S. Büttner von Stülpnagel (Eds.). – Coimbra, 2010. – P. 207–225.

REFERENCES

1. Beinhocker E. D. The origin of wealth: evolution, complexity, and the radical remaking of economics / E. D. Beinhocker. – Cambridge, MA, 2006. – 527 p.
2. Chaitin G. J. Meta Math! : the quest for omega / G. J. Chaitin. – N. Y., 2006. – 234 p.
3. Hidalgo C. A. The building blocks of economic complexity / C. A. Hidalgo, R. Hausmann // PNAS. – 2009. - Vol. 106, № 26. – P. 10570–10575.
4. The atlas of economic complexity mapping paths to prosperity / R. Hausmann, C.A. Hidalgo [et al.]. – New Hampshire, 2011. – 80 p.
5. Oishi S. Optimal social-networking strategy is a function of socioeconomic conditions / S. Oishi, S. Kesebir // Psychol. Sci. – 2012. – Vol. 23, № 12 (Dec.). – P. 1542–1548.
6. The geometric structure of the brain fiber pathways / V. J. Wedeen [et al.] // Science. – 2012. – Vol. 335, № 6076. – P. 1628–1634.
7. Sporns O. The human connectome [Electronic resource] : courtesy of Little, Brown and Company [published in 6th Iteration (2010): Science maps for scholars] / Olaf Sporns, and Patric Hagmann // Places & spaces: mapping science : [website] / ed. by K. Börner, and E. F. Hardy. – Bloomington, IN, [2006–2014]. – URL: http://scimaps.org/maps/map/the_human_connectome_115, free. – Tit. from the screen (usage date: 06.06.2014).
8. Biologie : l'ère numérique / sous la direction de M. Roux ; préface de P. Tambourin et F. Russo-Marie. – Paris, 2009. – 259 p.
9. Follows S. How many people work on a Hollywood film? [Electronic resource] // [Blog of Stephen Follows]. – [San Francisco,Ca.], © 200-2014 Stephen Follows. – URL: http://stephenfollows.com/how-many-people-work-on-a-hollywood-film/, free. – Tit. from the screen (usage date: 31.05.2014).

UDC 338.27:621.039.003

Interdisciplinary Project Management of Structure Transformations in Staff Training in Nuclear Industry

National Research Nuclear University «MEPhI»

A.R. Avanesyan, G.A. Dolgikh, Ye.A. Myakota

In the article the topical questions concerning increase in the competence level of experts, carrying out the activity in the sphere of nuclear branch are raised. The role and place of innovations in social development of the nuclear industry, the purpose and the problem of innovative activity are revealed. The priority directions in the sphere of modernization and technological development of Russia are stated, basic stages of staff training are presented. The information and procedural model of the management mechanism is shown by interdisciplinary projects of structural transformations of nuclear branch.

Key words: nuclear branch, personnel potential, interdisciplinary projects, structural transformations, innovative economy.

A.R. Avanesyan

G.A. Dolgikh

Ye.A. Myakota

1. INTRODUCTION.

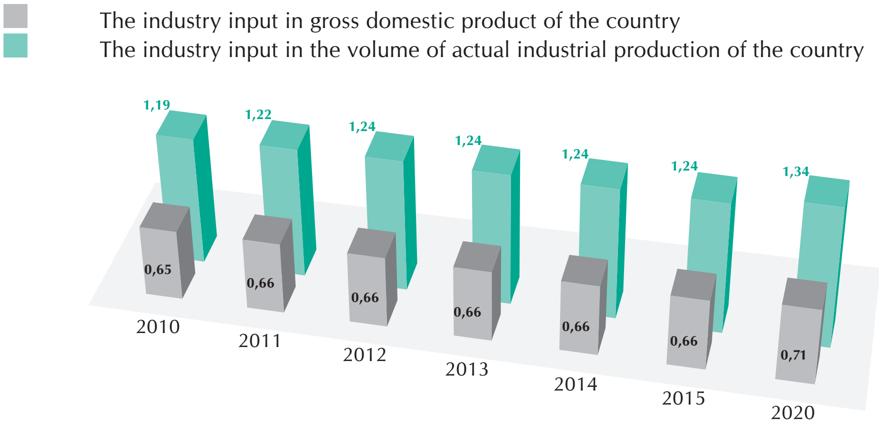
Staff training in nuclear industry is one of the most complex problems at the contemporary development stage of nuclear engineering. The predicted rate and scale of nuclear industry development require outrunning growth in staff competence of all structures of the nuclear energy complex, which implies the design of new interdisciplinary projects of structural transformations, with special attention being paid to establishing and developing the relevant programs within universities.

In theses conditions Russia sets the global, these achievable goals for the long-term development – provision of high rate of population wellbeing, consolidation of the country's role as one of the key leaders determining the world policy. The only possible way to achieve these goals is to transit the economy into innovative socially-oriented development model – innovation-based economy.

2. STRUCTURAL TRANSFORMATION IN STAFF TRAINING IN NUCLEAR INDUSTRY

Innovative trends in economy are the most important condition for nuclear industry development in modern conditions that involve the need for leadership and innovation economy, development of interdisciplinary projects [1]. Quantitative indicators of such economy can make a significant share in the market of hi-tech and knowledge services by 2020. To provide the double increase in the share of hi-tech sector in gross domestic product (GDP), 5-6 times increase in the share of innovative pro-

Fig. 1. Development of Nuclear Engineering - Role of Innovations



duction in industry output and 4-5 times increase in the share of innovation-active enterprises (Fig. 1).

Moreover, transition to the economy of innovative type is possible only under the condition of efficient and dynamic development of industrial branches determining scientific engineering progress. The experience of economically developed countries shows that in modern conditions the main competitive branches are those of hi-tech sector, the basic aims of which are:

- powerful, innovatively active potential, including scientific engineering, scientific experimental and experimental and production bases, innovation projects, highly-qualified staff;
- government participation in support and development of current scientific engineering, production and staff potentials.

The world economic crisis of 2008-2009 hindered the achievement of the goals, since it had stipulated innovation spending cuts in private business and aggravated the structural weaknesses of the Russian innovation system. Nevertheless, such an economic situation in short-term perspective does not imply the necessity of long-term development goal review, rather the rate and quality of economic development can increase in 2013-2020.

The solution of post-crisis recovery problems and transition to innovation development route is made under the influence of internal and external challenges on Russia, on the one hand, complicating the set goal achievement, on the other hand, dictating the necessity of even more intensification in efforts to solve the problems existing in Russian economy and innovation system [2].

One of the key challenges for our country is global development of competitive struggle for the factors shaping the competitiveness of innovation systems, first of all, for highly-qualified work power and «intelligent» money (investments injecting new knowledge, technologies, competencies into projects), sharp increase in mobility of these factors. In the condition of low efficiency of national innovation system in Russia it means accelerated decrease in remaining competitive potential – personnel, techniques, ideas, projects, and capital [3, 4].

Hence, these challenges determine the necessity of priority development in the definite spheres of research and engineering developments («pure» engineering, genomic medicine etc.), in most of which there is no sufficient capacity in Russia. To be up to the challenges it is necessary for Russia to integrate drastically into the world innovation system overcoming the isolation that still exists.

The failure of Russia to meet the challenges means reduction of «possibility window» for transition to innovative economic, loss of existing scientific potential, weakening of geopolitical positions, inclusion of Russia into the group of countries with imitation innovation system, unable to production of new knowledge and achievement of global leadership in the key engineering spheres.

Started in the beginning of the 1990's transformations had a negative effect on both the situation in hi-tech industries that resulted in decrease of production rate, reduction of its quality and competitiveness. Among the main causes for existing crisis situation the analysts have stated: changes in the sphere of economic governmental management such as shrinking the governmental investments and state-guaranteed orders, disintegration of intrasectoral and intersectoral relations, replacement of domestic products by import ones and others. At the level of enterprises the situation is influenced by inefficient restructuring, equipment depreciation and obsolescence, absence of funds for new technologies, lack of qualified staff and disintegration of their training system, particularly, in engineering specialties.

Obviously, in current situation the task of structural transformations in hi-tech spheres is to be considered a priority, as it would allow developing of the base (projects) for all other types of organizational changes.

By structural transformations the intended enhancement, improvements, modernization of separate parts in branch (company) structure is the result of changes in enterprise's specialization, size and other important parameters.

Peculiarities of structural transformations in hi-tech spheres comprise, first of all, enhancement of science role and integration of research departments into developed structures, since it is science that is the base of engineering achievements and innovations [5]. On the course of transition to market economy the integrated relations between science and industry were destroyed. Restitution of hi-tech branches of fundamental and applied sciences in the structure would permit to produce the goods of higher research-engineering level and contribute to:

- strengthening of industrial and scientific relations between separate enterprises enabling achievements of synergetic effect;
- optimal combination of modern production capacities and advanced research and development base;
- improvements in existing projects;
- increase in diversity and achievements of optimal length of processing chains;
- large-scale application of engineering, production, and management innovations.

Structural transformations are labour-consuming, time-consuming systematic process which is to be controlled. In managements of hi-tech plants there appear many methodological problems including:

- determination of strategic goals of transformations;
- choice of transformation direction and mechanism taking into account production and engineering peculiarities as well as character of inner and outer industrial bonds;
- selection of enterprises for development of structures relevant for the market environment in accordance with the reforming goals and tasks.

Setting the goals is the starting point in the management process. Taking into account the significance of hi-tech spheres, the goals of structural transformations are determined not only by owners' and managers' interests but also by government's interest for which the development of hi-tech branches determines the rate of high technologies and is connected with the issues of national security.

According to the goal, structural transformations can be implemented by means of either integrative or disintegrative processes (see Table 1).

The Table demonstrated that the strategy suggested is a continuation of stimulation policy for innovation activity performed within the last decade. In 2005 program "The Basic Trends in the Development of Innovation System in the RF by 2010" was adopted, in 2006 – "The Strategy of Science Development in the Russian Federation up to 2015". In the course of the program and strategies implementation the bases for the current national innovation system are laid, the essential efforts in the development of research and development sector, formation of developed innovative infrastructure based on technological innovations are made [1].

First and foremost, over the recent years financing both fundamental and applied sciences by the government funds has increased through the Federal Target Programs and state funds of scientific investments. The modern system of development institutions in the sphere of innovations including institutions of pre-sowing and showing investments and venture capital funds with government participation was established (through OJSC «Russian Venture Company»), Bank of Development and Foreign Economic Affairs (Vnesheconombank), State Corporation «Rosnanotech» supporting the projects in the sphere of nanotechnologies.

3. SIMULATION OF SCIENCE AND EDUCATION INTEGRATION.

Significant efforts were made for stimulation of researches and innovative developments in higher education. Financial support of innovative programs in 57 universities was performed, nearly thirty universities were given the status of National Research Universities on the competitive base and were granted money for development program implementation including introduction of innovation infrastructure, development of research activity. Measures on involvement of internationally recognized scholars into research of Russian universities, support of cooperation of universities and industry, further development of university innovation infrastructure are taken.

The work on arrangement of national research centers has started (such a center was established on the basis of

Table 1. Comparative Characteristic of Integrative and Disintegrative Structures

Indicator	Integration	Disintegration
Mobility	Low, due to need for coordination of actions at all stages of production and marketing	High, due to small volume of production and clear intra-structural relations
Demand for different resources (financial, staff, production etc.)	High, due to constantly increasing production volume	Depending on the specificity of goods produced, but, as a rule, lower than at integration
Management and intracorporate relations	Multi-level management structure; challenges in building vertical and horizontal communications	Usually simple management structure and clearly structured communicative bonds that makes it possible to take decisions quickly
Investment attractiveness	High, including the factor of large company share quotation in the market	Average except the cases when output product is of high innovation potential

Kurchatov's Institute). The infrastructure of innovation activity support is formed – technology development special economic zones providing sufficient benefits for innovation companies, technoparks, business incubators in universities, centers of technology transfer, centers of core facilities etc. A special place is occupied by the support for establishment and development of innovation clusters on a competitive base.

The foundation was laid for creation of new Russian «innovation territory» in Skolkovo near Moscow where an unprecedented legal framework minimizing administrative and taxation burden is developed for the resident companies.

The system of government co-funding is developed for innovation projects support of private corporations – through management organization of Skolkovo project as well as, in future, through the Russian Fund of Technological Development after its reorganization. As for companies with government participation the system of support for development and implementation of innovation development programs is formed (Fig. 2).

Significant work has been done to improve the legal regulation of innovation activity – the necessary legal bonuses have been and are still being introduced. The law permitting budget-financed educational and research organizations to establish small innovation enterprises was adopted, during the first year of its application about 600 small innovation enterprises have been established in universities and research institutions [6, 7].

It should be noted that the key problem is low demand for innovations in the Russian economy as well as its inefficient structure – redundant excess in the sphere of buying off-the-shelf equipment aboard to the detriment of our new facilities.

Simultaneously, there is a new unfavorable tendency of retardation in achieving the indicators set by the Basic Trends of the RF Government for the period up to 2012 in the sphere of science and innovations.

Those trends determine the necessity to realign the policy in the sphere of innovations performed up to now, shift the focus from buildup of general volume of support in all constituents of the national innovation system to radical increase in efficiency, concentration of governmental efforts for solution of problems urgent for innovative development [1, 2].

One of the most important competitive advantages remaining in Russia from the point of view of innovative development is human capital assets. Involvement of all population in the basic education, one of the first places in the world in the share of population with higher education (23,4 % of the number involved in economy that corresponds to the rate of some leading foreign countries, such as Great Britain, Sweden, Japan, and it outstrips the rate of such countries as Germany, Italy, France), high level of higher education in natural-science and engineering specialties – all these creates the foundation for efficient innovation system. At the same time, the conditions in this sphere are characterized by a number of negative tendencies that, in fact, can devaluate the competitive advantages in future.

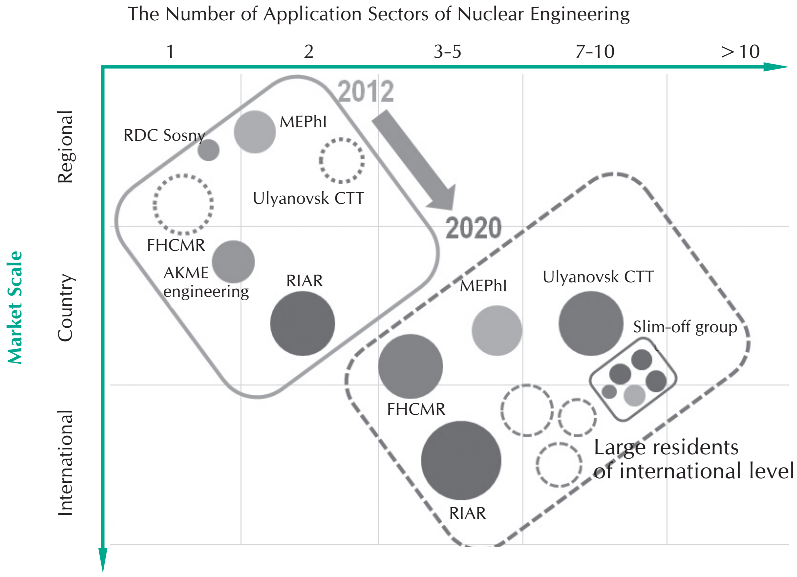
Firstly, the quality of education tends to decrease at all levels – from basic, elementary and secondary vocational education to higher one, as well as PhD program.

Secondly, apart from quality of education significant role for the future innovative development is also played by life goals, behavior models developed in a man that either contribute to innovation extension in economy and society or prevent from it.

Within the 2000's the internal cost for research and development in the Russian Federation mounts constantly in absolute values. As a result Russia is inside the top ten of the world leading countries in general volume of such costs, though it goes sufficiently behind the leaders in such an indicator as the cost share for research and development of GDP (1,24 % as compared to 2,77 % in USA, 2,64 % in Germany and 4,86 % in Israel). The investments in all types of

ENGINEERING
EDUCATION
14'2014

Fig. 2. General scheme of nuclear-innovation cluster development (2012-2020.) as a potential concentration of unique research infrastructures and competencies



research are increasing. For instance, cost for research and developments in universities from 2002 to 2009 has increased from 5,4 to 30,8 bln rub. Thus, if in such indicator as cost of research and development per capita Russia went behind all developed countries of East Europe at the beginning of the 2000's, the gap was if not closed, but reduced significantly by the end of decade.

In terms of absolute scale of its research sector Russia is still in one of the leading positions in the world, giving place only to China, USA and Japan. However, in terms of the researchers' number per 1000 of involved in the economy Russia cedes to more than 20 countries including Finland, France, Germany, USA, Japan etc. The growth of general volume of investments, on the one hand, and reduction in the number of researchers, on the other, enable the significant increase in domestic costs for research and development per one researcher in Russia.

There is still complex situation with reduction of the generation gap appeared in Russian science as soon as the 1990's. Though in 2000's the share of researchers at the age of up to 29 in the whole number of researchers grew, but simultaneously to 2006 there was no growth in the next age category (30-39), that meant failure of many research institutions to draw young specialists. At the same time the share of researchers at the age of 60 and older has grown within 8 years from 20,8 to 25,2 %.

Nevertheless, in spite of remarkable achievements of definite Russian scientists, Russia is presented in the world science by rather low indicators. For instance, for Russia there was only 2,48 % of articles (published in scientific journals indexed in Web of Science database), whereas for France – 5,5 %, Germany – 7,5 %, China – 9,7 %. For its specific weight in the entire volume of scientific publications Russia is between Brazil (2,59 %) and Netherlands (2,46 %). There are still low indicators of research results. In fact, in Singapore per one article in internationally recognized editions there is 3,6 active researchers, in Germany and France - 3,5 researchers, in Argentina - 5,8, in Japan – 9,2. In Russia this indicator is as high as 16,4 (in China, for example, - 13,2).

There is still low rate of citation of Russian scholars that demonstrates their low relevance to international scientific community. If the share of Russia in the world number of scientific publications amounted to 2,48 %, its share in the world number of citation in scientific journals made only 0,93 % within 2004-2008. In this case the «cost» of one Russian publication (relationship of domestic cost for research and development and the whole number of scientific publications) was growing in the 2000's with advanced pace and amounted to 848 thou. US dollars in 2008 as compared, for example, to 221 thou. US dollars in Poland [2-4].

The infrastructure of innovation activity in Russia is in general comparatively developed. Within the last 10 years in all the country there were established hundreds of innovation infrastructure units with the support of government – technoparks, business-incubators, technology transfer centers, common use centers etc.

For instance, the whole number of common use centers reached 75 by the end of 2008, where nearly 2500 items of equipment are concentrated the general cost of which amounts more than 11 bln. rub. In 2005-2007 with the governmental support of the general sum 239 mln. rub. More than 100 technology transfer centers were founded. In the course of state support program for small and medium enterprises 34 innovative business-incubators were established, in this case the general cost of federal budget amounted to 863 mln. rub. Besides, more than 140 innovative-engineering centers and technoparks operate, in the framework of the state technopark program in the sphere of high technology the money was given for 9 technoparks (Fig. 3).

Technology development special economic zones have been set. Innovation infrastructure was formed nearly in every university. At the same time, efficiency of infrastructure still remains at insufficient level, first of all, it is limited by stagnation in demands for innovation on the part of the Russian companies.

4. CONCLUSION

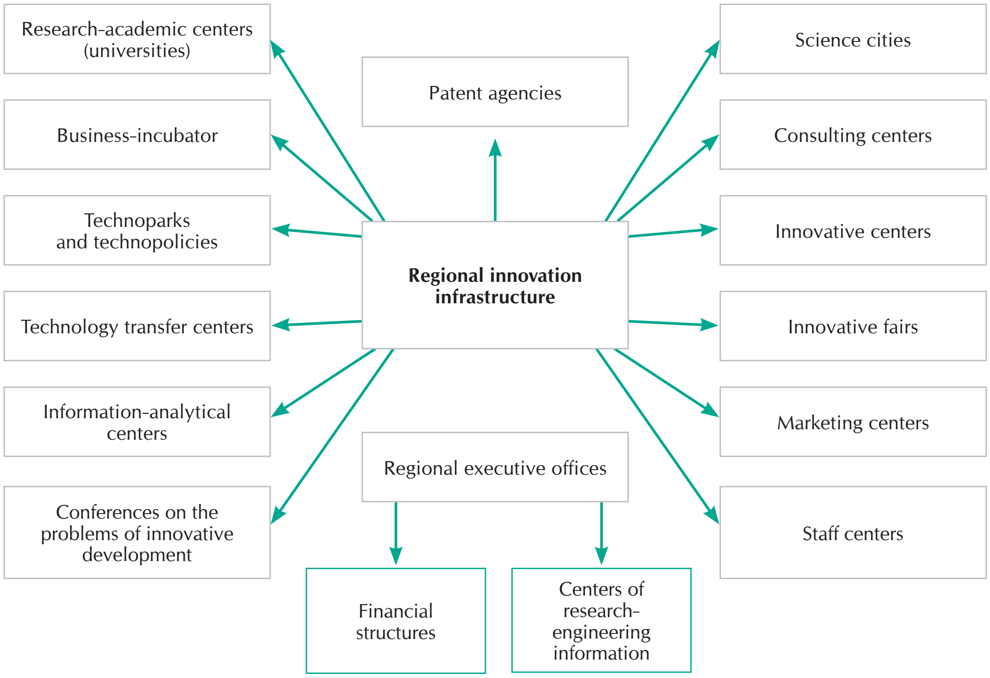
The analysis of modern conditions of Russian innovative system has shown that the current challenges are connected with long-term perspectives of international competition aggravation, hence the following conclusion can be made: the main goal of innovative economy is to create efficient mechanisms for stimulating engineering modernization in all industries and services as well as to develop and introduce new interdisciplinary projects including staff training of nuclear industry. In addition, as practice shows, the process is to be moderated by definite branches of industry among which nuclear industry occupies a leading place [6, 7].

Unfortunately, in any country one can observe low interest of business in performance of complete innovative cycle – from the stage of research and developments to positioning of new products and technologies within the market. At present Russian businessmen invest in research activity and technology developments and projects significantly less than their competitors in the developed and many developing countries. Efficient innovative economy should contribute to reconcile this contradiction.

Inflow of young staff into nuclear industry is a principle task in implementation of innovative development scenario. The key issue is connected with provision of the industry with the specialists of high level. In this aspect the basic version of development strategy for nuclear industry of Russia has been developed and approved for the period up to 2050 that permit for estimation of perspectives in selection of strategic trends in development of the given industry. It should be noted that the basic statements of the innovative economy are focused on performance of its main tasks with the help of State Corporation «Rosatom», under the supervision of which there is the complete operation cycle of nuclear power-industrial complex, that makes it possible to minimize engineering and economic risks in realization of development strategy of nuclear industry as a whole [7].

ENGINEERING EDUCATION 14'2014

Fig. 3. Elements of Regional Innovation Infrastructure



REFERENCES

1. Putilov A. V. Innovative Activity in Nuclear Industry. Book 1. Basic Principles of Innovative policy / A. V. Putilov, A. G. Vorobiev, M. N. Strikhanov. – M., 2010. – 184 p.
2. Strategy-2020: New Development Model – New Social Policy [Electronic resource]: final report about the results of experts' monitoring in topical problems of social-economic strategy of Russia for the period up to 2020. – [Moscow, 2012]. – 864 p. – URL: 2020, http://2020strategy.ru/data/2012/03/13/1214585985/itog.pdf, free. – Title from the screen (reference date: 13.05.2014).
3. On Education in the Russian Federation [Electronic resource] : Federal Law of the Russian Federation from 29.12.2012 № 273-FL. – Access from information-reference system «Kodex».
4. On science and government research-engineering policy [Electronic resource] (with changes by November, 2, 2013) : Federal Law of the Russian Federation from 08.1996 № 127- FL. – Ed., since 1st January, 2014 – Access from information-reference system «Kodex».
5. Il'ina N. A. Analysis of development, current condition and perspectives of development of main participants of the world innovation nuclear market / N. A. Il'ina, A. V. Putilov // innovations. – 2012. – № 9. – P. 10-15.
6. Sidorenko V. A. About strategy of nuclear engineering in Russia up to 2015 // Rosenergoatom. – 2012. – № 6. – P. 9-18.
7. State corporations and development of hi-tech branches of economy: historical review and international experience / A. A. Putilov, A. G. Vorobiev, A. V. Putilov, Ye. L. Goldman // Economika v promyshlennosti. – 2009. – № 2. – P. 2-13.

УДК 001.2

Interdisciplinary Curriculum Projects at the Confluence of Science and Art: Project Development Experience and First Results

St. Petersburg National Research University of IT, Mechanics and Optics
S.K. Stafeev, A.V. Olshevskaya

S.K. Stafeev

A.V. Olshevskaya

The article presents a review of interdisciplinary projects developed and implemented during the last 5 years at the National Research University of IT, Mechanics and Optics (NRU ITMO). The overall concept of such implemented projects fits into the 3D domain scheme "Science-Arts-Techne" as a basis in designing integrated subject ontology. The establishment of an on-line exhibition "Museum of Optics" embracing a harmonious blend of artifacts and art objects with a science frame and up-dated information communication technologies (ICT) furthered new possibilities and prospects which are described in the article below. Copyrighted programs and examples of student creative works in such courses as "Optics and Arts: in the retrospect of time" and "Optics and Arts: theatrical projection" are presented.

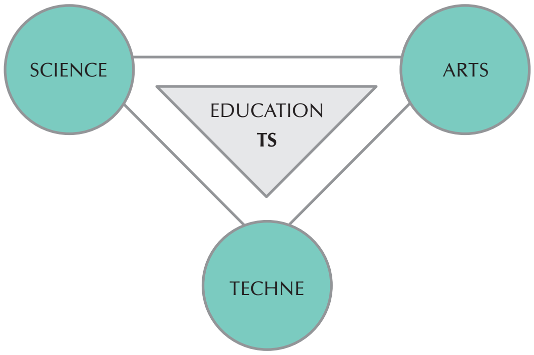
Key words: Interdisciplinarity, educational projects, interactive expositions, optical science, visual arts, history of science, ontology, information and communication technologies.

According to the canonical definition, "interdisciplinarity" is creating something new by crossing boundaries and thinking across them and involving more than one academic discipline. If speaking about crossing the traditional boundaries between natural science and humanities, then the even relevant standard approach involves looking at different science fields (physics, mathematics, chemistry, biology, etc.) "backward", i.e. engaging historical sciences. In case of the harmonious merging of specific knowledge and an understanding of this / that process, then a remarkable educational response is accomplished. However, this response would be repeatably intensified through knowledge application of current wide- range problems in popular art or sophisticated technology which today's student community is encountering daily, but not the application of abstract theories or technical devices. The proposed curriculum projects illustrate the possible implementation of interdisciplinary principles within the framework of optics, visual arts and media-technology.

The fundamental principle of the described projects is the ontologically-renewed classical concept "Triangle Space" - three integrated domains- Science, Arts and Techne (Fig.1). During the formation of European universities seven disciplines of the classical trivium

ENGINEERING EDUCATION
14'2014

Fig. 1. Synthesis of Science, Arts and Techne as the Base for Interdisciplinary Curriculum Projects



(grammar, logics, dialetics) and mathematical quadrivium (arithmetics, geometry, astronomy, harmony) were taught at "liberal arts" departments. Each of these science disciplines embraced elements of arts, where creative Muses were interlinked with specific rational knowledge. For example, arithmetics included the skill of counting, while music – science of chimes. Horoscopy was based on astronomy, while poesy was impossible without the science of grammatical forms.

Those sciences, investigating objects and phenomena irrespective of man, represent a logical investigation method of the world itself. Arts, inherently subjective and manifistated in the artist himself, not only reflect the irrational metaphysical aspect of knowledge, but also are bred by the most outstanding scientific theories and hypotheses. Besides, arts are continuously developing through more and more technological innovations. At the same time technology as such is regarded as the result of precise scientific computing and definite aesthetic perception.

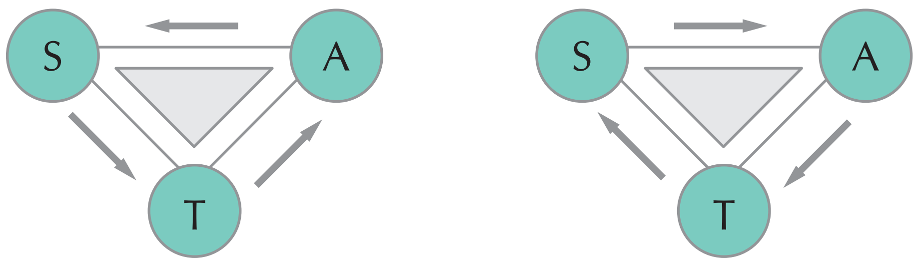
Dating back to the so-called medieval concept: "Science of Liberal Arts," this diagram illustrates a linear dialectic interrelation of Science and Arts and finally Techne. This reflects the principal difference between previous hand-made activities and post-industrial society reality, where a wide range of advancing technological progress benefits exceed the real understanding of their applications.

On the other hand, the pattern Science-Arts-Techne (S-A-T) is practically optimal in designing interdisciplinary curriculum projects. The transfer of knowledge process (Translatio Studii — TS), as depicted in the following diagram, in both directions- clockwise and counter-clockwise (Fig. 2)- dynamically unites the three "top elements."

In the represented information stream 2a the following continuity can be observed: craftsmen achievements (technological innovations) reveal new possibilities for masters of arts, heritage of these masters become the source of inspiration for scientists, scientific discoveries become engineering process (technologies) in time. The 2b stream illustrates the following two facts: (1) the role of engineering problem-solving in ultimate research experiments and (2) the creation of individual and unique visual images under the influence of new scientific concepts. The fact is that aesthetic consideration is "the cornerstone" of the most brilliant engineering developments and there are numerous examples that prove this.

The mid-position within the framework of this Education Space furthers the possible new conception in designing interdisciplinary courses based on the ontological integrated understanding

Fig.2. Two-Direction Transfer of Knowledge Process within Pattern S-A-T



of the three elements (science-techne-media). Domain ontology itself as an up-dated tool of knowledge engineering generates the development of educational standards, curricula and course programs [1,2]. According to ontology, the maximum number of typological dichotomies of objects-concepts facilitates the integrated pattern S-A-T as the central core in an interdisciplinary curriculum project.

Ontologically designed interdisciplinarity involves numerous ideas and approaches inherent in different sciences and arts, and, at the same time, excluding chaos within this framework, but, conversely, generating an absolute knowledge breakthrough. In this case, interdisciplinarity is the advanced interaction mode between science-arts-techne during ontological perception of our surrounding reality.

Another important issue is the implementation of the game-model approach (on-line, competitive) within the framework of educational interdisciplinary projects (EIP). Thus, in designing EIP a balance between cognitive, emotional and technological aspects should be observed.

Examples of ontologically designed EIP are "Optics and Arts: in the retrospect of time " and "Optics and Arts: theatrical projection" which are included in the portfolio of the National Research University of IT, Mechanics and Optics (NRU ITMO). The dominant in the first project is the historic-scientific element, while in the second one (Fig.3) – the interaction between optics and visual art technologies. Both pilot projects have been executed not only in NRU ITMO but also at St. Petersburg State Academy of Dramatic Art.

The historic-scientific element in both projects embraces a description of Euclid emission (vision) theory which became the fundamental principle in Greek scenography- "design" of a performance event (such as light, environment, costumes, etc.). The so-called architectural corrections – entasis columns (Classical columns), curling of stylobates, distortion of well-proportioned statues and other artistic devices – were based on the emission (vision) theory. It should be noted that the Roman author, architect and civil engineer, Vitruvius wrote in his well-known work "De Architectura" (known today as "The Ten Books on Architecture") the following: "An architect should not only be an architect, but also an optician" [3].

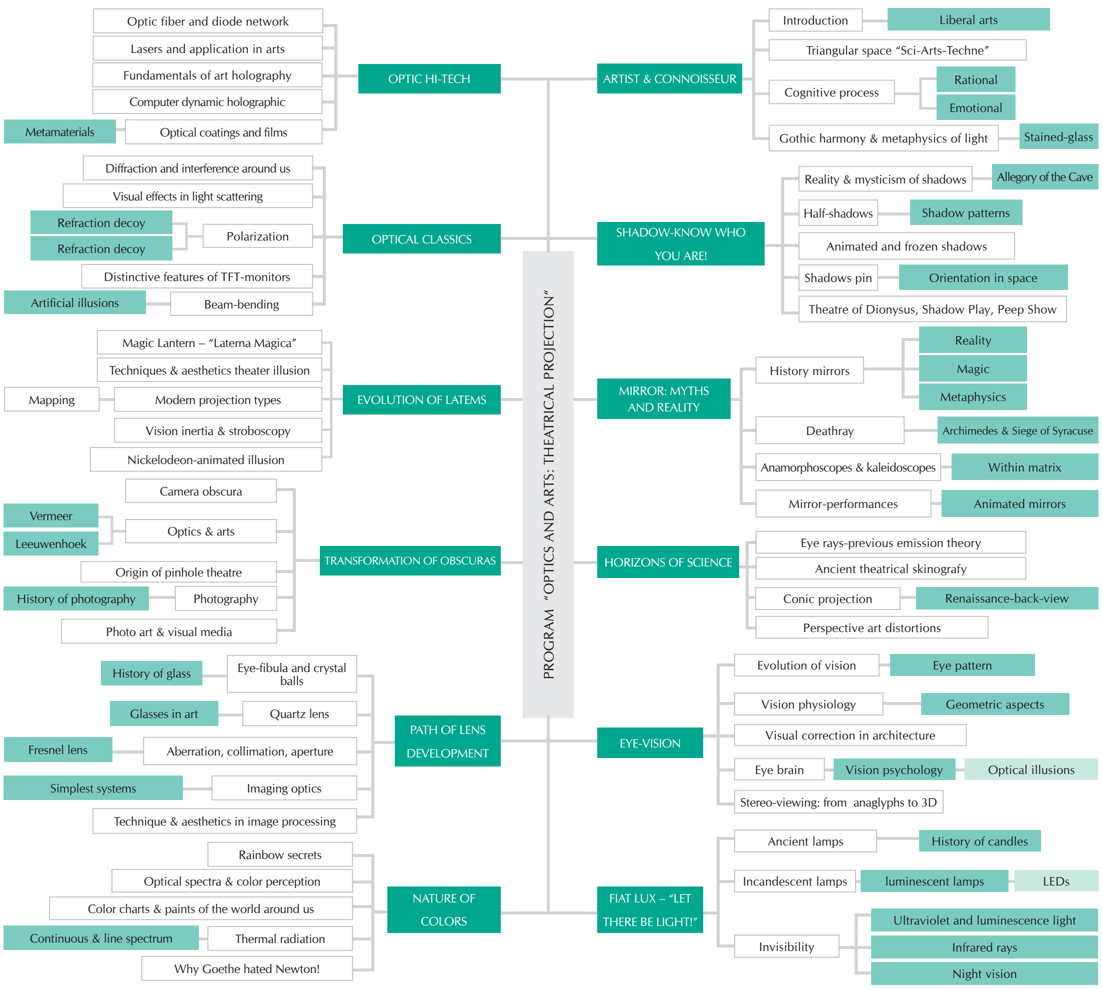
A good share of the cognitive and research activities, described in EIP, is conducted in the NRU ITMO Museum of Optics. The cornerstone of this Museum was the first Russian educational exhibition in optics created within the framework of an innovative curriculum (http://www.optimus.edu.ru/ru) in 2008. The Museum exhibit displays are unparallel in their scope and uniqueness. The museum guide at a snap of his / her finger can "wake up" any exhibit display, and one can not only touch it but also conduct one's own experiment.

ENGINEERING EDUCATION
14'2014

The Museum of Optics embraces the fundamental concept of creating an interactive interdisciplinary educational setting based on the Edutainment'a (education + entertainment) principle which would rekindle student and enrollee interest in the areas of laser physics, photonics and classical optics. Choosing such an interactive technology was based on world analogue museums of optics. Definitely, this technology of presenting instructional materials generates keen interest and is easily understood [4]. The exhibition display could be considered interdisciplinary as it includes not only elements of physiology, anatomy, biology, information science, but also involves a classical scientific base which becomes available for students through interactive information communication technologies (ICT) and is illustrated in the exhibition of popular art and audio-visual objects [5].

This exhibition has been awarded prizes of the RF Government and St. Petersburg and two grants from the "Dynasty" fund. Numerous visitors of the Museum, representatives of American and European optical communities, have noted that this Museum is the best in the world [6].

Fig. 3. Upper Ontology Structure of Interdisciplinary Course "Optics and Arts: theatrical projection"



Interdisciplinary projects can include the creation of two interactive scientific-entertaining centers- "Intellect Labyrinth" and "Erudites". The first interactive entertaining museum "Intellect Labyrinth" was established on December 25, 2010 in St. Petersburg (http://www.labirint-um.ru/about/). There were more than 80 exhibit displays which vividly illustrated the function principles of different physical laws and explained the nature and origin of the most amazing and attractive phenomena of the surrounding world. All exhibit displays were designed in Russia in collaboration with various St. Petersburg universities and enterprises. Core exhibition "Intellect Labyrinth" was the projection of the concept "House of Entertaining Science" established in Leningrad in 1935 under the supervision of J. I. Peremann. Without doubt, these historically intertwining and high-quality exhibit displays made a breakthrough in the implementation of EIP. The second interactive scientific-entertaining center "Erudites" was opened in St. Petersburg in 2011(October 18) with the direct involvement of NRU ITMO experts . The major goal of this center was to submerge students into the amazing world of science, i.e. to prove that science does not simply consist of complex formula and terms but includes fascinating experiments which in an easy-to-understand way illustrate how our world is created and what miracles sophisticated technology can perform; how self-perception of objective reality is shaped and how the aesthetic diversity is associated with science studies.

At present, the National Research University (NRU) ITMO is implementing an interdisciplinary project under the Federal target program "Culture of Russia" in collaboration with the Russian Museum and State Hermitage. Within the framework of this project an IT Support Center for cultural institutions will be established on the basis of NRU ITMO . This Center will embrace all the outstanding achievements of modern arts, science and technology in one. The project concept involves the combination of a modern twist and historical retrospect of arts, science and crafts domains through sophisticated ICT, applying digital images of valuable amenities and holographic images for museum artifacts. The project target is to create an outreach culture environment based on an expansive presentation of cultural object within an education and popular science context. This Center will be equipped with the most sophisticated laser and multi-spectral equipment for continuous monitoring, fact-based certification and restoration of object d'art.

ENGINEERING
EDUCATION
14'2014

REFERENCES

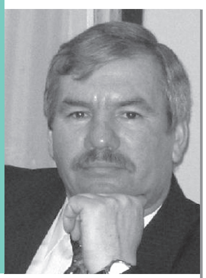
1. Gavrilova T.A., Muromtsev D.I. Intelligent Technology in Management: tools and systems / Higher Education Institution of Management, St.PSU.— St. Petersburg: Publish. House "Graduate School of Management". 2008. — P. 488
2. Boyarski K.K., Katkov U.A.,Muromtsev D.I., Olshevskaya A.V. Stafeev S.K., Jagovkin V.I. Integrated Visualization of Domain Ontology based on Interrelated Designs // Computer Tools in Education. — 2012. № 5. pp. 38-45.
3. Stafeev S.K., Tomilin M.G. Five-century Optics: antiquity// FormaT. — St. Petersburg: FormaT. 2010.
4. Stefeev S.K., Jagovkin V.I. Interactive simulator sets for state educational establishments // Scientific-technical Vestnik St. Petersburg SU ITMO — 2010. — № 5 (69).
5. St. Petersburg Vestnik of Higher Institutions. Unique Museum [Electronic resource]-URL:http://nstar-spb.ru/higher_school/print/article/new42198/, free,(usage date 18.04.2014)
6. Vasiliev V.N., Stafeev S.K., Tomilin M.G. Optical Museum Comes to Life in Russia // Newsletter. The International Commission for Optics – 2009. V. 80. – pp. 1–2.

Experience in Implementing Interdisciplinary Project at TGU in Terms of "Formula-Student" Team Work

Togliatti State University, Institute of mechanical Engineering

V.V. El'tsov, A.V. Skripachev

Implementation of an interdisciplinary project at university may only be possible when a student team for a task to be completed is organized and there are appropriate facilities and software. The main condition for sustained student design activity is the presence of regulations which enable to handle a permanent inflow of new participants without replacing the key ones. Besides, the instructional material and modules incorporated into the current education programs guarantee the highest quality graduate training within various subject areas. Such interdisciplinary project is being implemented in terms of "Formula-Student" at Togliatti State University.



V.V. El'tsov

A.V. Skripachev

Key words: educational programme, the project «Formula-Student», team, training module, learning results.

One of the main objectives in implementing the Development program of Togliatti State University (TSU) is to develop an effective and competitive education system in accordance with the state education development policy, specifically a concept of science and education integration. To accomplish this, particular emphasis is placed on developing active learning techniques, as well as enhancing international cooperation in terms of launching new education programs and recognition of qualifications. Most universities are striving to provide continuous improvement of the quality of education adjusting the current curricula to future engineering activity, as well as technical, technological, economic and social development prospects of the society [1]. It is new content of engineering education program, as well as active learning techniques and practice-oriented training that guarantee the achievement of new learning outcomes which correspond to a set of engineer's competencies.

Project-based learning and student teamwork when they have the opportunity to work in team on a design project are of great importance in innovative engineering education. The conditions that support project-based learning should correspond to real-world engineering so that students will have the opportunity to gain experience in solving complex engineering problems, distributing functions and responsibilities. At TSU, such learning technique is being implemented in terms of "Formula-Student" project.

Interdisciplinary project "Formula-Student" is an international competition for engineering students which combines the elements of education, engineering and sport as it contains not only competition itself but also the elements of technological creativity, economic calculations, managerial decisions and presentations, marketing and business. The project was launched by the Society of Automotive Engineers (SAE). According to the regulations, a student team is allowed to be involved in the project for a year. Next year the team is partially renewed with young students and a new task is set. Except for "Formula-Student" project, there are also similar projects as "Buggy" and "Formula Hybrid". "Buggy" project is aimed at designing, planning and manufacturing a buggy. "Formula Hybrid" is a relatively new and fast growing project and its aim is to build a hybrid race car based on the standard cars manufactured within "Formula-Student" project. Usually, students take the race car which was manufactured last year.

The key concept of the project is as follows: during an academic year, students must organize a team themselves, share their responsibilities, find sponsors and draw up a business plan, design and, finally, fabricate a racing car which is presented to a panel of leading engineers and PR-managers. One of the obligatory phases of the project is to judge the cars in a series of static and dynamic tests which demonstrate car characteristics and participate in the most spectacular event – the final racing competition.

The main peculiarity of the project is that students should design and produce innovative and high-tech car race products to a strict set of rules, technical and cost restrictions. Despite being supervised by a skillful "master", students must design and manufacture a race car by themselves. In work process, from the very beginning up to the final stage, i.e. car production, each participant gains valuable experience in teamwork and various aspects of automotive engineering, which in its turn promotes careers and excellence.

The objectives of the interdisciplinary project:

1. To design a race car according to the rules of «Formula-Student» SAE project.

2. To provide additional financial support through different grants, sponsorship, new manufacturing process, and etc.

3. To fabricate a competitive race car.

4. To participate in the international competition «Formula- Student».

5. To develop and implement practice-oriented training model based on «Formula- Student» project.

«FORMULA-STUDENT» PROJECT TEAM.

At the first stage of the project students must organize a team themselves. As the project consists of a number of stages, starting from the design of a race car and ending with car testing at the racing competition, including budgeting, marketing and PR issues, the team must be made up of students with different education background and from different subject areas. As in any team, a team leader is selected.

Team structure (Fig.1) is defined in relation to project tasks. These tasks can vary from project to project but in most cases they remain the same. The number of students and post-graduates who participate in the project can vary every year. However, the team is never completely dissolved even at the end of a definite stage of the project. The number of TSU team members usually ranges from 15 to 35. For example, in 2012, when it was the fourth year of project implementation, TSU team was made up of students from the following departments:

- Institute of Mechanical Engineering – 8 students: 2 students - 230303 "Operation of Technological Machines and Complexes"; 4 students – 230202 «Ground Technological Complexes»; 2 students - 150301 "Mechanical Engineering".
- Institute of Electronics and Electrical Engineering – 4 students; 2 students - 110304 "Electronics and Nano-electronics" and 2 students - 130303 "Power Engineering".

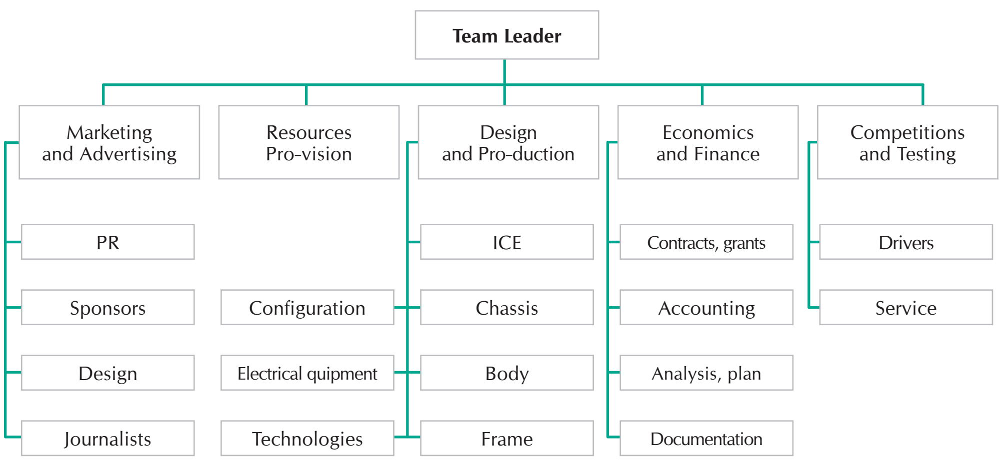
Besides the above-mentioned departments, TSU team usually includes the students from other subject areas. They are as follows:

- Institute of Architecture and Civil Engineering – 1 student
- Institute of Mathematics and Information Science – 2 students
- Institute of Humanities and Education – 3 students
- Institute of Economics and Finance – 3 students
- 1 Post graduate

Each sub-team is accountable for its definite task set by the team leader in cooperation with the scientific advisor of the project, who is typically a faculty member. All the problems which arise in a definite sub-team during the project implementation are stated in terms of technical tasks and discussed at general meeting of project members in order to find the most appropriate solution. Performance efficiency of each sub-team is evaluated in accordance with the obtained results and these results, in turn, anticipate the final goal achievement. For example, the sub-team "Sponsors", a part of "Marketing and Advertising" division, became involved with approximately 20 companies and organizations to attract financial and technical assistance during 2011- 2012. Among them are the following distinguished sponsors:

- Delcam – granted the license on the use Delcam software;
- Process Flow – also granted the license on the use its software;
- Lada-Credit Bank – provided financial assistance;
- Auto Center "Premiera" – provided free painting of the race car body;
- "Togliatti" Foundation – gave grant funding in the project de-velopment;
- JSC AvtoVAZ – made its testing grounds (Sosnovka village) available to team members;
- LLC "MZSA" – provided free transportation of the race car;
- SPEEDFREAK – assisted in website development;
- LLC "AKtis" – presented car batteries;
- Expo-Togliatti – provided free participation in trade fairs;
- LLC "TorgMash"– presented sport facilities for testing the race car;
- Automobile Newspaper «Sem Verst» - provided free informa-tional support;
- Magazine «AvtoSreda» - provided free informational support;
- The innovative-investment fund of the Samara region – gave a grant of 600 000 rubles.
- In 2012, the sub-team "PR" promoted the participation of team

Fig.1. «Formula-Student» Project Team Structure at TSU



members in different regional and national events:
Special flash mob and "Formula-Student" promotion action organized within the framework of the regional extreme sport festival "Panika" by team members and TSU students in May, 2012.

- Participation in public demonstration run "Avtoparad-2012", Togliatti.
- Participation in TSU event "Vypusk-2012" where the race car was demonstrated.
- Participation of «Formula-Student» team members in Russian Youth Forum "Seliger-2012".

Due to the software granted by DELCAM Company, students of the sub-team "Design and Production" developed a mathematical model of Honda RR engine in order to use it in the newly designed frame of the race car (Fig. 2a). The race car frame chassis design requires not only careful calculations of load bearing capacity of the elements (Fig. 2b), but also determination of the most convenient positioning of the pilot and control elements, as well as thorough understanding of race car safety and ergonomics.

The students from the sub-team "Transmission Line" designed a driven sprocket of the differential gear and calculated its strength applying ANSYS program (Fig.3). Also, they calculated the break system of the race car and determined the minimum diameter of the caliper piston required to lock the wheels.

The sub-team "Race Car Configuration" generated the conceptual design of the race car and defined the positioning of the basic and integral units.

The primary configuration of the race car integral units which was carried out in accordance with weight characteristics and total weight distribution on front and back axles is given in Fig.4.

Besides, the students of this sub-team found the optimal solutions for wheel base problem, diameter of wheel rims, clearance and general height of the race car.

The students of the sub-team "Competitions and Testing" ran a series of static and dynamic tests in a special testing ground of JSC AvtoVAZ (Sosnovka village) and together with other members of "Formula-Student" project members participated in the analogous Russian (Moscow, Togliatti) and international (Italy) competitions.

Training Process and interdisciplinary project «Formula-Student»

Previously, we fully considered the list of the modules incorporated into TSU education programs for those students who participate in "Formula-Student" project [2] and outlined the procedure for the introduction of these modules into the educational process (Fig.5).

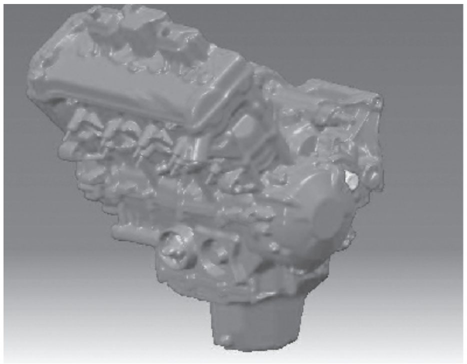
The tasks which students must solve working within a definite project team define the structure and contents of each module. Each module contributes to the achievement of education program outcomes. One of the main advantages of module learning outcomes is that students can apply textbook theories to real work situations and, doing so, acquire corresponding skills and competencies that are closely linked with their future workplace. In work process, students must organize PR actions, draw up a business plan, provide race car structural and conceptual design, defend their project in the English language, publish research results in newspapers and scientific journals, and etc.

The following is the list of disciplines and courses which modules were taught to the students participated in "Formula-Student" project in 2012.
If students complete these modules independently, the instructors can grant students credits for this discipline or course paper.

1. English Language.
2. Documentation and Operations Management.
3. Computer Technologies and Networking.

Fig.2. Design of New "Formula-Student" Race Car .

a) Engine Mathematical Model



б) 3D Model of Race Car Frame Chassis

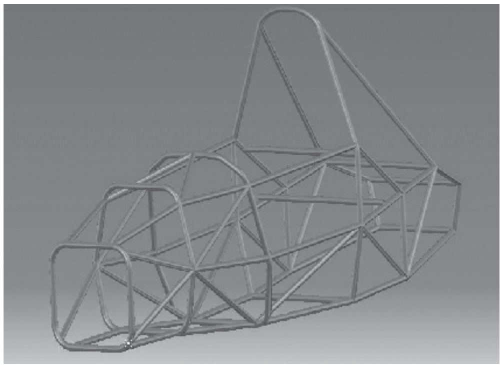


Fig.3. Race Car Sprocket Strength Calculation.

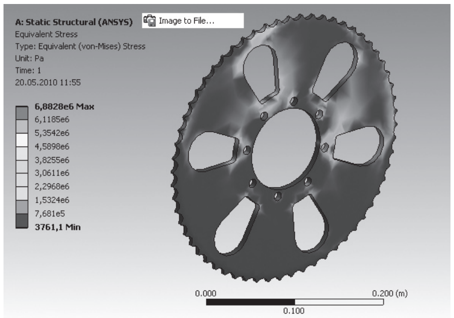
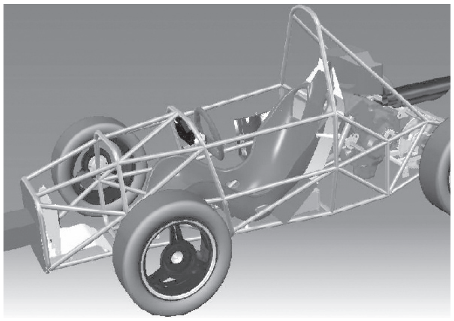


Fig.4 Primary Configuration of "Formula-Student" Race Car.



4. Branch Economics.
5. Control System Design, course project.
6. Engineering Graphics.
7. Theory of Machines and Mechanisms, course project.
8. Machine Elements, course project.
9. Mechanical-Engineering Technology, course project.
10. Motor Car Design, course project.
11. Motor Car design and Calculation.
12. CAD system in Mechanical Engineering.

Final qualification papers are considered to be an important stage in implementing "Formula-Student" project within engineering education framework.

More than 10 qualification papers have been defended since 2010. Here are a few of them:

1) The Conceptual Design of the "Formula-Student" Race Car, student – Aleksander Puchkov.

2) Development and Fabrication of the Race Car Body Parts for "Formula-Student" project, students – Aleksey Kurchev, Ivan Borisov, Pavel Chekushkin.

3) Calculation of Tuning Induction System for "Honda CBR600 F4" Engine in «Wawe» software within "Formula-Student" project, student – Ilya Ganyushkin.

4) Engine for the "Formula-Student" Race Car, student – Mikhail Ponizov.

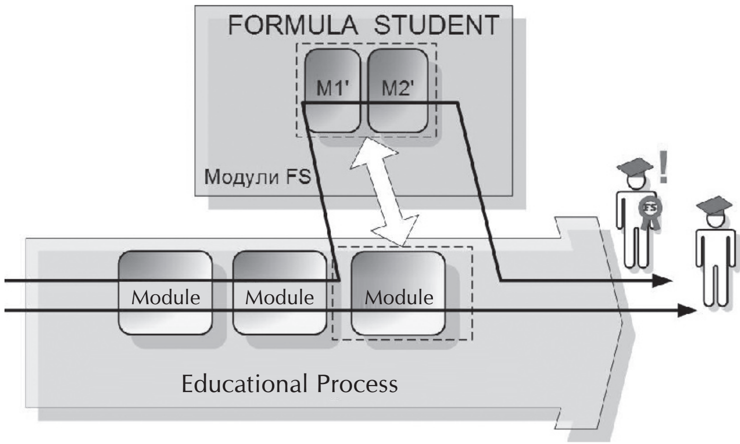
5) Validation of Innovative Education Project Financing within "Formula-Student", student – Svetlana Ivashechkina.

STUDENT RESEARCH WORK

The members of the "Formula-Student" project are constantly involved in research work, participate in various scientific conferences and publish articles in scientific journals. Usually, 2 or 3 students present their research in

ENGINEERING EDUCATION 14'2014

Fig. 5. Interdisciplinary "Formula-Student" Project in Educational Process.



annual conference "Students' Science Days TSU" and submit their findings for publication in the journal "Vektor Nauki TSU". In 2009, students I. Borisov and P. Chekushkin took the first place at the annual Contest for Students' Research Works arranged by DECLAM Company [3]. In 2013, "Formula-Student" project team successfully presented their findings at the investment forum "i-Volga" of Volga federal district.

CONCLUSION

The move toward implementing the interdisciplinary «Formula-Student» project in the educational process makes a significant contribution to improving the quality of higher education in general, including not only engineering subject areas but also humanities and economic science. Above all, this project can spur the interest of school leavers, their parents, as well as employers who are proved to be "consumers" of high school graduates.

REFERENCES

1. Chuchalin A. I. Development of Competency-Based Education Programs in Accordance with Quality Criteria [Electronic resource] : [presentation, Seminar № 1 "Quality of Engineering Education Programs" held within the framework of International Engineering Education Forum, Saint-Petersburg, 15 – 22 May, 2009 г. // Association for Engineering Education of Russia (AEER) : [offic. site]. – [M.], 2003 – 2011. – URL: http://ac-raee.ru/colloquium/RAEE_Worcshop1.php, free. – Title from the screen (reference date: 16.04.2014).
2. El'tsov V.V. "Formula-Student" Project as a Platform for Practice-Oriented Training of Engineering Graduates / V.V. El'tsov, A. V. Skripachev // Engineering Education. – 2013 – № 13 – P.12–19.
3. Borisov I. Combined Application of CAD/CAM/CAE – Systems for Race Car Design and Fabrication / I. Borisov, P. Chekushkin // Collaboration of Delcam plc with the Universities of Russia and Ukraine: 11 report book. – Birmingham, 2009 – P. 3–21.

УДК 69.05:658.5

Interdisciplinary Diploma - Project in “Civil Engineering”

Northern (Arctic) Federal University n.a. M.V. Lomonosov, Arkhangelsk, Russia

A.L. Shepelev, E.A. Shepeleva

Recommendations, defining the scope of graduate qualification papers on organizational-engineering issues within the framework of interdisciplinary diploma-project “Civil Engineering,” were designed on the basis of diploma-project assessment of Specialists and Bachelor students in “Civil Engineering.” Specifications of time scheduling and their reference data have been determined.

Key words: building, organizational-technological documentation, calendar planning, diploma projecting, interdisciplinary project.

A.L. Shepelev

E.A. Shepeleva

The existing education standards [1, 2] specify high competent requirements for the qualification level of engineers (specialists) and Bachelors in “Civil Engineering.” The first level of the 2-tier higher professional education system involves the Bachelor qualification in accordance to the Standards [2], identifying (in comparison with engineer qualification) the reduction of:

- total study time;
- in-class learning hours to total discipline hours, including core professional course hours. In this case, the SSD (self-study development) hours are increased including the performance of tests, calculation in graphics, term papers, term projects and final qualification project (FQP).

Based on experience synthesis and analysis of leading civil engineering institutes (Moscow State University Civil Engineering- MSUCE, St. Petersburg State University of Architecture & Civil Engineering- SPSUACE) and other institutes and departments (including Northern (Arctic) Federal University) the problem - to improve the graduate qualification level- was designated. This furthers the possible performance of self-development assignments on a tight schedule at previously required SSD hours.

This is currently important in implementing final qualification projects (FQP) (diploma-projects) where the performance period for specialists is 16 weeks, while for Bachelors-10 weeks. However, the FQP content is insignifi-cantly reduced as the project itself insignificantly such specific coherently integrated sections as architecture, engineering and organizational-technological elements, as well as other types of project development. The problem solution could be not the FQP content reduction itself, but designing guidelines and reference data which would decrease the effort intensity in performing the FQP by means of consolidated indices. Such indices could be relevant R&D projects of administering departments in collaboration with leading regional project (design) and construction organizations.

There are five administering departments in the Architecture and Civil Engineering Institute of Northern (Arctic) Federal University n.a. M.V. Lomonosov: Engineering Geology, Bases and Foundations (EGB&F), Engineering Constructions and Architecture (EC&A), Construction Operations (Technology) (CO), Highway Department (HD), Chemistry and Ecology in Construction

ENGINEERING EDUCATION 14'2014

(C&EC). Highly-qualified specialists and Bachelors of different professional domains and profiles in Civil Engineering have graduated from this Institute.

Traditionally, FQP is considered to be an interdisciplinary diploma-project within the framework of three basically interrelated departments (EG B&F, EC&A and CO). Final qualification projects in Highway Department and C&EC significantly differ from those in other departments, thus, these departments were not included (Table 1).

Three major sections (architecture, engineering and organizational-technological) are included in the interdisciplinary diploma-project [3, 4]),i.e. relevant to the administering departments. The content scope of each section directly depends on:

- selected department where this or that FQP will be executed;
- speciality (professional domain) or profile;
- approved final qualification project topic;
- project development task;
- reference data for specific tasks.

There are three major sections in the interdisciplinary diploma-project where the most difficult one is considered to be the organizational-technological, especially the calendar planning (CP) which is executed within the framework of Construction Operation (Technology) Department.

Organizational process design (OPD) within the interdisciplinary diploma-project is rather time-consuming due to the fact of calculating the overall quantity of work, as well as determining the labour requirements of working and computer time

Table. 1. Basic FQP Content Characteristic Features in Organizing Construction Operations (technology).

Speciality / profile	Administering department	Content scope %	Designed Common Technical Document (CTD)		
			Type	Detail level of calendar plan	Reference data
Specialist Degree					
Industrial and Civil Engineering (ICE)	EGB&F	10...12	PEP	Activity summary	Consolidated indices / or comparable
	EC&A				
	CO (T)	20...25		Work activities	Project design
Expertise and Property Management (EPM)		17...20	CMP (construction management plan)	Construction stages (activity summary)	
Building Design (BD)	EC&A	10...12			Consolidated indices / or comparable
Bachelor degree					
Industrial and Civil Engineering (ICE)	EC&A	10...12	PEP	Activity summary	Consolidated indices / or comparable
	CO (T)	20...25		Work activities	Project design
Expertise and Property Management (EPM)		17...20	CMP	Construction stages (activity summary)	
Structural Engineering (SE)	EC&A	10...12			Consolidated indices / or comparable
Construction in North Climatic Conditions (CNCC)	EGB&F	10...12	PEP	Activity summary	Consolidated indices / or comparable
Underground Constructions, Bases and Foundations(UCBF)					

to develop database sources for designing the calendar plan itself. Different organizational – technological (design) documentation (OTD) of calendar plans [5- p. 41] have various detail levels which depend on the following:

- site improvements (construction engineering);
- hierarchy level where the OPD type is considered;
- stated objectives and targets of OPD;
- specialization (profile) of construction and assembly organization (CAO);
- designers' and users' competence in documentation development.

Earlier, to develop construction management plans (CMP) consolidated requirement norms of different resources (for example, 1 million rub. estimated cost of construction-assembly operations) existed and were widely used in different sectors. Today, as such a system has not been updated its application is becoming more and more complicated. As a result, students experience distinct difficulty in performing self-development assignments and / or final qualification projects as they do not have the possibility to look through the overall engineering design package. In this case, developing skills in calculating the overall quantity of work is important for different disciplines (construction technology and others; organization, management and planning, etc.).

This could be an advantage, however, providing that within interdisciplinary self-development activities once obtained results in one discipline become the reference data for another discipline, and then alternatively it involves the following:

1) performance of self-development activities is deferred due to the compulsory repetitive calculations, as each discipline itself includes its individually specific construction sites and their elements, and these calculations could be identical;

2) new knowledge acquisition is retarded as this knowledge becomes "invisible" in the enormous "run-over" of time-consuming calculations.

The above-mentioned issues are currently very important in performing interdisciplinary diploma-projects. As the diversity of OTD is significant and the detail level of the project is different within each specific stage of civil engineering [5, p. 41], then the following aspects should be formulated:

- content scope of relevant final qualification project section;
- type of designed OTD;
- detail level of specific documents;
- possible application of consolidated comparable indices determined within the framework of R&D projects executed in the Department of Construction Operations (Technology) and other similar leading university departments.

On the basis of all the above-stated and review of existing long-term experience in progress of tutorial of diploma-projects, the organizational framework of the FQP, including different specialities and profiles, as well as those being executed in various administering departments, was systematized (Table 1).

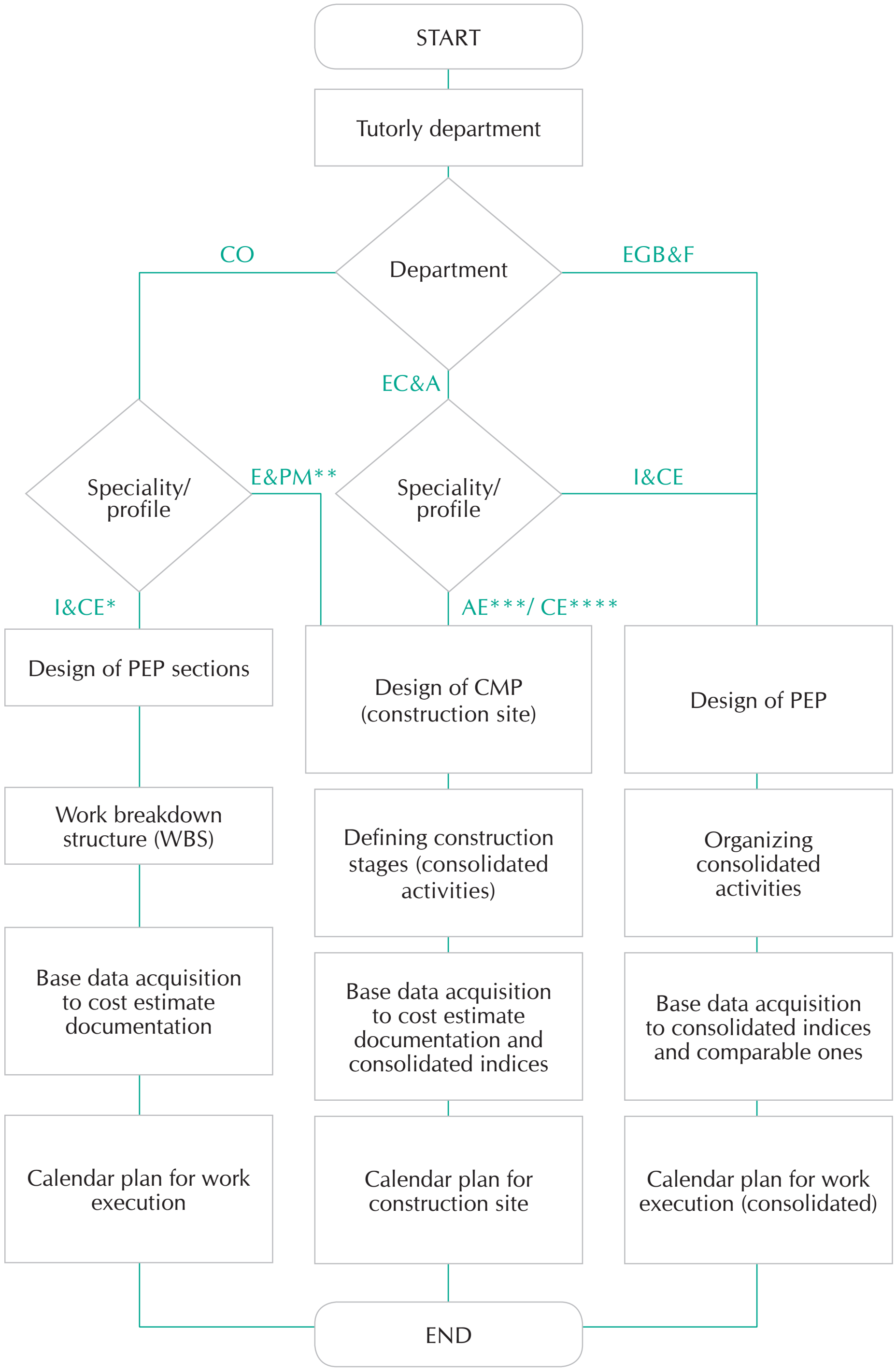
The calendar plan can be considered as the fundamental document, as it is included in the OTD designed at different stages of OPD:

- construction site calendar plan [6, p. 16] within the construction management plan (CMP);
- consolidated calendar plan within activity management plan (AMP) and/or detailed project execution plan (PEP) plus specified activity summary;
- calendar plan of construction project [7, p. 9] included in PEP.

The following flow diagram of OTD type selection and its specification clearly illustrate the calendar plan classification (Fig. 1).

These methodological approaches are only suggestive and can vary in the

Fig. 1. Flow Fiagram of OTD type Selection and its Specification.



* I&CE- Industrial and Civil Engineering
** E*PM-Expertise and Property Management
*** AE- Architectural Engineering
****CE- Civil Engineering

context of relevant substantiation and this, in its turn, depends on such factors as project targets, availability of base data, specification and standards and other necessary information. Customer demands in this or that project can also be taken into account which would be executed within the framework of R&D activities of relevant department.

The application of suggested recommendations could improve the quality of final qualification projects due to the decreased time-consuming data base search for the organizational framework of the interdisciplinary diploma-project, and, as a result, released time could be used for a more detailed study of the profile section included in the FQP.

The above-mentioned facts are of significant importance in enhancing engineering education, improving its quality level and solving those current questions arising during the execution of interdisciplinary diploma-projects in construction institutions (institutes and departments). Suggested recommendations could be instructive for students and FQP tutors of different specialities and profiles and could be included in advanced training and continuing education courses.

REFERENCES

1. State Educational Standard of Higher Professional Education. Training profiles of specialists 653500 Construction. Qualification- engineer: approved by Decree of RF Ministry of Education, dated 02.03.2000 № 686. – Introduction 07.03.2000 № 12-Technical document – M. 2000. – 62 P.
2. FES HPE in the Bachelor Degree program 270800 Construction [Electronic resource] : approved by Decree of RF Ministry of Education, dated Jan. 18, 2010 № 54 // Russian education : Federal Educational portal [M., 2002–2012]. – URL: http://www.edu.ru/db-mon/mo/Data/d_10/prm54-1.pdf, free, (usage date: 28.04.2014).
3. Expertise and property management: methodological recommendations for pre-graduation internship and diploma projects / edited by V.I. Rakovski, et al.- Arkhangelsk, 2008– 52 P.
4. Methodological guidelines in pre-graduation internship for students of 270100"Construction", speciality 270102.65 "Industrial and civil engineering" / ed, by V.I. Rakovski, S.V. Belyaeva – edition 2– Arkhangelsk, 2011– 18 P.
5. A. L. Shepelev Composite application of network models in industrial and civil engineering // Industrial and civil engineering 2012. – № 10. – pp. 41–44.
6. Description of project documentation sections and requirements : [Electronic resource]: enactment of RF Government, dated 16.02.2008 № 87 (amended by enactment of RF Government, dated 26. 3.2014 № 230). – Access from Information system "ConsultantPlus"
7. Federal program 48.13330.2011. Construction organization. Revised edition Construction Notrms & Regulations 12-01-2004 [Electronic resource]/ Ministry of Regional Development – Introduction 2011–05–20. – M., 2011. – III, 22P.– Electronic version – URL: http://www.srogen.ru/upload/files/doc/SP48.pdf, free,(usage date: 28.04.2014).

UDC 372.881.111.1

The Interdisciplinary Project in Engineering Education

Siberian Transport University

E.S. Bykadorova, S.A. Veselova

The paper focuses on the interdisciplinary project aimed at developing engineering student's competence in foreign language within the "Bachelor – Master – PhD" education system. Complex approach is proposed to be used as the theoretical and methodological basis of project elaboration. The proposed multimedia learning package has been developed for the students of Siberian Transport University and displayed in Moodle.

Key words: foreign language competence, interdisciplinary project, complex approach, social oriented learning model, Moodle.

E.S. Bykadorova

S.A. Veselova

Despite a great number of different technologies, methods and tools applied in the higher engineering education, future engineers demonstrate insufficient knowledge of and competence in professional communication. Today, the communication behavior of students is shaped within various education programs offered by different departments which do not represent unified approach toward education. It hinders the efforts to ensure all-round personality development in future engineers to prepare them for daily professional-related tasks which they would solve based on professional principles.

Importance and relevance of the research problem is defined by the following reasons:

- transition to the innovative engineering education, revision and updating of training technologies based on the modern trends and approaches applied in high-tech engineering, which, in its turn, influences the content of foreign language training that becomes an effective tool in personality professional development;
- the need for foreign language study for professional purposes since foreign language acquisition can help students adapt new social roles to adjust to the requirements of the current labor market where effective communication skills are highly demanded by the employers;
- the need for successive acquisition of a foreign language within a three-tier higher education system: Bachelor's (Specialist's)-Master's degrees and PhD programs;
- foreign language training based on socially-oriented training (on-line/non-linear) models;
- the need to investigate how relevant professional skills and attributes are shaped at the different stages of future engineers' professional identity development.

The novelty of the problem discussed and soundness of the proposed solutions are determined by:

- the current theoretical basis: multimedia training package (MTP) aimed at developing engineering students' foreign language competence, i.e. a special medium which being analogous to the real one grants learners the possibility of social adjustment;
- methodological basis for MTA development, i.e. complex approach and a set of scientific principles (social adjustment, interactivity, collaboration, syndicate, openness, simplicity, integrity and interdisciplinarity);

- practical implications of the research: MTP is designed for the online foreign language training model (socially-oriented or non-linear) applied in the three-tier higher education system: Bachelor's (Specialist's)-Master's degrees and PhD programs. It enables to optimize educational process and effectively shape the aspects of future engineers' professional competence which are related to the knowledge of bilingual terminology and communicational skills, as well as professional broad-mindedness.

The move toward social software tools and web-technologies is one of the main conditions for effective implementation of the present multimedia training package. The analysis of the relevant bibliographical references has revealed that web-based learning (or web-based training) is one of the forms of distance education provided through the Internet. E-learning 2.0, e-training, on-line learning and etc. are used as synonyms to the web-based learning [10; 11].

In foreign countries, the problem of MTP development is discussed in relation to e-learning and is referred to virtual universities and open educational resources which provide free access to educational materials through the social software tools. It is stated that such multimedia training packages stipulate collaboration of educators and academics in developing education program content (partially or completely) and allow them to adjust it to the definite educational needs. Also, these packages can be applied in all study modes: full-time, distance and hybrid (blended) one [12-15].

In general, educators and academics agree that Moodle is one of the most popular, convenient and free Learning Management Systems in Russia and abroad which allows not only creating, but also updating internet-based courses [15].

As one of the concepts of the web-based learning (non-linear) is socialization, the following social theories and models have been taken as a methodological basis for MTP development: constructivism learning theory; social constructivism learning theory; practice theory; conversational learning theory; theory of social construction of technology; blended learning model; connectivism theory; social network theory.

Besides the above-mentioned theories and models, a complex approach has been also applied. It is defined as interdisciplinary paradigmatic (the structure of study object), syntagmatic (content of study object) and pragmatic (purpose, objectives, peculiarity of study object use) specific features related to the application of the sum of scientific approaches (system-activity approach, integrated development approach, individual and differentiated approach, context- and content-based approach, pragmatic and competence-based approach) in stage-by-stage development of technological educational product with regard to the general education program.

Involving various approaches and knowledge from a number of different disciplines (pedagogics, psychology, economics, engineering, ergonomics, information science and etc.) is methodically required in terms of the complex approach.

The present interdisciplinary project, i.e. MTP aimed at developing engineering students' foreign language competence within the three-tier higher education system (Bachelor's-Master's degrees and PhD programs), has been developed based on the learning management system Moodle which has the following benefits: 1) collaborative work due to the Wiki tool; 2) individual project work on course topics due to the possibility to interact with a coacher through the webinars; 3) along with online education programs, asynchronous learning programs when each student can study course material at his/her own pace; 4) interactivity and active communication during educational process (forum, chat, newsflash, webinars, questionnaire activity) – an instructor can display materials in different formats for his/her students or a student can share the materials with the members of the online group; 5) building chat communities in an online environment.

The list of social software tools is rather long and freely accessed. Following are the information dissemination systems which are involved in interdisciplinary projects: a) http://www.youtube.com; b) http://learningenglish.voanews.com; c) https://www.ted.com; d) http://www.howstuffworks.com/videos and etc.

The MTP includes theoretical, practical and control materials, as well as pedagogical monitoring, computer, scientific-methodological and ergonomic support.

The fact that the content of the present MTP can be changed allowed the authors to develop interdisciplinary projects which can be applied both in classroom and as independent work for the engineering students of the 1st and 2nd year of education: «English for Builders and Architects», «Water in Science and Engineering»; «English for Mechanical Engineers»; «Railway Engineering» [1–9].

Throughout the approbation period (2009-2014) it has been revealed that the best results in foreign language acquisition are achieved in a case of full-time/distance education (blended learning), with the efficiency performance increasing by 20 %.

Based on the conducted research, it is possible to make the following conclusions:

1. The proposed MTP can ensure effective development of engineering graduates' communication skills within the three-tier education system "Bachelor's (Specialist's)-Master's degrees and PhD programs".

2. The MTP contributes to shaping engineering graduates' soft skills which are defined as communication skills required for effective team work and successful career.

3. The perspective lines of further MTP improvement within the three-tier education system can be as follows: a) integration of the English language not only into engineering courses, but also into humanities; b) integrated cooperation of high engineering education and real work experience; c) revision of such multimedia learning packages as «English for Mechanical Engineers», «English for Builders and Architects», «Water in Science and Engineering», «Railway Engineering» in the context of the distance education and assessment tool improvement during professionally-oriented higher education.

REFERENCES

1. Bykadorova E.S. Professional Language Culture of Mechanical Engineers [Electronic resource] / E.S. Bykadorova, E. G. Skibitskiy // Education and science: [site]. – [M., 2004–2014]. – URL: http://www.rusnauka.com/28_PRNT_2011/Pedagogica/2_92562.doc.htm, free. – Tit. from the screen (usage date: 22.04.2014).
2. Bykadorova E.S. English for Builders and Architects: textbook / E.S. Bykadorova, S. A. Veselova. – Novosibirsk, 2013. – 193 p.
3. Bykadorova E.S. English for Builders and Architects: practicum for independent student work / E.S. Bykadorova, S. A. Veselova. – Novosibirsk, 2013. – 48 p.
4. Bykadorova E.S. English for Builders and Architects. [Electronic resource] / E.S. Bykadorova, S. A. Veselova // Testing System Moodle 2: site. – [Novosibirsk, 1998–2014]. – URL: http://moodle2.stu.ru
5. Bykadorova E.S. Water in Science and Engineering [Electronic resource] / E.S. Bykadorova, D. V. Volodina // Testing System Moodle 2: site. – [Novosibirsk, 1998–2014]. – URL: http://moodle2.stu.ru
6. Bykadorova E.S. English for Mechanical Engineers: textbook / E.S. Bykadorova. – Novosibirsk, 2011. – 152 p.
7. 7. Bykadorova E.S. English Language: tests / E.S. Bykadorova. – Novosibirsk, 2011. – 47 p.
8. Bykadorova E.S. English for Mechanical Engineers [Electronic resource]: electronic education information resource / E.S. Bykadorova // Testing System Moodle 2: site. – [Novosibirsk, 1998–2014]. – URL: http://moodle2.stu.ru.
9. Railway Engineering [Electronic resource] / E.S. Bykadorova, E. M. Anikina, E. T. Kitova, O. A. Palagina, S. K. Yavorskaya // Testing System Moodle 2: site. – [Novosibirsk, 1998–2014]. – URL: http://moodle2.stu.ru
10. Goroshko E. I. Education 2.0 – Future of National Education? (An attempt of theoretical reflection) Part 1) [Electronic resource] // Educational Technologies and Society. – 2009. – T. 12, № 2. – P. 455–469. – URL: http://ifets.ieee.org/russian/depository/v12_i2/pdf/12.pdf/, free. – Tit. from the screen (usage date: 18.04.2014).
11. Daniel J. Open educational resources (OER) [Electronic resource]: The coming of age of ICT in education? / J. Daniel, and S. Uvalić-Trumbić // e-Learning Korea-2012 : 7 Int. conf., Seoul, Korea, Sept. 12–14, 2012. – URL: http://sirjohn.ca/wordpress/wp-content/uploads/2012/08/120912KoreaELearningJSDSUT1.docx, free. – Tit. from the screen (usage date: 24.04.2014).
12. Daniel J. Collaboration and networking [Electronic resource]: The role of open educational resources (OER) // XX Int. Summit on Distance Education, Guadalajara, Mexico, Nov. 26–29, 2012. – URL: http://sirjohn.ca/wordpress/wp-content/uploads/2012/08/20121127Mexico.pdf, free. – Tit. from the screen (usage date: 24.04.2014).
13. Daniel J. Computers in education [Electronic resource]: dreams, disappointment and disruption : [speech] at Seoul Nat. Univ., Seoul, Sept. 19, 2012. – URL: http://sirjohn.ca/wordpress/wp-content/uploads/2012/08/20120919SeoulNationalTX.docx, free. – Tit. from the screen (usage date: 24.04.2014).
14. Kybartaite A. Technologies and methods in virtual campus for improving learning process / A. Kybartaite, J. Nousiainen, and J. Malmivuo // Comput. Appl. Eng. Educ. – 2013. – Vol. 21, Iss. 1. – P. 185–192.
15. Web usage mining for predicting final marks of students that use Moodle courses / C. Romero, P. G. Espejo, A. Zafra, J. R. Romero, S. Ventura // Comput. Appl. Eng. Educ. – 2013. – Vol. 21, Iss. 1. – P. 135–146.

UDC 378.147

Towards the Issue of Interdisciplinary Project Implementation in Engineering Education

Immanuel Kant Baltic Federal University

I.G. Kartushina, I.V. Garifullina, E.S. Minkova

The paper analyzes the function of interdisciplinary projects in the process of engineering staff training. It reveals the potential of a project method in the framework of the practice oriented approach while training students in a technical university.

Key words: Federal state educational standards, engineer, engineering education, educational process, active learning methods, problem-oriented methods, project organized training technology, design method, types of projects, the requirements for the implementation of designing method, professionally important qualities.

I.G. Kartushina

I.V. Garifullina

E.S. Minkova

There are great changes in modern practical engineering activities that set new requirements to the Bachelors, Masters and Specialists of Engineering. The modern society requires from engineers to combine the competencies of researchers, team leaders, managers, etc. Thus, it determines new competitive approach to the forms, methods and content of modern engineering education.

It explains the fact that the Federal State Education Standards of Higher Professional Education (FSES of HPE) of new generation include not only core social and functional competencies that are the basis for job performance but also such competencies as "to be ready to implement innovative projects into service industry" [1] and "to be a team member engaged in problem-solving, analyzing different solutions, consequence prediction, planning project implementation under uncertain conditions..." [2].

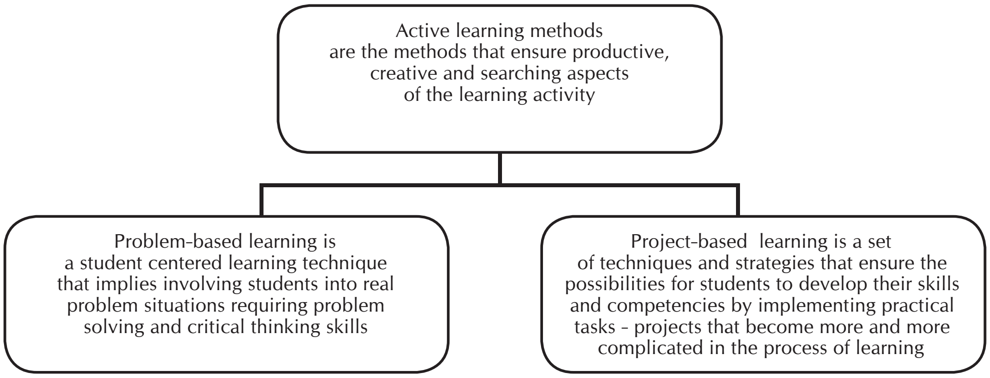
Thus, one of the main goals of modern higher school is to teach future specialists to determine and solve problems in their professional domain and to develop the personal skills that are important for project work. For this, it is necessary for the students to learn/acquire not only professional knowledge domain but also to develop the skills and techniques of problem solving in the framework of professional tasks. These aims can be achieved by organizing effective learning activity. It is the basic student's activity that plays the most important role in development of integral professional culture of a future specialist. It is the learning activity that significantly influences the personality of a future Bachelor, Master or Specialist, their ways of thinking, outlook, social behavior, character, capacity for work, problem solving skills, team work skills and personal development.

It is possible to state that student's learning activity is a way to form professional competencies and a motivating tool for cognitive and practical activities that, as a result, condition graduates' professional efficiency.

To increase the learning activity efficiency, a problem-oriented approach and project-based learning techniques are being widely used (Fig. 1).

These methods are considered to be active as they are student-centered. In this case a student has more opportunities to acquire practical knowledge and develop professional skills through creative and

Fig. 1. Types of Active Learning Methods.



searching activities, practical experience and problem solving skills development.

One of these methods is project-based learning. It's a pedagogical technique that is not aimed at integrating factual knowledge but is aimed at applying and deepening students' knowledge base, developing their skills and competencies.

The project-based technique always implies solution of some authentic problem that allows using diverse training techniques, on the one hand, applying integrated knowledge and skills from both engineering and social areas, on the other hand. It allows developing cognitive, creative skills, critical thinking, the abilities for knowledge structuring, data searching, working in team, which is significant for professional choice of the graduates. A lot of FSESs of HPE require such competence as "the ability for teamwork". It is project-based learning that provides the development of this competence through implementing group projects.

This learning method is often carried out in terms of students' independent learning activities – individual, paired or group- implemented during a certain period.

The types of projects used in educational process are shown in Table 1.

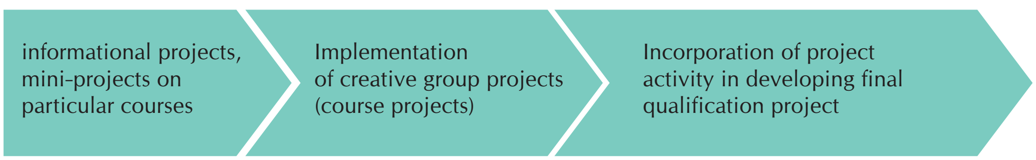
Mixed projects are most widely spread in the educational process of universities.

Regarding this process in Immanuel Kant Baltic Federal University (I. Kant BFU), programs "Service" and "Transport process technology", the following areas should be covered to develop students' competencies for successful project activities (Fig. 2).

One of the interdisciplinary projects implemented in the engineering programs in I. Kant BFU is a course project conducted by second-year students within the frame of the course "Machine Elements and Design Principles". The basic project stages are 1) Design - developing general construction of a product, and 2) Mechanical design – further detailed development of the idea that implies solving the problems related to real product implementation [3].

The course "Machine Elements and Design Principles" has the following prerequisites: Theoretical Mechanics, Strength of Materials, Applied Mechanics, Materials Science, Engineering Structural

Fig. 2. Areas of Project Activity Implementation in the University.



Materials Technology, Perspective and Shadow Projections and Engineering Graphics, Computer Graphics, Further Mathematics, Physics, etc.

A high level project in "Machine Elements" is a straight fusion of the courses mentioned above. These disciplines are integrated into one process and serve as a base for the final product.

Another example of an interdisciplinary project is the course project in "Passenger Traffic" that is supported by such prerequisites as Theory of Transport Processes and Systems, Simulation of Transport Processes, Social and Technical System Management, HR Management, Quality Management, Labour Safety in Highway Transport, etc.

This course project should contain specific proposals on improving passenger traffic management performed in the real system of city traffic routes.

While implementing different types of projects, students develop the following professional competencies:

- communicative skills
- open mindedness
- teamwork skills
- ability to prove his/her view point
- flexibility
- critical thinking
- ability to be engaged in independent lifelong learning and professional development.

The implementation of the project-based learning should meet the following requirements:

- scientifically or creatively significant issue/problem that involves application of integrated knowledge and research skills;
- practical, theoretical and cognitive importance of expected results;
- independent (individual, paired or group forms) students' activity;
- setting final goals of projects;
- determining the related competencies necessary for project implementation;
- project content structuring (with defining interim results);
- use of heuristic method of problem-solving, in case of group projects and statistical method if a project is individual.

For the foregoing reasons it is possible to conclude that project-based learning can be applied in any course module. This technique can be used in various forms as an in-class activity, independent students' work with different time limits and as a way of distant learning involving modern IT and computer technologies.

This approach to higher engineering professional education will allow considering professional and personal enhancement not only as a main indicator of professional activity but also as a core characteristic that indicates both specific professional competencies and opportunities for potential development of a future engineer.

ENGINEERING EDUCATION 14'2014

Table 1. Project Types.

Classification parameter	Project type	Brief characteristics
Number of participants	Individual project	It is carried out by one student
	Group (team) project	It is carried out by a group of students
Project content	One disciplinary project	Its implementation involves the knowledge of one particular course or subject
	Interdisciplinary project	It integrates knowledge area of some related courses or disciplines
	Above-disciplinary project	It is conducted as student's independent scientific research work
Purpose of project implementation	Final	It is used to assess students' competencies acquired during a module or a basic education program
	Current	It is used to assess students' knowledge delivered in a part of a module or a course
Types of contacts	Group	Project involves students of one group or one year
	University	Project involves students of different specialties and programs within one university
	Regional	Projects involve students from different universities of one region through telecommunication and internet support
	International	Projects imply international relations, which means participation of students from different countries. They are conducted through telecommunication and internet support
Prevailing learning activity of students	Practice-based	Independently developed and produced product(service), recommendation package, publication for practical use – starting from the idea up to its implementation
	Exploratory	Studying some issue in accordance with rules of scientific research
	Informational	Collecting and interpreting related information and further presentation to the audience
	Creative	Maximum free author's approach to problem solving
	Role-playing	Business games with varieties of results
Duration period	Mini-projects	They are conducted during one class
	Short-term	They last during some classes
	Long-term	These projects 30-40 student hours or more involve
Complexity level	Level of beginners	Informational and creative projects
	Intermediate level	The main goal of the project is to find interdisciplinary relations by integrating the acquired knowledge and skills in the project activity
	Advanced level	Final qualification project

REFERENCES

1. FSES of HPE in specialty 100100 [43.03.01] «Service» (Bachelor's Degree) [Electronic resource]: approved by the Ministry of Education and Science dated 18.11. 2009 № 627 // Russian education: federal education portal. – Moscow, 2002–2012. – URL: http://www.edu.ru/db/mo/Data/d_09/prm627-1.pdf, free – Title from the screen (reference date: 16.05.2014). (only in Russian)
2. FSES of HPE in specialty190700 [23.03.01] "Transport processes technologies" (Bachelor's Degree) [Electronic resource]: approved by the Ministry of Education and Science dated 22.1 2. 2009 № 803 // Russian education: federal education portal. – Moscow, 2002–2012. – URL: http://www.edu.ru/db/mo/Data/d_09/prm803-1.pdf, free – Title from the screen (reference date: 16.05.2014). (only in Russian)
3. Shteinblit A.E. Course project in machine elements. Teaching guide. –Moscow, 1991. P. 432.

UDC 65.01:378

Implementation of Interdisciplinary Projects within Bachelor Degree program in "Quality Management"

National Research University Moscow Institute of Electronic Technology, Moscow, Russia
M.V. Akulenok

The article describes an example of an implemented interdisciplinary project within the framework of Bachelor Degree program 221400.62. The following aspects were defined: experimental analysis, advantages and specific characteristics of such projects.

M.V. Akulenok

Key words: project-oriented learning, learning outcome, interdisciplinary communication.

To achieve sustainable success in the global market, enterprises should not only improve existing approaches to business management, but also define new requirements to the personnel, which, in its turn, furthers new standards and specifications for graduate quality and learning outcomes. Advanced training programs focused on future job market-place requirements furthering the combination of graduate training activity approach with interdisciplinary components and professional-oriented education approach would be the relevant response to job market-place expectations, i.e. competitively trained graduate possessing such skills as creativity, risk management, team-player, self-development and organizational qualities [1].

Due to the reduction of course duration there is an acute necessity for developing new methods and tools to improve student self-development (SSD) performance and to overcome the existing formalism in education. All in all, the complexity and enormous knowledge volume results in the devaluation of "unconsumed" knowledge and skills forming the so-called "silent" zone [2, 3].

One tool of professional-oriented training focused on developing key competencies is the project method which is based on the synergy of parallel (or sequenced) integrated studied disciplines.

Complete implementation of the project method [3] is a very difficult task requiring not only the optimization of the curriculum itself, but also coordination of teamwork and feedback. However, this also involves the local optimization of the professional discipline cycle.

In NRU MIET the project method, i.e. modeling professional activities, was implemented within the framework of the program "Quality Management" as interdisciplinary projects focused on enhancing interdisciplinary communication and furthering the synergy effect. Such a project is considered to be a specific type of learning assignment stipulating those skills, abilities and knowledge shaped in two (or more) disciplines and targeting the applicable development of these skills, abilities and knowledge in this or that professional domain.

Specialists in quality management should not only manage quality management tools, understand and apply education standard requirements (as

ENGINEERING EDUCATION
14'2014

compulsory courses of a curriculum), but also have engineering problem-solving competency in this or that professional domain, as well as being actively involved in engineering activities and having a positive economic behavior.

Pilot projects, integrating such disciplines as "Process Management", "Quality & Economy" and "Quality Auditing" were included in the specialist program (220501- "Quality Management")[4]. This experience was integrated into the Bachelor Degree program 221400 which included an interdisciplinary project involving such disciplines as "Fundamentals of Quality Assurance", "Process Management", "Quality & Economy" and "Certification of Quality Management System (QMS) Effectiveness." This project embraced both traditional term projects and virtual projects which assure sequential communication between above-mentioned disciplines. Further, the next stage is the implementation of parallel project sections relevant to the following discipline pattern: "Process Management – Business Modeling" and "Quality & Economy – Marketing."

The key aspect, combining all above-mentioned disciplines, is definite program learning outcomes (relevant to professional competencies), such as: (PC-1) analyze existing dynamics of development projects through relevant methods and analytical tools; (PC-4) apply knowledge appropriate to engineering speciality, including models, methods, tools, technology and algorithms for problem-solving; (PC-7) apply knowledge in quality management; (PC-10) prepare documents pertinent to quality management system and its monitoring; (PC-13) formulate targets and make risk-management decisions; (PC-17) select appropriate engineering tools to execute problem-solving tasks (project, research), define specific interrelations, model task-systems (problems), analyze and clarify reasons of such problems.

The following cross-cultural competencies (CC) are also attained: (CC- 3) communicate effectively with the engineering community and with the society at large; (CC-5) administer and execute regulatory documentation (policies and procedures); (CC-9) apply basic principles and methods of social, humanitarian and economic sciences in solving social and professional tasks.

Executed projects embrace the general principle of a specific product, service or production (as a rule, virtual). Nominally termed as "virtual" projects we do not exclude the possibility of practical project tasks, for example, focused on topics of on-the-job training or research and development projects.

Additional key elements of discussed interdisciplinary projects are:

- individual and team (3-5 persons) tasks;
- annual refresh tasks;
- balancing requirements and alignment of planned academic studies of project disciplines to the task itself;
- consultations;
- public presentation of team project results (every semester) as either reports or PP.

It should be noted that the above-mentioned list of disciplines does not exclude the possibility of more disciplines which could be included in this or that project. Individual tasks determine the relevant development of industry standard requirements, for example, in the telecommunication domain- standard requirements TL-9000 or in the microelectronics domain- SEMI and ASTM standards and others, as well as tailoring generalized approaches, requirements and methods of quality management to industry-based project.

Today's projects embrace four semesters, involving gradual learning of core disciplines.

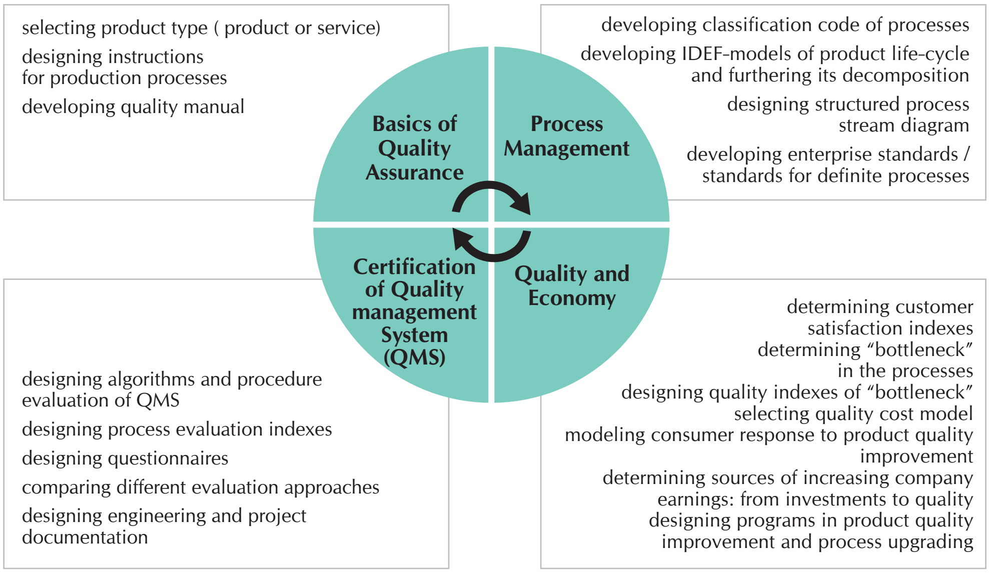
The project pattern and its content executed by students during each project stage is presented in Fig. 1 and Table 1.

It are be noted that alignment of structures tasks to the planned academic studies involves the application of qualifying tools and methods within in-class learning and furthering the implementation of team project tasks. This, in its turn, establishes monitoring of the

Table 1. Major Stages and Techniques in Interdisciplinary Project within the Framework of Bachelor Degree Program 221400.62. "Quality Management".

Semester	Major topic area	Stage content
4	Content-frame of quality manual (QM)	Selection of product type (product or service); Design instructions for production processes; Performance of standard requirements GOST ISO 9001; Quality manual design.
5	Process profile	Development of process classification code; Development of IDEF-models of product life-cycle and furthering its decomposition; Design of structured process stream diagram; Development of enterprise standards / standards for definite processes.
6	Quality cost model design	Determination of customer satisfaction indexes; Determination of "bottleneck" in the processes; Modeling consumer response to product quality improvement; Program designs in product quality improvement and process upgrading.
7	QMS Evaluation of virtual enterprise	Algorithm design and procedure evaluation of QMS; Design of process evaluation indexes; Questionnaire design; Comparison of different evaluation approaches; Engineering and project documentation design.

Fig. 1 Interdisciplinary Project Pattern within the Framework of Bachelor Degree Program 221400.62.



project implementation itself whereas a prominent part of this project can be observed throughout the in-class learning. Besides, positive recommendations in project implementation, based on in-class learning results, are formulated for each team individually within the framework of student self-development (SSD) activities.

This project method is consistent to the accumulating grade-rating system applied in many universities and facilitates in evaluating the contribution of each team-player in the project. The results of each project stage are evaluated in grades (from 5 to 10). Expected outcomes, performance indexes and criteria have been defined for each stage of the interdisciplinary project, including report drafting and presentation planning, as well as participation in the final stage-conference.

A diversity of positive advantages and characteristic features of interdisciplinary project development have been revealed and are the following:

- attained practical skills complement and enhance already obtained "theoretical" knowledge (disciplines) in required time, i.e. the so-called "Just-in-Time" concept;
- interdisciplinary communication is maximized through active instructor interaction of relevant disciplines;
- constructive environment is developed throughout in-class learning and SSD activities;
- effective use of teaching hours, including SSD hours;
- communicative skills and team-work abilities are shaped;
- practical experience in public presentation and further academic assessment are developed.

The improvement of graduates' competitive abilities within job market-place is to be expected as the major positive result of this project method.

REFERENCES

1. Pokholkov Yu. P. Advanced Training of Elite Specialists and Global Professional Teams in Engineering & Technology / Pokholkov Yu. P., Agranovich B. l. // Engineering Education. – 2007. – № 4. – pp. 4–9.
2. Pokholkov Yu. P. Approaches in Developing National Doctrinal of Engineering Education in Russia within Modern Industrialization: problems, targets, challenges / Pokholkov Yu. P., Agranovich B. l. // Engineering Education. – 2012. – № 9. – pp. 5–11.
3. Project Method in Designing Elite Technical Education Programs / Akulenok M. V., Gulidov D. N., Pospelov A. S., Larionov N. M. // Elite engineering education 2004 : Regional Scientific Conference: Conference proceedings/ MIET. – M., 2004. – pp. 9–11.
4. Akulenok M. V. Project Method as a Tool in Shaping Key Competencies // Modern Technologies in Russian Education System: Conference Proceedings of IX Russian Scientific Conference / IRIC PSAA. – Penza, 2011. – pp. 8–12.

UDC 378.22:005

Implementation of CDIO Initiative in Bachelor's Programs of Management Specialties at St.-Petersburg Electrotechnical University

Saint Petersburg Electrotechnical University "LETI"

I.V. Pavlovskaya

Key words: CDIO Initiative, introduction to specialty training program, students' professional orientation.

I.V. Pavlovskaya

"CDIO Initiative" international project was conceived to reform engineering education by eliminating the gap between theory and practice in engineering activity. In the Initiative authors' opinion, an engineer with higher education should be able to create and modernize products and systems during their life cycle (Conceive (C) – Design (D) – Implement (I) – Operate (O)).

CDIO Initiative adopted 12 standards which are guiding principles to design education programs, supply educational resources and provide continuing professional education for teachers. The CDIO Standards taken together represent a comprehensive approach to engineering education.

CDIO Initiative was created to reform engineering education, but the problem of gap between the education and professional activities is of great concern for many management specialties as well. The analysis of several management training programs which were offered by Russian employers in 2014. Looking for young managers employers concentrate their attention not on the specialty, which an applicant has according to his diploma, but on individual competences and his/her "keenness of wit". To recognize the latter qualities the employers use logical tests, role plays and case competitions. There is also a tendency to employ the applicants with engineering education as managers, rather than those with management education proper, and many today top managers confess to be proud of their engineering education [1]. In such situation management competences are developed while working, when the person takes continuing professional education courses or participate in projects headed by experienced managers. This allows us to make the conclusion that lacking practical application, management education in Russia does not satisfy the employers' demands.

The lack of practical problem-oriented activities may become a serious disadvantage of alumni who studied Quality management at Management and Quality Systems Department (MQS) of St-Petersburg Electrotechnical University (SETU). Firstly, MQS, as well as STETU itself, prepare specialists for high-tech industries where the gap between theory and practice is especially tangible. Secondly, quality management at enterprises means to increase the efficiency of work under the current social and economical circumstances. Therefore, it is equally important to get theoretical knowledge as well as to plunge in current social and economical context and acquire problem-solving skills. One of CDIO Initiative priorities is problem-oriented education which presupposes inseparable connection between theoretical knowledge and practical skills by means of integrated courses and interactive learning.

The elements of the CDIO Standards have been implemented at Management and Quality Systems Department since the beginning of 2014. At the first stage the discipline "Introduction to the Specialty Training Program" is in the focus of attention. The discipline curriculum was developed in accordance with CDIO Standards requirements and the discipline was introduced into the curriculum for bachelor students of the second year of studying.

According to the CDIO Standards, there should be an introductory course which is directed to develop personal and interpersonal competences and serves like a fundamental base for further professional activities. The main objective of such course is to make the student aware of the educational goals and to prepare him/her for the program comprehension. This means to teach the student to be motivated for professional activities, to understand what kind of problems he/she is to solve as a specialist, to be aware of the importance of the disciplines which will be taught and personal and interpersonal skills necessary to take the specialty training course [2, p. 8-9].

There are other CDIO Standards requirements which the discipline "Introduction to the Specialty Training Program" fits as well. The discipline determines the role of the quality management specialist at every stage of CDIO products life cycle; develops personal, interpersonal and professional competences by means of integrated educational tasks; regards the subject from the practical perspective; explains social significance of the profession; deals with the questions of professional ethics etc.

Within the scope of the course there are four modules regarding four different topics. Each module is of integrated character or, in other word, is directed to both providing students with professional knowledge and developing competences of all necessary types. Every module includes theoretical part and practical tasks.

The objective of the first module is to determine the role of a quality manager in the technological progress under the circumstances of postindustrial society.

Theoretical part: Within this module historical, cultural and social contexts of the profession are determined: social conditionality of the development of management principles, concepts and methods depends on the level of social development. The module concerns current problems and responsibilities of the quality manager under the conditions of market globalization and ecological and social problems of consumer society.
– The module also deals with the questions of professional ethics and social responsibilities.

Practical part: within this block students work on their own to study the evolution of approaches to quality management which are based on the "classical" systems of Ford and Toyota and acquire practical skills of note taking, preparing reports and making presentations on the results of their studies, which will be used on the following educational stages.

To regard the questions of professional ethics the moderated discussion on ethical codes of different companies is organized. There is also a role play on the problem of deforestation caused by the need in agricultural lands. The students play roles representing different parts and protecting their interests during the round table discussion. Regarding the questions of professional ethics, the role play helps students to acquire skills of proper behaviour in actual conflict situations. [3, p.188]

The second module concerns different stages of products, processes and systems life cycles and the function of quality management at each of the stages.

Theoretical part: deals with "Conceive" stage of a new product and such important steps as consumer demand survey, "product" or "service quality" definition; analysis of the enterprise and technology potential, standard requirements study. At the stage of "Design" the quality of product is adjusted to technical requirements to products, processes and systems. The stage of "Implement" is production based on the plans, testing, probation and certification. "Operate" stage is after-sale support for the products and their recycling.

Practical part: to comprehend the stages of product life cycle and to develop problem-solving skills there is a case study "Technological process" designed by the students and teachers of the department. The case study is to represent a technological process by the example of paper planes assembling. The authors of the case study designed special traps which students have to overcome independently with the help of the teacher developing the most efficient ways to organize the production and to manage the quality.

Within this block there is another case study describing product life cycle in one of well-known companies. The case study not only provides students with knowledge of product life cycle stages but also develops the skills of getting information from open sources.

The third module objective is to introduce diverse options of professional realization within the scope of quality management.

Theoretical part: within this block students get information about the wide range of enterprises where the specialists of their professional profile are in demand. As far as quality is an essential characteristic of any product or service, quality managers have good job opportunities in almost any industry where there is a consumer who is concerned about the quality. Today, at Russian labour market the greatest demand for quality managers is made by manufacturing firms (in St-Petersburg it is, first of all, automobile industry and mass consumption products), the sphere of service (IT, telecommunications and retail), the sphere of certification, consulting and audit.

Practical part: to comprehend the information student visit the enterprises of the department partners (several manufacturing firms, service companies and IT-companies, an accreditation agency) and meet with specialists participating in different stages of a product life cycle – logistic specialists, technologists, product designers.

The forth module is dedicated to skills, knowledge, abilities and competences necessary to conduct professional activities effectively. The module is also designed to develop the skills of career planning.

Theoretical part: the students get information about the requirements to professional, personal and interpersonal qualities of the specialists, which are designated in educational and professional standards, including the CDIO standards. To teach the module successfully a professional psychologist is invited; this specialist suggests different ways to develop personal and interpersonal competences.

The HR-manager of the big company also teaches some classes sharing the experience of career planning, drawing up a CV, acing a job interview, taking continuous professional development courses and participating in case competitions.

Practical part: every student makes his/her own "career journal", which contains a detailed plan of bothclass and out-of-class activities necessary to develop the knowledge, professional and personal qualities essential to reach a desirable milestone on the career pathway.

The necessity of assessment is one of the important principles of the CDIO Standards. It is important of identify whether the goals and objectives have been reached and whether the students have comprehended the knowledge and developed the skills. The complex of indicators have been designed for the discipline "Introduction to the Specialty Training Program", which are applied to assess the motivation for professional activities, comprehension of the profession social context etc.

The problem is that the assessment has not been made as the course has not been completed yet. But it is indisputable that the implementation of CDIO Standards principles in teaching students of management specialties makes the educational process closer to real life conditions which young specialists will have to face. There is a hope that CDIO and other similar initiatives being implemented, Russian employers will not hire "smart guys" to be retaught while future alumni won't recall a sad joke which says: "Now you may forget everything you've been taught at the institute and should start learning again".

REFERENCES

1. Kartsev D. How to become a director // Russian Reporter (Russkiy Reportyor). – 2013. – № 22. – P. 58-61.
2. Engineering Education: Perspectives for Development. The CDIO Initiative. – S.-Petersburg, 2012. – 29 p.
3. Pakhomova N. Environmental management (Ekologicheskiy menedzhment) / N. Pakhomova, K. Rikhter, A. Andres. – S.-Petersburg, 2004. – 352 p.

УДК 378.22:005

Education of Engineers in Russia

Ural Branch of Engineering Science Academy

L.B. Khoroshavin

Ural State Mining University, Yekaterinburg

T.A. Bad'ina

The article discusses the need for education and training of specialists in our country in their harmonious unity, beginning from school and enhancing in engineering universities. The basic concept of educating creative individuals with high level of knowledge, intelligence and patriotism for strengthening the unity and progressive development of Russia is presented.

Key words: education, school, college, formula education.

L.B. Khoroshavin

T.A. Bad'ina

Training of engineers has to be started as soon as school days begin. Schoolchildren's motivation to become highly-educated Russian engineers and work for good and progressive advance of Russia is to be formed at school. It is conditioned by the fact that the processes of training and upbringing are overlapping in the education system. Therefore, the common golden formula of education and upbringing is as follows:

Advanced education and upbringing is a unified process intended for educating creative individuals with high level of knowledge, intelligence, and patriotism.

Education of individuals at school and engineering universities includes development of basic issues:

1. To develop the objective attitude to historical events in Russia without exaggeration, from the starting point to development of the great country.

2. To increase respect and love for Nature, to improve ecological condition.

3. To show the necessity of the technogenic world development in perfect harmony with nature by means of engineering and humanitarian knowledge.

4. To learn the heroic personalities' biographies of our country as examples of Russian patriots.

5. To learn to live and work in harmony with Nature and society.

6. To foster love for work.

7. To cultivate justice, objectivity and good will in all aspects of life. Always help each other.

8. To make friends only with clever people, not negative persons.

9. To foster the love for the Motherland, devotion to the homeland, and people. Learn and live in our country.

Development of the basic principles of education and upbringing allows for formation of creative personalities in schools and engineering universities of the country.

The main peculiarity of the Russian engineering education is a combination of all-round fundamental training with wide professional competencies, i.e. education principle based on science [3].

An engineer is a specialist possessing high level of awareness, particularly in the sphere of natural sciences.

Engineering staff training starts from pre-school and school education. These are the stages when development of fundamental base for natural sciences takes place in terms of a person's age and psychological features.

Development of logical thinking has to be started from kindergarten through motor skills activities and creative thinking games. Development of imaginative thinking is a job of primary school. In the subsequent class logical thinking is to be methodically developed which is based on imagination and confidence of thinking, will. If the given features are formed in a proper way, math, physics, informatics will be mastered by schoolchildren at a good level.

But, a number of problems raise that prevent from full actualization of the given abilities.

Firstly: hardly anybody observes the development of a child's mathematics gift, all the more, work on formation of logical and analytical thinking purposefully (hobby groups, elective courses, optional courses are not arranged, little time is spent for subject Olympiads). Therefore, modern generation of schoolchildren is not able to perceive physical-mathematical tasks and then master exact sciences at a psycho-physiological level.

Secondly: professional qualification of a school teacher affects directly the development of necessary pupils' competencies and further students' comprehension of mathematical sciences at universities. Professional competency of exact sciences' teaching in secondary education is not enough (results of Uniform State Exam (USE) on math, physics are lower than average) [1].

Hence, we can observe that logical, cognitive thinking of young generation is getting worth, which is connected with the problems of school education and early development of logical abilities.

Thirdly: without decent basic school training in "exact" sciences there could not be any further engineering development at universities. Students solve algebraic, geometrical, and physical problems using patterns of methodical manual without deep understanding and comprehension. Could we speak about thinking creativity?

Fourthly: In many cities there are vocational schools that are focused on pupils' preparation for university entrance and learning physical-engineering syllabus.

Prepared students lose their motivation for learning subjects in the first year of education, as they suppose that they know all (they are to study the same again and revise the school curriculum) and cannot realize their potential to the full extent. They neglect educational process and give up studies giving way to the students from ordinary schools.

Fifthly: It turns out that university system works for an average student discarding strong students! At «university» schools highly-qualified teachers capable to develop students' abilities and increase their scientific knowledge level are to be engaged. Student's training is a key problem of a university teacher, not a minor one.

Sixthly: half-educated bachelors and masters may do harm everywhere. The new educational standards and schedules lead to the only conclusion: first, teachers of special subjects disappear, as just the hours for majors are reduced (in some cases they are excluded) in the syllabus for future engineers' training. The bachelor will not have enough theoretical knowledge and practical training.

Seventhly: decay of education begins in the family. Many parents wish to give comfortable and happy life to their children, not keeping in mind that education requires hard work.

Eighthly: The engineer's image and respect for engineering jobs in the society should be considered the most important problems that hinder engineering education quality improvement. At present, it tends to be different in Russia: low wages of engineers, even in the key hi-tech branches of science and industry, absence of good artistic works, films about engineers, i.e. appropriate promotion [3].

Hence, profound education is in demand neither by society nor by the individual.

Engineers are the base for the country's modernization and its progressive development. The formula of advanced education and upbringing in Russia is growing of creative individuals with high level of knowledge, intelligence, and patriotism. Students have to pass the way from the first year to work place with the necessary assistance of their first helper – software of artificial intellect.

Conclusions:

1. It is necessary to increase the quality of engineering education in Russia and take again one of the leading places in the world in this sphere.

2. To increase the level of education one should stop «European-style renovations in education» and start development and adoption of «Russian Education Law» including all positive achievements in our country and abroad.

Thus, advanced development of engineering education in Russia is based on graduating highly-educated engineers who possess both engineering and humanitarian knowledge and demonstrate the high level of intelligence. The essence of engineering activity is cognition of unknown and creation of uncreated on the basis of the intelligence paradigm – all for fostering unity and progressive development of Russia.

* * *

Ask any Russian: «Would you like your children to obtain free education at all levels, the best in the world Russian education?». I guarantee a hundred-per-cent answer – YES. Then «Russian Education Law» should be adopted. This is the base of the truth.

ЛИТЕРАТУРА

1. Vinogradova I. V. The necessity of review of educational «intelligence paradigm» in modern vocational education / I. V. Vinogradova, T. A. Trunova // Problems of engineering education and professional orientation in educational institutions of different levels : collected abstracts and articles / SPbSUACE. – SPb., 2010. – P. 14–17.
2. Pokholkov Yu. P. National Doctrine of Advanced Engineering Education in Russia in the Condition of New Industrialization: Approaches to Formation, Goals and Principles // Engineering Education. – 2012. – № 10. – P. 50–65.
3. Fedorov I. B. Problems of national higher engineering education system // Education in Russia : Federal reference. – Moscow, 2011. – V. 8. – P. 137–140.
4. Khoroshavin L. B. Modernization of the country starts from education – increase in level of knowledge and intellect [Electronic resource]. – [2010]. – URL: http://refractories1.narod.ru/Modern.doc, free. – Title from the screen (Date of reference: 24.04.2014).

Implementation of PFUR Strategic Development Program in Department of Oil-field Geology and Mining Engineering

Peoples' Friendship University of Russia

A.E. Vorobyev, Ye.V. Chekushina, I.L. Kapitonova, A.V. Sinchenko

A.E. Vorobyev

Ye.V. Chekushina

I.L. Kapitonova

A.V. Sinchenko

This paper presents the operating results of the department of Petroleum Geology and Mining Engineering (PGMPE) aimed at engineering education development. It also describes the activities held in the framework of Strategic Development Program (SDP).

Key words: medium-term development program, educational activities, research activities, international activities.

The aim of the article is to analyze and find further prospects for petroleum education by comparing the indicators of an ideal department with the real department's indicators.

The objective of the article is to show possible ways of development for Petroleum and geological departments using the example of the department of Petroleum Geology and Mining Engineering (PGMPE).

In the XXI century the approach to the higher engineering education changed considerably all over the world. It has become more practice-oriented and allows graduates to get into production process without additional training period.

Different engineering universities use different ways to ensure this need.

People's Friendship University of Russia (PFUR) is the unique educational institution not only in Russia but also among more than 17000 higher education institutions in the world. The main strategic goal of the University is to form the global elite for the economy, science and culture of Russia and other countries of the world in terms of pursuing the RF geopolitical and economical interests through the export of the educational services. This aim determines the Corporate Policy and is implemented in the framework of the strategic development program (SDP) of PFUR for the period of 2012-2015 [4].

The program includes the following directions [4]:

1. Education process improvement by increasing the number of Master Degree programs in foreign languages and training quality level as well as by conducting other activities in the framework of international collaboration.

2. Improvement of research and innovative activities, which includes [4]:

- Development of research work/ student research work (RW/SRW) infrastructure;
- Development of the incentive system to encourage research, innovative and publication activity of the faculty and recognition of PFUR at the federal and international levels (including the development of a support system for prior fundamental and applied research in natural, mathematical and technical sciences based on research and education centers and labs of PFUR).

3. Human resource development and development of the best school leavers selective system, which means making conditions for human resource development and optimal average age maintenance, attracting talented Russian and foreign students by means of different kinds of competitions and conferences.

4. Infrastructure modernization implying the improvement of working conditions both for the students and the faculty.

5. Development of the effective management system in PFUR, in terms of which the restructuring, human resources optimization, personnel distribution and faculty competence development are carried out.

Reaching the planned indicators of the SDP will double the existing indicators (Fig. 1)

The PGMPE department of engineering faculty (PFUR) takes an active part in SDP. It attracts a lot of new students giving career guidance in schools. It also delivers courses for more foreign students: there is a group of 9 Chinese students from Xian Oil University who study Russian oil and gas terminology. The department faculty develops teaching materials. In 2013 it edited a workbook «The current state of the Russian oil and gas industry» approved by the Board of Educational Methodical Association (BEMA) in applied geology, specialty 130101.3 "Petroleum geology". There is also a new laboratory with a drilling simulator «Transas Shelf 6000 Drilling Simulator" and a simulator designed to conduct research and training related to the rescue operations - PISCES II.

As of 01.01.2014 it is possible to distinguish the following aspects of the SDP development of the department (Table 1, 2) [1-3]

There were 12 research works (fundamental and applied ones) conducted at the department from 2009 to 2013 for a total amount of 29 millions of rubles. Besides, there were 3 grants under the Federal Target Program (FTP). They were conducted by post-graduates.

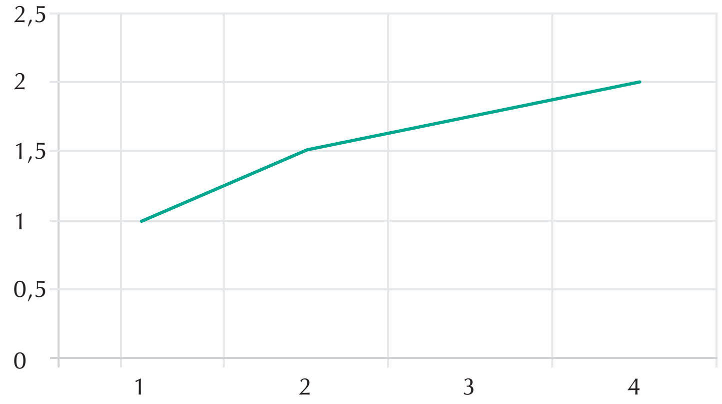
No less than 50% of the whole grant pay-roll was paid to young scientists, postgraduates and students.

Thus, there were119 participants under 35 years old who participated in scientific research projects. They are 49 students, 43 post-graduates, 7 young faculties, 21 PhDs and 3 external PhD students. They earned about 10 millions rubles. The average number of participants in the research projects is the following – 5.4 students, 4.4 postgraduates, 1.4 young scientists and 3 PhDs under 35 years old.

These are the research projects conducted in the department:

010511-1-173 "Innovative geotechnologies of oil shale development and high viscosity oil field development", 2009, (the project supervisor is Vorobyev A.E). 3 students, 3 post-graduates and

Fig. 1. Development of Generalized Indicators of PFUR.



1 instructor received 50% of the grant funded salary that is 260486 rubles.

010512-1-173 "Geochemistry of uranium mine spoil heap technogenesis as a base of effective reclamation and recovery of stored mined rock", the project supervisor and performer is Chekushina E., a post-graduate. The project was conducted in the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013. (State contract № П1689 dated 03.09.2009) – 445 000 rubles.

010513-2-073 " Development of effective exploration methods and methods for environmentally friendly development of gas hydrate fields, lake Baikal, Teletskoye lake (Russia) and Issyk Kul lake (Kyrgyzstan)", the project supervisor is Vorobyev A.E, D.Sc. in engineering, professor. The project was conducted in 2009-2011 within the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013, (State contract № П1405 dated 03.09.2009). 11 students, 4 postgraduates and 2 young PhDs under earned 50% of the grant funded salary that is 1369365 rubles.

010514-2-073 "Environmentally friendly oil shale reservoir engineering", the project supervisor is Gladush A.D. PhD in engineering, associate professor. The project was conducted in 2009-2011 within the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013, (State contract № П1436 dated 03.09.2009). 8 students, 4 postgraduates, 1 instructor and 1 young PhD under 35 years old received 50% of the grant funded salary that is 873000 rubles.

010515-2-073 "New and recycled power sources based on lithosphere reactor organic-containing wastes recycling into oil-like products", the project supervisor is Gladush A.D. PhD in engineering, associate professor. The project was conducted in 2009-2011 in the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013, (State contract № П1659 dated 15.09.2009). 4 students, 3 postgraduates, 3 young PhDs under 35 years old received 50% of the grant funded salary that is 654000 rubles.

010516-2-073 "Mining technique of underground manganese leaching from low-grade ore", the project supervisor and performer is Chekushina E., a post-graduate. The project was conducted in 2009-2011 in the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013, (State contract № П2024 dated 02.11.2009). The salary fund is 550000 rubles.

010517-2-144 "Development of resource-saving technology of controlled natural mineral wastes treatment in U-mines", the project supervisor is Vorobyev A.E, D.Sc. in engineering, professor. The project was conducted in 2010-2012 in the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013, (State contract № 02.740.11.0681 dated 29.03.2010) 6 students, 8 postgraduates, 6 young PhDs and 2 external PhD students received 50% of the grant funded salary that is 3442613 rubles.

010518-2-074 "Underground coal mining safety improving based on the adaptive techniques for coal mass displacement monitoring", the project supervisor is Pobyvanets V.S., DSc in economics, PhD in geology and mineralogy. The project was conducted in 2010-2012 in the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013, (State contract № 14.740.11.0642 dated 05.10.2010). 4 students, 6 postgraduates, 1 external PhD student and 3 young PhDs under 35 years old received 50% of the grant funded salary that is 413841 rubles.

0105 19-1-173 (Templan, 2012 year, the supervisor is Vorobyev A.E) – 3 students, 3 postgraduates and 1 young scientist earned 50% of the grant funded salary, which makes 236183 rubles.

010520-1-173 (Templan, 2012 year, the supervisor is Vorobyev A.E) – 3 students, 3 postgraduates and 1 young scientist without academic degree and 2 PhDs under 35 years old earned 50%

ENGINEERING EDUCATION 14'2014

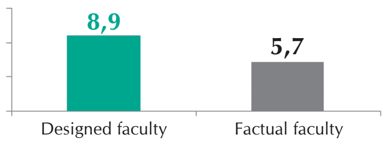
Table. 1. The Input of the Department into the SDP.

DEPARTMENT FACULTY

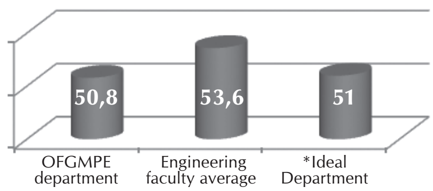
Tenured faculty:	
1. Vorobyev A.E. Head of the department, D.Sc. in engineering, professor. 2. Kipriyanov N.A., D.Sc. in chemistry, professor 3. Malyukov V.P. PhD in engineering, associate professor 4. Gladush A.D. PhD in engineering, associate professor	5. Yankevskiy A.V. PhD in economics, instructor 6. Abdulatipov Zh.Yu. Instructor 7. Sinchenko A.V. Instructor 8. Mastonov R.A. Instructor 9. Kaukenova A.S. Instructor
Tenure and Non-tenure tracks:	
10. Kochofa A.G. PhD in geology, associate professor 12. Neguritsa D.L. PhD in engineering, associate professor	11. Chekushina T.V. D.Sc. in economics, PhD. in engineering, associate professor
Hourly-paid faculty:	
13. Lev A.M. PhD in engineering, associate professor 14. Kapitonova I.L. instructor	
Consultants:	
15. Panin I.M. PhD in engineering, professor-consultant	16. Mashkovtzev I.M. PhD in engineering, professor-consultant

GENERALIZED CHARACTERISTICS

Comparison of designed and factual faculty of the department

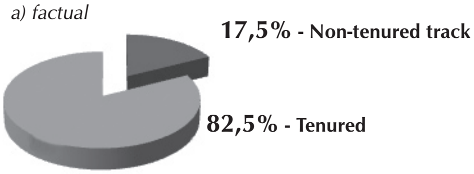


Average age of the faculty, years
**** University recommendation***

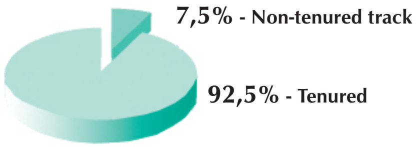


Tenured/Non-tenured track ratio

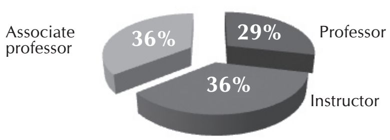
a) factual



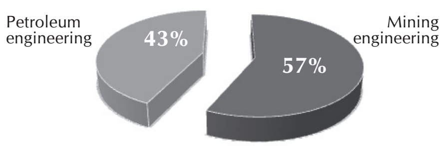
b) planned



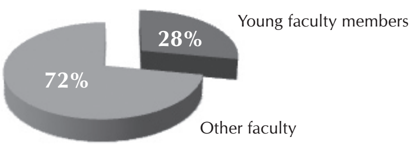
Professor/Associate professor/Instructor ratio



Faculty specialization



Percentage of young faculty (9% of young 's faculty is the university administration recommendation)



Academic degree levels of the faculty, number of people

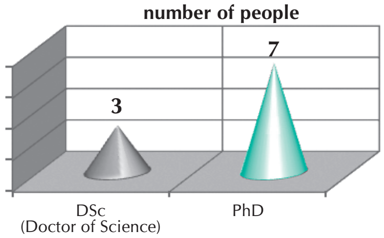
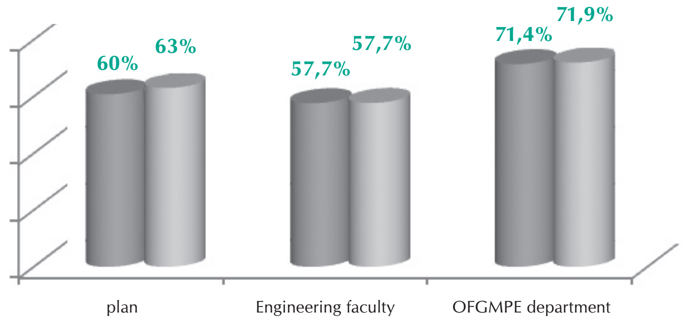


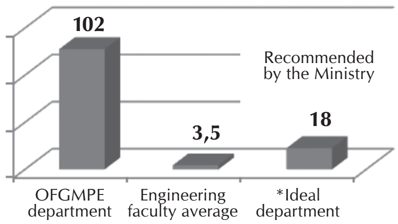
Table. 1. The input of the Department into the SDP.

GENERALIZED CHARACTERISTICS

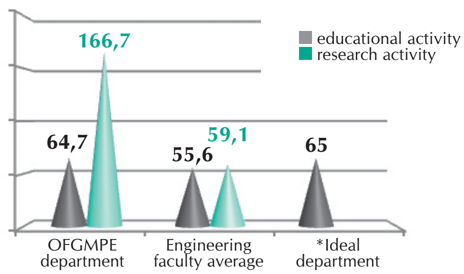
Percentage of the faculty having academic degrees



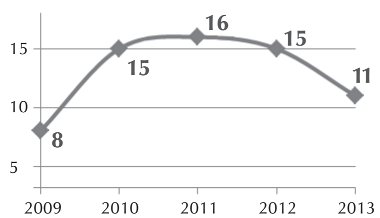
Scientific Research financing, thousands rub./person



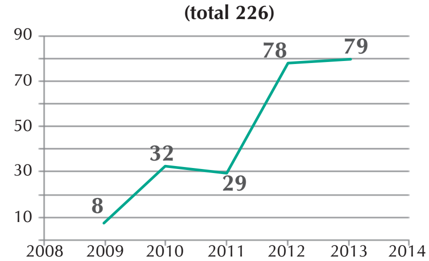
Average salary of the faculty, thousands rubles



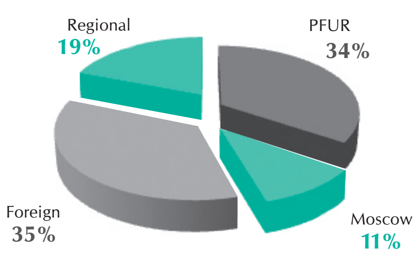
Number of published training materials, books and monographs (total 65)



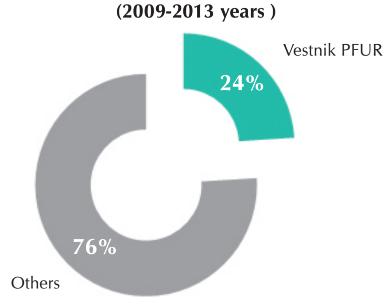
Number of publications in national journals (total 226)



Publishing houses with the publications of the faculty (2009-2013 years)



Journals with the faculty publications (2009-2013 years)

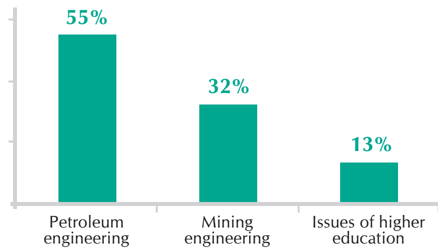


ENGINEERING EDUCATION
14'2014

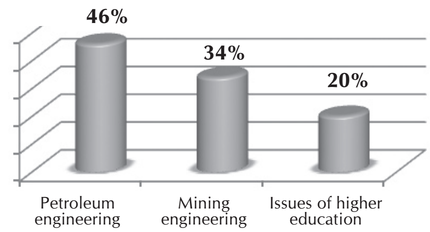
Table. 1. The input of the Department into the SDP.

GENERALIZED CHARACTERISTICS

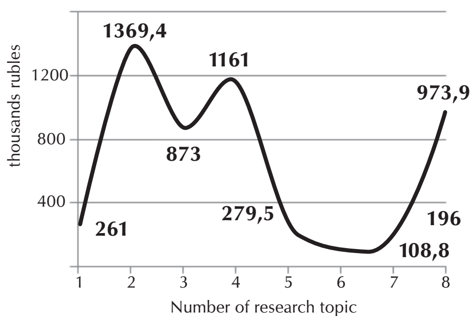
Scientific areas of books published by the faculty (2009-2013 years)



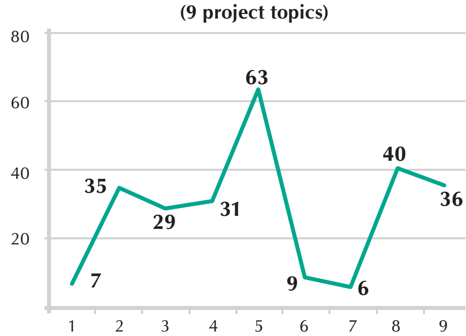
Scientific areas of articles published by the faculty (2009-2013 years)



Sum of salaries paid to students, post-graduates and young scientists



Number of students, post-graduates and young scientists taking part in research projects (9 project topics)



of the grant funded salary, which makes 336900 rubles.

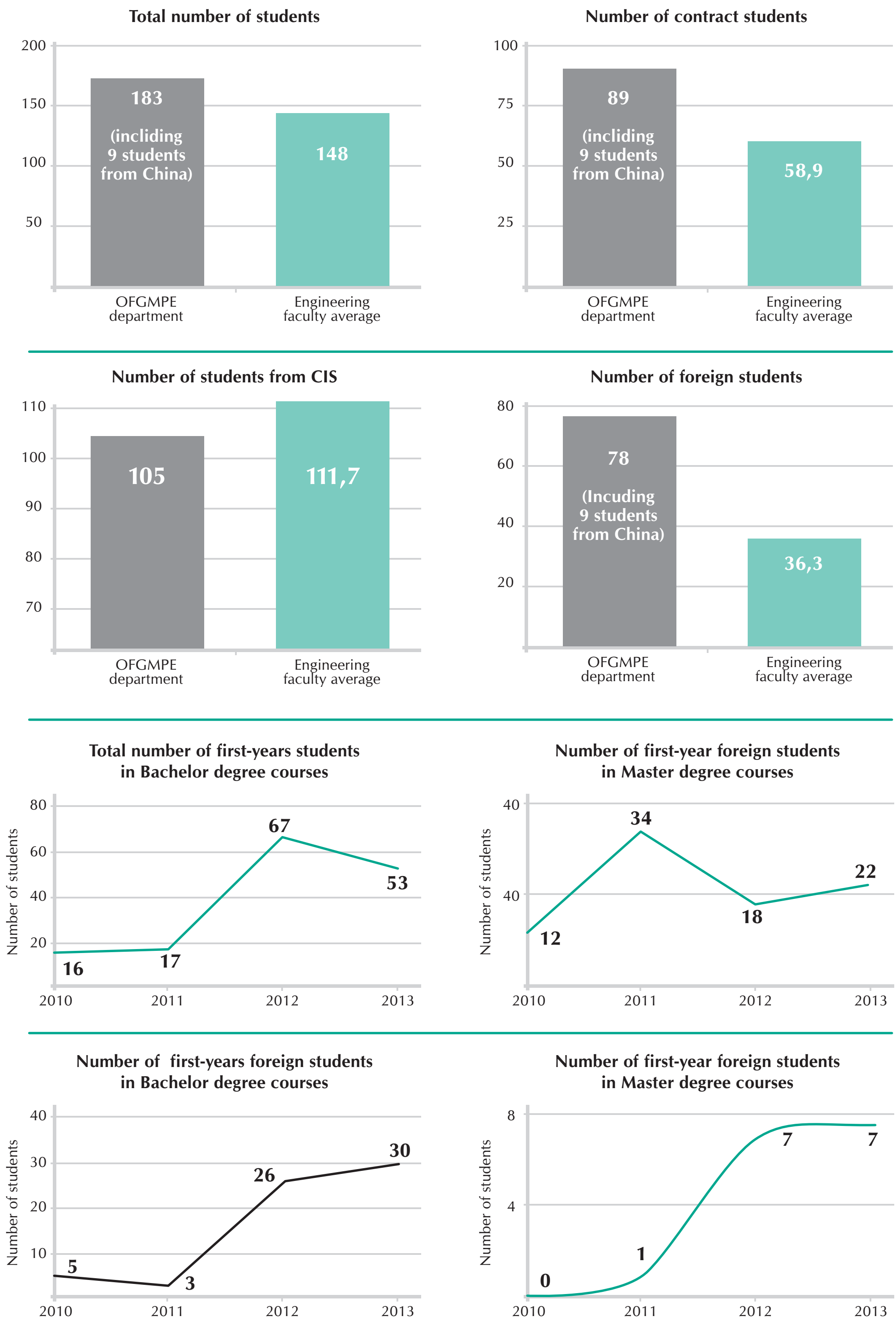
010521-2-074 "Development of innovative methods of methane extraction from natural and technogenic waters based on theoretical and experimental research of hydrogeological basins", the project supervisor is Vorobyev A.E, D.Sc. in engineering, professor. The project was conducted in 2012-2013 in the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013, (State contract № 14.B37.21.1254 dated 21.12.2012). 7 students, 6 postgraduates, 1 external PhD student and 4 young PhDs under 35 years old earned 50% of the grant funded salary, which makes 951492 rubles.

Unnumb. "Research of coal gob piles as pseudo-volcanic features (Contract with the Ministry of education and science of the RF dated 03.10.2012 №4.132.21.1816)", the project supervisor and performer is Abdulatipov Z.Y., a post-graduate. The project was conducted in 2012-2013 in the framework of the Federal Target Program «Scientific and education personnel for innovative Russia» for 2009-2013; the grant funded salary is 428000 rubles.

Nowadays, at the department there are students from 79 countries (Table 2). The total number of nations and nationalities represented by PFUR's students is 156. It gives great possibilities for international contacts as well as good foreign language practice. Besides, there is a possibility to obtain a Diploma "Translator in professional activity area".

During the training course the students have internships on the training testing grounds in Moscow (MGRI-RSGPU, Sergiev Posad) and St. Petersburg (National Mineral Resources University – University of mines). Our students have

Table 2. Characteristics of the students trained at the department.



also internships in leading petroleum universities of German, China, Estonia, Poland, Kazakhstan, Kyrgyzstan, etc, in the leading Russian and international oil and gas companies (Lukoil, Rosneft, etc.) as well as in science and research institutions.

Most part of our bachelors continue their study at the department taking Master Degree program in specialization "Management" that has 3 specialties: "Management in petroleum engineering", "Audit of subsurface use" and "Innovative techniques in subsurface use".

The conditions of the modern labour market make us produce engineers not only with the competencies required by the FSES (Federal State Educational Standards) but also with some special (additional) competencies (Fig. 2), which are necessary for producing competitive innovative products.

There are some examples of effective development of such competencies:

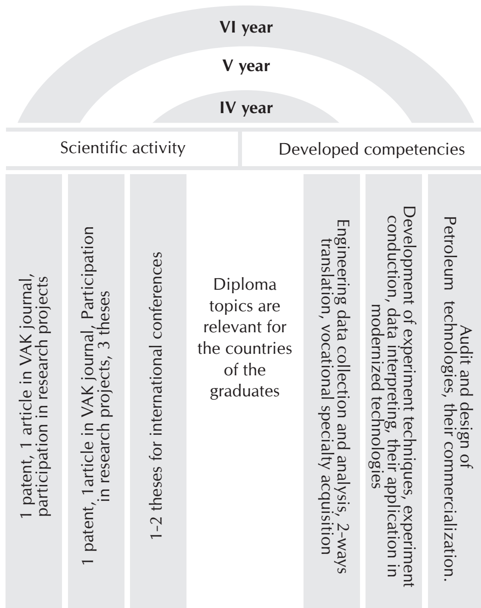
1. The use of the computer system "Academic portal" that provides a 24-hour access for students to the faculty data base (including lectures, training materials, presentations, etc.);

2. The opportunity for students to improve their skills in foreign languages and computer use;

3. The opportunity for the students to take part in international scientific conferences. By now PFUR (the cochairman is Vorobyev A.E, D.Sc. in engineering, professor, the head of the OFGMPE department) has conducted 12 international conferences "International Conference on Mining, Mineral processing, Metallurgical and Environmental Engineering" in Russia (Moscow), Dagestan (Makhachkala), Kazakhstan (Karaganda, Ust-Kamenogorsk), Uzbekistan (Tashkent and Navoi), Kyrgyzstan (Bishkek and Kyzylkiya), Armenia (Erevan), Benin (Africa, Cotonou), Algeria (Algiers), Estonia (Tallinn)and Iran (Tegeran), where more than 5900 scientists and specialists participated in different ways.

4. The opportunity for the students to enhance their educational learning performance through a wide variety of additional professional qualification programs.

Fig. 2. System of additional competencies developed in the course of the programs acquisition.



REFERENCES

1. Vorobyev A.E. Development of Innovative Education project at the OFGMPE Department// Vestnik KRSU. 2009, Vol. 9, №2. pp. 78-82. (only in Russian)
2. Vorobyev A.E., Vakker O.V. Influence of Innovative Activities on the Department's Indices.// Vestnik KRSU. 2010, Vol. 10, №3. pp. 79-86.
3. Vorobyev A.E., Development of the Department of Petroleum Geology and Mining Engineering of PFUR from 2001-2008. // Nauchnyi vestnik Norilskogo industrialnogo instituta. 2009. № 4. pp. 51–56.
4. Report on Strategic Development Program Implementation for 2012. [Electronic resource]. Moscow, 2013, P. 84. URL: http://www.rudn.ru/file.php?id=2961, free. Title from the screen (reference date: 23.04.2014).

UDC 378

Designing General Engineering Module for Bachelor's Production and Technology Programs

Ural Federal University named after the first President of Russia B.N. Yeltsin

S.A. Berestova

S.A. Berestova

The article describes the experience of "General Engineering" module development for the educational program of Higher engineering school of UrFU. Being developed in the context of relevant international projects and initiatives, the module is designed as interdisciplinary, practice-oriented and student-centred. There are examples of the module learning outcomes correlated with the methods of their development and assessment. The main idea of the module design is the development of the process map which includes the module learning outcomes, achievement indicators, methods to define the module learning outcomes and the course content. Special attention is paid to assessment tools, in particular to the interdisciplinary project.

Key words: interdisciplinarity, the module learning outcomes, assessment of learning outcomes, educational project, internationalisation of education, standards CDIO initiative.

In this work we would like to share the experience in designing module-based bachelor's program "Production and Technology" of UMMC-UrFU describing one of the program modules.

Let us consider some learning outcomes of bachelor's program "Production and Technology", which are stated in the Higher engineering school standard [1], developed by faculty members and approved by the Scientific Council of UrFU. Upon completion of bachelor's program "Production and Technology" the graduates are to be able to:

- apply the system of fundamental knowledge (mathematics, natural-science, engineering, economics) to identify, define and address profession-related issues;
- apply efficient methods of information processing in professional activity, using modern IC-technologies;
- plan and provide experimental and industrial testing and analyze the data obtained ;
- analyze scientific and technical information, observe national and international experience in the sphere of professional activity;

etc.

The methods to define learning outcomes of the module largely overlap those to define learning outcomes of the educational program. While the expressions may be different, they should be within the same semantic scope, and the learning outcomes of the module are to be correlated with the learning outcomes of the program itself [2]. Interdisciplinary projects play an important role in learning outcomes assessment [3], which allows us to avoid fragmented information and connect the disciplines within the module.

The learning outcomes may be defined in details with regard to different disciplines but at the level of a separate discipline it seems to be more efficient not to define the learning outcomes but to determine the indicators to measure the results. In this case the connection between the module learning outcomes, the indicators of the achievements at the level of the separate discipline, the course content and assessment procedures is transparent. It is indubitable that the learning outcomes should be connected with the other modules. The number of learning outcomes is directly dependent on the size of the module and is about 5-7 outcomes on average.

Let us turn to the development of module learning outcomes by the example of the module "General Engineering" which is included in the basic bachelor's program "Production and Technology", developed and implemented by UrFU.

The aim of the module, that is "to develop the scientific worldview and the skills to apply general engineering knowledge for scientific and technical task solving", was defined according to the competences designated in bachelor's program "Production and Technology" (Metallurgy) – practice-oriented training of engineers and technicians of the lowest and middle levels of management structure under the order of UMMC.

To reach the aim vertical and horizontal relationships between course curriculums within the education program were improved and the list of integrated competencies, which are to be developed in the result of the multidisciplinary module learning, was designed. Upon completion of "General Engineering" module the student will be able to:

- find out the matter of problems which he/she faces within professional activity; determine the sphere of engineering knowledge; use appropriate physical tools and mathematical methods to solve problems.
- design mathematical modules for engineering tasks.
- plan and carry out theoretical and experimental research, counting, and data analysis.
- use modern software products and information services to solve engineering tasks.
- design engineering and workshop documentation in accordance with standards, technical requirements and other prescriptive documents.

This is how the learning outcomes of "General Engineering" module were designated in bachelor's program "Production and Technology" of UrFU.

Let us give an example of an achievement indicator at the discipline level – "to identify the sphere of general engineering knowledge". This indicator reflects the ability of the student to refer the task to the sphere of engineering knowledge. To assess the outcome of "using modern software products and information services to solve engineering tasks" such indicators as using file lockers, e-mail, on-line calculators, e-learning tools etc. are applied.

Designing the module of the education program one should pay special attention to developing the methods to achieve and assess the outcomes. It is indisputable that active learning methods should be regarded as predominant when choosing the methods to obtain desirable outcomes, the educational tools, the educational resources and techniques. There are no doubts that active learning methods are the methods of future. As for assessment tools, the range of them is still limited, which is the result of the traditional curriculum. There is a quotation by professor D. Hawker, a consultant of the World Bank and an expert in education reforming and education quality assessment, which is to the point here: «Assessment system caters for education but not visa verse».

About 85 per cent of a diverse range of assessment tools are those to identify weak points and lack of knowledge. It is these assessment tools that are included in our curriculum: exams, pass-failed tests and graded tests. But they all presuppose remembering, immediate knowledge. The test checks the knowledge, while it only partially deals with comprehension. Tests, homeworks, reports, essays and others reflect a single and particular achievement.

What is the way to find out how much the student knows and what he/she can do? More and more often teachers use contextual tasks and case studies which expand the possibilities of assessment criterion application. Doing contextual tasks and working with case studies the student learns how to use the abilities and apply the skills, acquired in the process of education, not only within the scope of educational environment but also beyond it.

In our opinion, the project can be regarded as a special tool which represents integrated assessment of a range of knowledge, abilities and skills. The project may be a part of the student's portfolio and represent the dynamics of educational process. Therefore, the project was chosen as the main tool to assess the achievement of module outcomes.

There is no particular method to assess all learning outcomes so it is necessary and perspective to use several tools of assessment.

Within the module "General Engineering" the following assessment tools were chosen: testing (process monitoring and intermediate control), to esteem knowledge, an element of rating system of UrFU. The students familiarize with the base of test tasks in advance. The students submit their reports on laboratory works. Discussion of case studies takes place. The competition of contextual tasks solutions is held. The final pass-fail test is the tribute to traditional curriculum. The interdisciplinary project plays a special role in the educational process and we will turn to it later.

So, we have figured out the aim of the module, outlined desirable module outcomes, compared the indicators of the outcomes and proposed the methods to obtain and assess them. The next step is to develop the content of the course which will determine the disciplines of the module. Let us regard a fragment of the process map of "General Engineering" (Table 1). The content of the course specifies the disciplines to be taught, as well as the blocks within the latter.

The disciplines of "General Engineering" module are: engineering graphics (perspective geometry, machine drawing, computer graphics); mechanics (mechanics theory, mechanics of materials, machine elements and principles of design); materials science; metrology, standardization and accreditation.

Let us take as an example the discipline of engineering graphics which, according to the process map, is to contain the following blocks.

Block 1. Perspective geometry

The perspective method of space representation. Orthogonal projections. The ways of drawing conversion. Surfaces and their interactions. Axonometric projections.

Block 2. Machine drawing

The notion of standardization. The standards of USDD (Unified System of Design Documentation). How to draw and mark a component's parts. Sketches. Shop drawings. Assembly drawing.

Graphs, tables and diagrams making. Rendering. Computer-assisted drawing systems. Higher education institutions adapting to Federal State Educational Standards, the aim of modern engineering education is to make the educational process less fragmentary. It is possible to meet this goal by implementing project-oriented learning in practice-oriented bachelor's programs.

We turn to the crucial point – the interdisciplinary project within the scope of which students improve their integrated competences, demonstrate the knowledge of terms, methods,

Table 1. The Fragment of the Module Process Map.

Learning outcomes	Indicators	Assessment tools	Teaching methods	Module blocks
Upon completion "General Engineering" module the student will be able to design workshop documentation in accordance with the requirements.	The students make drawings of items in accordance with standards in force. The student is able to get through the drawing the form of the parts and there correlations within an assembling item. The student uses computer graphics to work with design documentation. The student is able to find, use and compile documents within the spheres of metrology, engineering law, standardization and accreditation.	Knowledge testing. The defense of the interdisciplinary project stages. The test in the form of the work presentation.	Practice classes oriented towards the interdisciplinary project. Laboratory work in well-equipped classrooms. Individual and group work on documents design. Students' works presentation and defense.	Orthogonal projections. The ways of drawing conversion. Surfaces and their interactions. The notion of standardization. The USDD standards. Component's parts drawing. Shop drawings and sketches of components. Types of components joining.. Assembly drawing. Detailing. Graphs, tables and diagrams making. Rendering. Computer 3D-technology for design documentation. Engineering law and standardization. Conformity assessment.

information technologies and spheres of learning outcomes application. The aim of the interdisciplinary project is to assess the achievement of module learning outcomes. It includes simple examples of project design stages, which help to demonstrate how fundamental knowledge to be applied and provide the integrated assessment of the student's activities. The project will become an important part of the student's portfolio.

The interdisciplinary project is to be completed within 4-5 semesters. The stages of the project are detailed design based on the device application, which implies component design and specifications; static, kinematic, dynamic and structural analysis, which includes analytical models, choice of solution methods, mathematical models, solving of the simplest optimization problems. In the result of decision analysis the geometry dimensions of the product are specified by means of the terms of references, the materials and components are chosen (power, rolled stock, bearing parts, cable etc.) While calculating and preparing specification, component drawings and the assembly drawing are produced by means of a computer-assisted drawing system (AutoCAD, COMPASS, Autodesk Inventor etc). The design documents are prepared in accordance with the standards of USDD. Engineering documentation connected with metrology, engineering law, standardization and conformity assessment is prepared. The choice of material is based on specified operation conditions with due regard to technological and economical requirements, as well as the product being reliable and long-life. The student's high level of knowledge and skills is obvious through 3D-modeling and dynamic visualization of detailing and assembling.

It is important that the number of practical and student individual tasks is constantly increasing throughout the module. The amount of hours spent on theory and illustrating examples should be minimal but sufficient, while more time should be devoted to creating analytical models and getting information of those calculation methods which will be applied during the interdisciplinary project. It is noteworthy that in the curriculum the hours necessary to get acquainted with information technologies and programming software are not compiled within a separate discipline but included into diverse modules.

If there is lack of time and it is impossible to pass though all stages of product design, the project may be reduced to component design and the team-based method of work may be applied (when subassemblies are designed by different students). This way students acquire an important competence – team work abilities and skills. There are two ways to organize team work: different tasks for five or six teams or three sub-tasks for united teams.

Let us turn to the interdisciplinary project the goal of which was a simple mechanism of electric hoist. There was a group of 25 students. 19 students actually participated in the project. There were five teams with different numbers of students; from two to six members in a team. The roles were distributed on the basis of students' relevant skills. Some students made accurate calculations, others gathered and analyzed the information, yet others prepared presentations and reports. The students were not eager to appoint the project manager since management is not an easy thing for them.

There were different approaches to solve the problem. The levels of complexity were determined by the students. For example, designing the bar which hold the electric hoist, one team reduced the hoist and the load it lifts to the concentrated force; the other team made the task more complicated having substituted the electric hoist with load by evenly distributed load and considered the components parameters and dispositions. The third team took the electric hoist as evenly distributed load plus additional load in terms of the concentrated force. There was an attempt to consider the electric hoist moving: there were several calculations depending on the position of the hoist on the holding bar and the most critical value was chosen.

The results of the work fulfilled within the interdisciplinary project were checked by means of production programs provided for educational purposes (calculation of coiling length of the drum, engine displacement and other parameters). The tutor of the group, professors of the graduating department and the employer representatives were invited for the projects defense. The students made presentations, answered the questions and got the experts' feedback. The experts made a note of team interaction and distinguished the leaders. The students were offered to fill in the form to assess their personal contribution to the project, the contribution of the team players and other teams' presentations. The final conclusion was made through the integration of these assessment lists.

The project is time-consuming: it takes the teacher much more time than a traditional course does. Working with the project the teacher has to analyze information gathered by students, monitor studying pathways, check the calculations, which were made through individually created formulas, work with assessment lists and the rating system , provide e-learning; the latter means creating a new form of materials representation and impossibility of materials direct conversion, "student-teacher" system of interaction being immature, students' being careless of time limits and, as a results, often shifts of the project deadline. The project increases the time of students' individual work as well: information search and analysis, preparing presentations, team work (team players transferred from one group to the other several times during the semester).

Implementation of these projects into practice-oriented bachelor's curriculum will broaden students' horizons, help them comprehend the disciplines being interconnected and also clarify some aspects of their professional activity.

REFERENCES

1. UrFU Educational Standards in Engineering. – Yekaterinburg, 2013. – 48 p.
2. Rebrin O.I. The Use of Learning Outcomes for UrFU Education Programs Design / O.I. Rebrin. – 2-d ed. – Yekaterinburg , 2013. – 32 p.
3. Worldwide CDIO Initiative. Standards / translated and edited by A.I. Chuchalin, T.S. Petrovskaya, E.S. Kulyukina. – Tomsk, 2011. – 17 p.

Application of Learning Outcomes Approach in Education Program Design

Ural Federal University n.a. B.N.Yeltsin, first President of Russia

O.I. Rebrin, I.I. Sholina

The paper provides methods of education program design based on learning outcome approach. It describes the application of this approach in different countries and suggests the ways of developing modular structure of education programs, projects and interdisciplinary tasks.

Key words: Integrated educational program, learning outcomes, modular structure, evaluation, educational project, standards initiatives CDIO, interdisciplinarity, educational standard.

O.I. Rebrin

I.I. Sholina

The learning outcomes approach is actively used at the universities of Europe, the USA, Canada, Australia and other countries. It is an effective tool for education program designing. The implementation of this approach implies achieving a triune goal: determining the learning outcomes, improving an educational process and developing educational programs appropriate for the target learning outcomes.

The notion "learning outcomes" should not be understood as an antithesis to the term "competence" that was introduced in the Russian Federal State Educational Standards (FSES). They are more likely to be different projections of an activity approach to determining the purpose of an educational process. The key point is the graduate's ability to use effectively skills, knowledge, experience and transferable skills acquired during a course in his/her further professional activity. European scientists often correlate the notion "competence" with a particular person who has this competence and applies it effectively in practice. The term "learning outcomes" is usually associated with an education program.

It should be taken into account that the learning outcomes should conform to the corresponding level of the education program (applied Bachelor Degree course, academic Bachelor Degree program, Master Degree program and Post-Graduate program). The consistency of the program goals with the learning outcomes is set by the Dublin Descriptors and the National qualifications framework.

The learning outcomes are divided into some groups while designing European and international engineering programs.

EUR-ACE Framework Standards for the Accreditation of Engineering Programs [2] has six groups of Program outcomes:

- Knowledge and Understanding;
- Engineering Analysis;
- Engineering Design;
- Investigations;
- Engineering Practice;
- Transferable Skills.

There is UK-SPEC (United Kingdom Standards for Professional Engineering Competence) [3, 206-209] that have four groups of learning outcomes:

- Knowledge and Understanding;
- Intellectual Abilities;
- Practical skills;
- General Transferable skills.

The similar approach is observed in the classification of CDIO Syllabus [4, 22] that classified learning outcomes into four categories:

- Technical knowledge;
- Personal and professional attributes;
- Interpersonal skills;
- Skills specific to the engineering profession.

ENGINEERING EDUCATION 14'2014

Benjamin Bloom's Taxonomy, suggested in 1956 [5, 56-59] became a theoretical framework for modern systems of classifying educational goals and objectives. It is a classification system for thinking behaviours that are important in the learning process.

The classification describes an interdependent and consistent way of a learner's cognitive development that includes six increasingly complex levels: Knowledge (information memorizing), Comprehension (understanding), Application (use of knowledge), Analysis (understanding through knowledge decomposition), Synthesis (production of a unique communication), and Evaluation (judgment based on knowledge). To conceive the learning outcomes, that indicate a particular level achievement, a list of action verbs is attached to the classification.

Apart from the cognitive domain which is the most elaborated one, the same approach can be applied to define the learning outcomes in the affective and psychomotor domains.

To prove the fact that Bloom's taxonomy is the base of the learning outcomes classifications existing nowadays, it is possible to give the comparison of Bloom's taxonomy and the learning outcomes classification adopted by Britain Universities:

Learning outcomes categories	Domains of Bloom taxonomy
Knowledge and comprehension	Knowledge, Comprehension (levels of the cognitive domain)
Intellectual Abilities	Application, Analysis, Synthesis, Evaluation(levels of the cognitive domain)
Practical skills	5-7 levels of psychomotor domain
General transferable skills	5 levels of affective domain

While setting learning outcomes the main objective is to define them in a clear and unambiguous way. Learning outcomes are quality indicators of a program or a course that are assessed by colleagues, employers and learners. It should be noted that the learning outcomes set a minimal barrier for the student to have a required number of credits hours or units.

So, the primary task of the education program design is setting learning outcomes for a particular program degree. To work in the CDIO framework it is naturally to use the CDIO Syllabus [6], using so-called the second level of detail in the four determined domains for learning outcomes formulation.

It is necessary to note that the CDIO Syllabus combines the best world experience in developing engineering education programs and allows us to use this experience without "reinventing the wheel". The CDIO Syllabus is compared with a "shopping list" which is very comfortable to make purchases with. At the same time, it is not a ready and unchangeable recipe but a manual for creative users.

As a rule, the number of program learning outcomes is not more than 20. They don't sum up the learning outcomes of the program modules but reflect the integrated knowledge, skills and personal values developed in the course of the whole program.

The setting of program learning outcomes is the most important step in the whole process of a program development. It is the milestone to take into accounts all employers' and educators' interests and join efforts for consistent decision making.

It is quite reasonable at this milestone to use professional standards, if potential employers have such. It is also necessary to take into consideration the prospects of industry development in predicting future needs of the labour market.

In general, the same recommendations can be applied to set the learning outcomes of a program module. But it should be noted that module learning outcomes depend on the program learning outcomes. Though being formulated in different ways they should have a clear conceptual correlation.

As a rule, there are 5-7 learning outcomes defined for each module. The learning outcomes assessment criteria should be clear and consistent not only for the faculty but also for students.

The module learning outcomes should be the result of agreement of all the participants including the learners and the faculty members who develop post/following modules even if these modules are separated in time.

There is a method to set a combination of separate modules, which is called "black box", i.e. the designers of separate modules (or courses) compare the learning outcomes expected at the input of a module with the learning outcomes received at the output of the pre-requisite modules without peering into the whole structure of the program content. Thus, they achieve the consistency of the modules.

Learning outcomes-program relationship formalization is carried out by developing an operation flow chart of learning outcomes. While designing such a chart it is possible to evaluate the suggested modules by assessing the consistency of their learning outcomes with the program outcomes.

The operation flow chart is a matrix where columns identify the program learning of outcomes and rows refer to the particular program modules. The marks at their crosses identify the connection of a particular module with a particular program learning outcome [7, 34].

As a rule, one module is aimed at achieving some program learning outcomes, whilein its turn one program learning outcome is achieved by a number of modules.

A mutually agreed approach to the formation of the module learning outcomes ensures the most effective performance factor of the modules. That is why, teamwork and mutual understanding of the program designers is an important factor of education program development. We should really "start with ourselves" and show the teamwork competencies that we are going to develop in our students.

The modular structure of an education program does not exclude such things as course, project, internship and other educational activities included in the module. While defining general learning outcomes of a module the designers of particular course syllabi correlate their training plans, change the training content to meet the module requirements. There are cases of more detailed learning outcomes setting with a direct correlation of particular courses (or parts of courses) with particular learning outcomes.

To design a module syllabus is another important milestone in the education program design based on the learning outcome approach. It is developed to ensure coherence of the module learning outcomes with the content of module courses, as well as the assessment tools.

The CDIO concept has a number of standards that determine the distinguishing features of the program developed in the new framework. One of such fundamental standards is standard №3 that is called "Integrated Education Program".

This standard sets quite a difficult task to develop the education program in a way to achieve a number of the Syllabus tasks by combining personal, interpersonal, and system building knowledge and skills that will allow future engineers to produce real products and systems.

The standard recommends that the program should contain these training tasks that when completed would ensure the development of a number of competencies simultaneously, both saving time and improving training quality.

But what is this magic task that boosts the education program so much?

The concept gives a definite answer: this magic tool is educational projects. It is the kind of activities that provides the best opportunities for combining not only knowledge and skills to make engineering products but also for developing personal and interpersonal competencies, such as communicative skills, leadership, teamwork skills, responsibility, engineering ethics, etc.

The common approach to training, when a set of courses is delivered in a definite term, could be transformed into the integrated program that contains these magic tasks and projects. The project work is conducted parallel with the background knowledge acquisition. It starts with some time delay, which allows students to save some "seed capital" that soon will be necessary to fulfill the project tasks. It is this necessity that activates the knowledge and transforms it into a more reliable form – "understanding", which ensures its effective use to solve a project task.

There may be more advanced forms of the training process where the projects are the cornerstones of the educational process. In this case, the knowledge is given as and when necessary. We are studying these forms, trying to gain foreign experience.

What we really can do at this development stage is to incorporate interdisciplinary project programs into the modules. Thus, the project implementation should require the competencies developed during the courses of the module and the previous modules. It also implies team work, assessment of each student input and supervision and result evaluation made by those teachers involved in the module.

CONCLUSION

The learning outcomes-based approach to the education program design, though appearing simple and obvious, has its "hidden pitfalls". The main risk is a desk-top oriented approach to defining learning outcomes because unconsidered and compiled learning outcomes induce the weakness of the corresponding programs and modules. Another risk is a simplified approach to the learning outcomes setting, that can be caused by the use of simplified tools and criteria and be excused by poor competencies of the students entering the universities. The same results can be achieved by strict adherence to employers' recommendations more resulted from current problems rather than pursuing development prospects. In any case, while developing learning outcomes it is necessary to "raise the bar" and be guided by the highest levels of intellectual development, practical skills and behavior patterns. It's necessary to note that this approach makes us change our attitude to the education program implementation since it gives more active role to students in the educational process by providing them with clear forms of learning outcomes, assessment criteria and active learning techniques. The application of the learning outcomes-based approach will facilitate the process of international accreditation of our programs and ensure real student and staff mobility. Professional standards and reasonable consideration of employers' recommendations should be used as a base for setting learning outcomes. It gives the possibilities for independent accreditation of our programs and, thus, for objective assessment of our work and applicability of the approach.

REFERENCES

1. Rebrin O.I. Use of learning outcomes for education program design in UrFU / O.I. Rebrin. Second edition. Ekaterinburg, 2013. P. 32. (all in Russian)
2. EUR-ACE framework standards for the accreditation of engineering programmes [Electronic resource] : approved by the ENAEE Administrative Council on 5 Nov. 2008. – [S. l., 2008]. – 14 p. – URL: http://www.enaee.eu/wp-content/uploads/2012/01/EUR-ACE_Framework-Standards_2008-11-0511.pdf, free. – Tit. from the tit. screen (usage date: 28.04.2014).
3. Business scenarios for engineers / J. Drysdale, B. K. Temple, A. Eastwood, D. S. Ross, C. Zhou // Sharing experience to increase internationalisation and globalisation in engineering education : conf. proc., Mannheim, 1998. – Hockenheim, 1998. – P. 206–209.
4. Worldwide CDIO Initiative. Planned learning outcomes (CDIO Syllabus). Translation from English edited by Chuchalin A.I., Petrovskaya T.S., Kulyukina E.S. Tomsk, 2011. P. 22.
5. Taxonomy of educational objectives. Handbook I, Cognitive domain / Ed. by B. S. Bloom [et al.]. – N. Y., 1956. – P. 56–59.
6. The CDIO Syllabus v2.0 [Electronic resource]. An updated statement of goals for engineering education / Crawley Edward F., Malmqvist Johan, Lucas William A., Brodeur Doris R. // Proc. 7 Int. CDIO Conf., Copenhagen, Denmark, June 20–23, 2011. – [Copenhagen, 2011]. – P. 2–43. – URL: http://orbit.dtu.dk/fedora/objects/orbit:86837/datastreams/file_5751109/content, free. – Tit. from the tit. screen (usage date: 25.04.2014).
7. Rebrin O.I. Technological modernization of higher professional education. Rebrin O.I., Sholina I.I., Tretyakov V.S. Ekaterinburg, 2012. P. 34.

OUR AUTHORS

KARTUSHINA
IRINA GENNADIEVNA
PhD (Pedagogic Sciences), Associate Professor, Transport Processes and Service Technology Department, Immanuel Kant Baltic Federal University
E-mail: IKartushuna@kantiana.ru

EL'TSOV
VALERIY VALENTINOVICH
DSc (Engineering Sciences), Deputy Director Togliatti State University, Institute of Mechanical Engineering
E-mail: VEV@tltsu.ru

SKRIPACHEV
ALEXANDER VIKTOROVICH
PhD (Engineering Sciences), Director of Institute of Mechanical Engineering, Togliatti State University
E-mail: VEV@tltsu.ru

SHEPELEVA
ELENA ALEXANDROVNA
PhD (Engineering Sciences), Associate Professor of Standardization, Metrology and Certification Department, Institute of Theoretical and Applied Chemistry, Northern (Arctic) Federal University n.a. M.V. Lomonosov
E-mail: eshepeleva@yandex.ru

SHEPELEV
EVGENIY ALEXANDROVICH
5th-year student, Humanities, Social Sciences and Political Sciences Institute, Northern (Arctic) Federal University n.a. M.V. Lomonosov, the Department of Foreign Affairs and Regional Studies
E-mail: shepelev.alsh7@yandex.ru

MINKOVA
EKATERINA SEMIONOVNA
PhD (Pedagogic Sciences), Associate Professor, Transport Processes and Service Technology Department, Immanuel Kant Baltic Federal University
E-mail: EMinkova@kantiana.ru

GARIFULLINA
INGA VJACHESLAVOVNA
PhD (Pedagogic Sciences), Associate Professor, Transport Processes and Service Technology Department, Immanuel Kant Baltic Federal University
E-mail: stroy-rial@yandex.ru

BYKADOROVA
EKATERINA SERGEEVNA
Senior Lecturer, Foreign Language Department, Siberian Transport University
E-mail: bykadorova_es@mail.ru, snezhana_v75@mail.ru

VESELOVA
SNEZHANA ALEXANDROVNA
Lecturer, Foreign Language Department, Siberian Transport University
E-mail: snezhana_v75@mail.ru

KHOROSHAVIN
LEV BORISOVICH
DSc (Engineering Sciences), Senior Research Scientist, Ural Branch of Engineering Science Academy, Senior Research Scientist of Ural Branch of the Institute of Ministry of Emergency Situations of Russia
E-mail: Tsiganova_32@olympus.ru

BAD'INA
TATIANA ANATOLIEVNA
Senior Lecturer, Geoecology Department, Ural State Mining University
E-mail: Tsiganova_32@olympus.ru

VOROBYEV
ALEXANDER EGOROVICH
DSc (Engineering Sciences), Professor, Head of Oil-Field Geology Department, Mining and Petroleum Engineering, Peoples' Friendship University of Russia, Prize winner of USSR Ministry of Non-ferrous Metallurgy, Skochinskiy prize winner, Honored Worker of Kazakhstan Coal Industry, Honored Miner of Kyrgyzstan
E-mail: fogel_al@mail.ru

CHEKUSHINA
ELENA VLADIMIROVNA
Mathematician of the 1st rank of Oil-field Geology Department, Mining and Petroleum Engineering, Peoples' Friendship University of Russia
E-mail: fogel_al@mail.ru

KAPITONOVA
IRINA LEONIDOVNA
1st-year postgraduate student of Oil-field Geology Department, Mining and Petroleum Engineering, Peoples' Friendship University of Russia
E-mail: tubalarka@mail.ru

SINCHENKO
ANNA VLADIMIROVNA
3d-year postgraduate student of Oil-field Geology Department, Mining and Petroleum Engineering, Peoples' Friendship University of Russia
E-mail: anna_sinchenko@list.ru

AKULENOK
MARINA VIKTOROVNA
PhD (Engineering Sciences), Associate Professor of Systems Quality Environment Department, National Research University Moscow Institute of Electronic Technology, Honorary Worker of Higher Professional Education
E-mail: amv@s2q.ru

OLSHEVSKAYA
ANASTASIA VLADIMIROVNA
Head of Department of Licensing and Accreditation, St. Petersburg National Research University of IT, Mechanics and Optics
olshevskaya@mail.ifmo.ru

STAFEEV
SERGEI KONSTANTINOVICH
DSc (Engineering Sciences), Prof. Dean of Natural Sciences Faculty, St. Petersburg National Research University of IT, Mechanics and Optics
E-mail: stafeevs@yahoo.com

AVANESYAN
ALEXANDRA ROMIKOVNA
Post-graduate Student of Economics Department of National Research Nuclear University «MEPhI», Leading Expert of the Analytical Perspective Research Center of National Research Nuclear University «MEPhI»
E-mail: a_avanesyan@mail.ru

DOLGIKH
GEORGII ALEXEEVICH
PhD (Economic Sciences), Deputy Chief of the Analytical Center of Perspective Researches of Resource Providing Department of National Research Nuclear University «MEPhI»
E-mail: kati79@list.ru

MYAKOTA
EKATERINA ALEXANDROVNA
Senior Lecturer of Economics Department of National Research Nuclear University «MEPhI».
E-mail: kati79@list.ru

SHEYNBAUM
VIKTOR SOLOMONOVICH
PhD (Engineering Sciences), Associate Professor, Rector Advisor , Professor, Department of Mashinery and Equipment of Oil and Gas Industry, Gubkin Russian State University of Oil and Gas
E-mail: shvs@gubkin.ru

SARDANASHVILI
SERGEI ALEXANDROVICH
DSc (Engineering Sciences), Associate Professor, Head of Oil and Gas Pipeline Design and Construction Department, Gubkin Russian State University of Oil and Gas
E-mail: sardan@gubkin.ru

PYATIBRATOV
PEOTR VADIMOVICH
PhD (Engineering Sciences), Director of Innovative Educational Projects and Management Research Institute, Associate Professor of Field Development and Operation, Gubkin Russian State University of Oil and Gas
E-mail: pyatibratov.p@gmail.com

MARTYNOV
VIKTOR GEORGIEVICH
DSc in Economics, Professor, Rector of Gubkin Russian State University of Oil and Gas, Honorary Worker of Higher Professional Education
E-mail: com@ gubkin.ru

PAVLOVSKAYA
IRINA VLADIMIROVNA
PhD (Engineering Sciences), Assistant of Systems Quality Management Department, Saint Petersburg Electrotechnical University "LETI"
E-mail: ivpavlovskaya@etu.ru

BERESTOVA
SVETLANA ALEXANDROVNA
DSc (Physics and Mathematics), Associate Professor, Theoretical Mechanics Department, Institute of Fundamental Studies, Ural Federal University named after the first President of Russia B.N. Yeltsin (UrFU)
E-mail: s.a.berestova@yandex.ru, s.a.berestova@urfu.ru

REBRIN
OLEG IRINARKHOVICH
DSc (Chemical Engineering), Professor, Director of Higher Engineering School, Ural Federal University named after the first President of Russia B.N. Yeltsin (UrFU)
E-mail: oirebrin@gmail.com

SHOLINA
IRINA IVANOVNA
Director of Engineering Development Center of Higher Engineering School, Ural Federal University named after the first President of Russia B.N. Yeltsin (UrFU)
E-mail: iisholina@gmail.com

GUBERTI ELISA
Dr., Ad interim Director, "Engineering Education Research" Interdep. Reasearch Unit, School of Engineering, Università di Firenze, Italy.
E-mail: elisa.guberti@unifi.it

BURGUETE MARIA
Senior Researcher, Rocha Cabral Research Institute, Lisbon, Portugal.
E-mail: mariamartins434@gmail.com

NICOLÁS LORI
Fulbrighters Portugal,
Vice-President
E-mail: nicolas.lori@gmail.com

ENGINEERING
EDUCATION
14'2014

Summary

REALIZATION OF INTERDISCIPLINARY TRAINING IN A VIRTUAL ENVIRONMENT OF PROFESSIONAL ACTIVITIES

V.G. Martynov.
Gubkin Russian State University
of Oil and Gas.

Adherence to standards of international initiatives CDIO provides shift to a paradigm of the activity of learning and interdisciplinarity . The article in relation to the oil and gas industry shows that the reconstruction in the technical university of virtual engineering environment as a system of interconnected computer workstations for team of different specialists which are working in the oil and gas companies and a set of digital models of objects and technological tools more suited to implement this paradigm in practice.

INTERDISCIPLINARY PROJECTS FOR ENGINEERING EDUCATION: FOCUSING THE GAP BETWEEN TEACHING PROFILE AND PROFESSIONAL SKILLS

E. Guberti.
Engineering Education Reserach" Interdep. Reasearch Unit School of Engineering, Università di Firenze, Italy.

The continued globalization of manufacturing and service delivery has led to a concomitant globalization of the engineering profession. Engineers increasingly engage in international projects, including service on multinational teams at different points around the globe, collaborating on a common project through real-time, electronic communication...

NATURAL SCIENCE AND HUMANITIES CONCEPTS IN INTERDISCIPLINARY PROJECTS: BRIDGE THE GAP BETWEEN HUMANISTS AND SCIENTISTS

M. Burguete.
Senior Researcher/Rocha Cabral
Research Institute, Lisbon, Portugal.

All earnest and honest human quests for knowledge are efforts to understand Nature, which includes both human and nonhuman systems, the objects of study in science. Thus, broadly speaking, all these quests are in the science domain. The methods and tools may be different; for example, the literary people use mainly their bodily sensors and their brain as the information processor, while natural scientists may use, in addition, measuring instruments and computers.

INTERDISCIPLINARITY IN ENGINEERING EDUCATION: TRENDS AND CONCEPTS

Lori, Nicolás Francisco.
Fulbrighters Portugal, Vice-President.

Interdisciplinarity in engineering is a topic whose potential is not always matched by actual success. A perspective is presented here on when interdisciplinarity is capable of being helpful to success. Different examples of interdisciplinarity are presented in fields like neuroscience, films, computer games, gene development, and power grids. The role of interdisciplinary complexity in defining both the wealth of a nation and the value of universitary education are also discussed.

INTERDISCIPLINARY PROJECT MANAGEMENT OF STRUCTURE TRANSFORMATIONS IN STAFF TRAINING IN NUCLEAR INDUSTRY

A.R.Avanesyan, G.A.Dolgikh,
Ye.A. Myakota.
National Research Nuclear University «MEPhI».

In the article the topical questions concerning increase in the competence level of experts, carrying out the activity in the sphere of nuclear branch are raised. The role and place of innovations in social development of the nuclear industry, the purpose and the problem of innovative activity are revealed. The priority directions in the sphere of modernization and technological development of Russian are stated, basic stages of staff training are presented. The information and procedural model of the management mechanism is shown by interdisciplinary projects of structural transformations of nuclear branch.

INTERDISCIPLINARY CURRICULUM PROJECTS AT THE CONFLUENCE OF SCIENCE AND ART: PROJECT DEVELOPMENT EXPERIENCE AND FIRST RESULTS

S.K. Stafeev, A.V. Olshevskaya
St. Petersburg National Research University of IT, Mechanics and Optics

The article presents a review of interdisciplinary projects developed and implemented during the last 5 years at the National Research University of IT, Mechanics and Optics (NRU ITMO). The overall concept of such implemented projects fits into the 3D domain scheme "Science-Arts-Techne" as a basis in designing integrated subject

ontology. The establishment of an online exhibition "Museum of Optics" embracing a harmonious blend of artifacts and art objects with a science frame and up-dated information communication technologies (ICT) furthered new possibilities and prospects which are described in the article below. Copyrighted programs and examples of student creative works in such courses as "Optics and Arts: in the retrospect of time" and "Optics and Arts: theatrical projection" are presented.

EXPERIENCE IN IMPLEMENTING INTERDISCIPLINARY PROJECT AT TGU IN TERMS OF «FORMULA- STUDENT» TEAM WORK

V.V. El'tsov, A.V. Skripachev.
Togliatti State University, Institute of mechanical Engineering.

Implementation of an interdisciplinary project at university may only be possible when a student team for a task to be completed is organized and there are appropriate facilities and software. The main condition for sustained student design activity is the presence of regulations which enable to handle a permanent inflow of new participants without replacing the key ones. Besides, the instructional material and modules incorporated into the current education programs guarantee the highest quality graduate training within various subject areas. Such interdisciplinary project is being implemented in terms of "Formula-Student" at Togliatti State University.

INTERDISCIPLINARY DIPLOMA - PROJECT IN "CIVIL ENGINEERING"

A.L. Shepelev, E.A. Shepeleva
Northern (Arctic) Federal University n.a. M.V. Lomonosov, Arkhangelsk, Russia.

Recommendations, defining the scope of graduate qualification papers on organizational-engineering issues within the framework of interdisciplinary diploma-project "Civil Engineering," were designed on the basis of diploma-project assessment of Specialists and Bachelor students in "Civil Engineering." Specifications of time scheduling and their reference data have been determined.

THE INTERDISCIPLINARY PROJECT IN ENGINEERING EDUCATION

E.S.Bykadorova, S.A.Veselova.
Siberian Transport University.

The paper focuses on the interdisciplinary project aimed at developing engineering student's competence in foreign language within the "Bachelor – Master – PhD" education system. Complex approach is proposed to be used as the theoretical and methodological basis of project elaboration. The proposed multimedia learning package has been developed for the students of Siberian Transport University and displayed in Moodle.

TOWARDS THE ISSUE OF INTERDISCIPLINARY PROJECT IMPLEMENTATION IN ENGINEERING EDUCATION

I.G.Kartushina, I.V.Garifullina,
E.S. Minkova.
Immanuel Kant Baltic Federal University.

The paper analyzes the function of interdisciplinary projects in the process of engineering staff training. It reveals the potential of a project method in the framework of the practice oriented approach while training students in a technical university.

IMPLEMENTATION OF INTERDISCIPLINARY PROJECTS WITHIN BACHELOR DEGREE PROGRAM IN "QUALITY MANAGEMENT" (AN EXAMPLE)

M.V. Akulenok.
National Research University Moscow Institute of Electronic Technology Moscow, Russia.

The article describes an example of an implemented interdisciplinary project within the framework of Bachelor Degree program 221400.62. The following aspects were defined: experimental analysis, advantages and specific characteristics of such projects.

IMPLEMENTATION OF CDIO INITIATIVE IN BACHELOR'S PROGRAMS OF MANAGEMENT SPECIALTIES AT ST.-PETERSBURG ELECTROTECHNICAL UNIVERSITY

I.V. Pavlovskaya.
Saint Petersburg Electrotechnical University "LETI".

The article studies the mechanisms to implement the elements of CDIO Initiative in management specialties by the example of Bachelor's program "Quality Management" at Saint Petersburg Electrotechnical University "LETI"

EDUCATION OF ENGINEERS IN RUSSIA

L.B. Khoroshavin,
Ural Branch of Engineering Science Academy
T.A. Bad'ina
Ural State Mining University, Yekaterinburg

The article discusses the need for education and training of specialists in our country in their harmonious unity, beginning from school and enhancing in engineering universities. The basic concept of educating creative individuals with high level of knowledge, intelligence and patriotism for strengthening the unity and progressive development of Russia is presented.

IMPLEMENTATION OF PFUR STRATEGIC DEVELOPMENT PROGRAM IN DEPARTMENT OF OIL-FIELD GEOLOGY AND MINING ENGINEERING

A.E.Vorobyev, Ye.V. Chekushina, I.L.Kapitonova, A.V. Sinchenko, G.A. Baltayeva.

This paper presents the operating results of the department of Petroleum Geology and Mining Engineering (PGMPE) aimed at engineering education development. It also describes the activities held in the framework of Strategic Development Program (SDP).

DESIGNING GENERAL ENGINEERING MODULE FOR BACHELOR'S PRODUCTION AND TECHNOLOGY PROGRAMS

S.A. Berestova.
Ural Federal University named after the first President of Russia B.N. Yeltsin.

The article describes the experience of "General Engineering" module development for the educational program of Higher engineering school of UrFU. Being developed in the context of relevant international projects and initiatives, the module is designed as interdisciplinary, practice-oriented and student-centred. There are examples of the module learning outcomes correlated with the methods of their development and assessment. The main idea of the module design is the development of the process map which includes the module learning outcomes, achievement indicators, methods to define the module learning outcomes and the course content. Special attention is paid to assessment tools, in particular to the interdisciplinary project.

APPLICATION OF LEARNING OUTCOMES APPROACH IN EDUCATION PROGRAM DESIGN

O.I.Rebrin, I.I.Sholina
Ural Federal University n.a. B.N.Yeltsin, first President of Russia.

The paper provides methods of education program design based on learning outcome approach. It describes the application of this approach in different countries and suggests the ways of developing modular structure of education programs, projects and interdisciplinary tasks.

List of Accredited Programs, Russian Federation (as of 01.06.2014)

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
	Altai State Technical University named after I.I. Polzunov				
1.	100400	INT	Electrical Supply	AEER	1997-2002
2.	120100	INT	Mechanical Engineering Technology	AEER	1997-2002
3.	120500	INT	Welding Equipment and Technology	AEER	1997-2002
4.	150900	FCD	Technology, Equipment and Automation of Mechanical Engineering Productions	AEER	2003-2008
	Dagestan State University				
1.	210104	INT	Microelectronics and Solid State Electronics	AEER EUR-ACE®	2013-2018
2.	280201	INT	Environmental Protection and Rational Use of National Resources	AEER EUR-ACE®	2013-2018
	Ivanovo State Power University				
1.	140404	INT	Nuclear Power Plants and Installations	AEER EUR-ACE®	2009-2014
2.	210106	INT	Industrial Electronics	AEER EUR-ACE®	2009-2014
	National Research Irkutsk State Technical University				
1.	130100	INT	Aircraft and Helicopter Construction	AEER	2004-2009
2.	250400	INT	Chemical Engineering of Natural Power Sup-plies and Carbon-base Materials	AEER	2004-2009
	Kazan National Research Technical University named after A.N. Tupolev				
1.	150600	FCD	Science and Technology of New Materials	AEER EUR-ACE®	2011-2016
2.	160100	FCD	Aircraft Construction and Rocket Production	AEER EUR-ACE®	2011-2016
3.	230100	FCD	Computer Science	AEER EUR-ACE®	2011-2016
	Kazan National Research Technological University				
1.	240100	FCD	Chemical Technology and Biotechnology	AEER	2004-2009
2.	240100	SCD	Chemical Engineering for Innovative Entrepreneurship	AEER EUR-ACE®	2013-2018
	Kemerovo Institute of Food Science and Technology				
1.	240700	FCD	Food Biotechnology	AEER EUR-ACE®	2013-2018
	Krasnoyarsk State Technical University				
1.	200700	INT	Radio Engineering	AEER	1997-2002
2.	220100	INT	Computers, Systems and Networks	AEER	1997-2002
3.	210302	INT	Radio Engineering	AEER	2003-2008
	Komsomolsk-on-Amur State Technical University				
1.	140600	FCD	Electrical Engineering, Electromechanics and Electrical Technology	AEER	2005-2010
2.	140601	INT	Electromechanics	AEER	2005-2010
3.	140604	INT	Electrical Drives and Automated Industrial Sets and Engineering Systems	AEER	2005-2010
	Moscow State Technological University "Stankin"				
1.	120100	INT	Mechanical Engineering Technology	AEER	1993-1998
2.	120200	INT	Metal-cutting Machines and Tools	AEER	1993-1998
3.	120400	INT	Machines and Metal Forming Technology	AEER	1993-1998
4.	210200	INT	Automation of Technological Processes and Manufacturing	AEER	1993-1998

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
5.	210300	INT	Robots and Robotic Systems	AEER	1993-1998
6.	220300	INT	Automated Production Systems	AEER	1993-1998
	Moscow State Mining University				
1.	90400	INT	Mine and Underground Construction	AEER	1996-2001
2.	90500	INT	Open-pit Mining	AEER	1996-2001
3.	130408	INT	Mine and Underground Construction	AEER EUR-ACE®	2010-2015
	Moscow State University of Applied Biotechnology				
1.	70200	INT	Low Temperature Physics and Technology	AEER	1996-2001
2.	170600	INT	Food Production Machines and Devices	AEER	1996-2001
3.	210200	INT	Automation of Technological Processes and Manufacturing	AEER	1996-2001
4.	250600	INT	Plastic and Elastoplastic Processing Technology	AEER	1996-2001
5.	270900	INT	Meat and Meat Products Technology	AEER	1996-2001
6.	271100	INT	Milk and Dairy Products Technology	AEER	1996-2001
	Moscow State Technical University of Radio Engineering, Electronics and Automation				
1.	210302	INT	Radio Engineering	AEER	2004 -2009
2.	220402	INT	Robots and Robotic Systems	AEER	2005-2010
3.	200203	INT	Optoelectronic Devices and Systems	AEER	2005-2010
4.	220401	INT	Mechatronics	AEER	2005-2010
5.	210104	INT	Microelectronics and Solid State Electronics	AEER	2005-2010
6.	230105	INT	Computer Technology and Automated Systems Software	AEER	2005-2010
7.	230201	INT	Information Systems and Technologies	AEER	2005-2010
8.	230101	INT	Computers, Systems and Networks	AEER EUR-ACE®	2008-2013
9.	210104	INT	Microelectronics and Solid State Electronics	AEER EUR-ACE®	2010-2015
10.	200200	FCD	Optical Engineering	AEER EUR-ACE®	2010-2015
11.	210300	FCD	Radio Engineering	AEER EUR-ACE®	2010-2015
12.	211000	SCD	Quality Assurance and Certification of Electronic Equipment	AEER EUR-ACE®	2013-2018
13.	210100	SCD	Measurement and Information Technologies and Systems	AEER EUR-ACE®	2013-2018
	Moscow Institute of Electronic Technology (Technical University)				
1.	210100	FCD	Electronics and Microelectronics	AEER	2003-2008
2.	230100	FCD	Computer Science	AEER	2003-2008
	National Research University of Electronic Technology (MIET)				
1.	140600	FCD	Electrical Engineering, Electromechanics and Electrical Technology	AEER	2005-2010
2.	140602	INT	Electrical and Electronic Machines	AEER EUR-ACE®	2007-2012
3.	140604	INT	Electrical Drives and Automated Industrial Sets and Engineering Systems	AEER EUR-ACE®	2007-2012
4.	140609	INT	Electrical Equipment for Aircraft	AEER EUR-ACE®	2007-2012
5.	140611	INT	Insulators, Cables and Capacitors	AEER EUR-ACE®	2007-2012
6.	140403	INT	Technical Physics of Thermonuclear Reactors and Plasma Installations	AEER EUR-ACE®	2010-2015
	«MATI» -Russian State Technological University				
1.	190300	INT	Aircraft instruments, Measuring and Computing complexes	AEER	1996-2001

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
2.	110400	INT	Foundry of Ferrous and Non-ferrous Metals	AEER	1996-2001
3.	110500	INT	Metal Science and Thermal Treatment of Metals	AEER	1996-2001
4.	110700	INT	Welding Metallurgy	AEER	1996-2001
	National Research Tomsk Polytechnic University				
1.	71600	INT	High Voltage Engineering and Physics	AEER	1996-2001
2.	80200	INT	Geology and Prospecting of Mineral Resources	AEER	1996-2001
3.	180100	INT	Electromechanics	AEER	1996-2001
4.	200400	INT	Industrial Electronics	AEER	1996-2001
5.	210400	INT	Applied Mathematics	AEER	1996-2001
6.	250900	INT	Chemical Engineering of Modern Energetic Materials	AEER	1999-2004
7.	250800	INT	Chemical Engineering of Refractory Non-Metal and Silicate Materials	AEER	2000-2005
8.	70500	INT	Nuclear Reactors and Power Plants	AEER	2000-2005
9.	220100	INT	Computer Science	AEER	2000-2005
10.	100500	INT	Thermal Power Plants	AEER	2000-2005
11.	101300	INT	Boiler and Reactor Engineering	AEER	2000-2005
12.	230100	FCD	Computer Science	AEER	2003-2008
13.	140600	FCD	Electrical Engineering, Electromechanics and Electrical Technology	AEER	2003-2008
14.	140601	INT	Electromechanics	AEER	2004-2009
15.	140604	INT	Electrical Drives and Automated Industrial Sets and Engineering Systems	AEER	2004-2009
16.	230101	INT	Computers, Systems and Networks	AEER	2004-2009
17.	20804	INT	Geoecology	AEER	2004-2009
18.	130100	FCD	Geology and Prospecting of Mineral Resources	AEER	2005-2010
19.	200106	INT	Measurement Devices and Technologies	AEER EUR-ACE®	2007-2012
20.	200203	INT	Opto-Electronic Equipment and Systems	AEER EUR-ACE®	2007-2012
21.	240304	INT	Chemical Engineering of Refractory Non-Metal and Silicate Materials	AEER EUR-ACE®	2007-2012
22.	240901	INT	Biotechnology	AEER EUR-ACE®	2008-2011
23.	140200	FCD	Electrical Power Engineering	AEER EUR-ACE®	2008-2013
24.	150917	SCD	High-technology Physics in Mechanical Engineering	AEER EUR-ACE®	2008-2013
25.	230100	FCD	Computer Science	AEER EUR-ACE®	2008-2013
26.	140600	FCD	Electrical Engineering, Electromechanics and Electrical Technology	AEER EUR-ACE®	2008-2013
27.	140200	SCD	High Voltage Engineering and Physics	AEER EUR-ACE®	2010-2015
28.	130100	SCD	Groundwater Resources Formation and Composition	AEER EUR-ACE®	2010-2015
29.	150900	FCD	Technology, Equipment and Automation of Mechanical Engineering Productions	AEER EUR-ACE®	2011-2016
30.	220301	INT	Automation of Technological Processes and Manufacturing (Gas and Oil field)	AEER EUR-ACE®	2011-2016
31.	210100	SCD	Physical Electronics	AEER EUR-ACE®	2011-2016
32.	140200	SCD	Mode Control of Electric Power Systems	AEER EUR-ACE®	2011-2016

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
33.	140400	SCD	Electrical Drives and Electrical Drive Control Systems	AEER EUR-ACE®	2011-2016
34.	200100	SCD	Stabilization and Navigation Systems	AEER EUR-ACE®	2011-2016
35.	130500	FCD	Petroleum Engineering	AEER EUR-ACE®	2011-2016
36.	130500	SCD	Geologic-geophysical Problems of Oil and Gas Field Development	AEER EUR-ACE®	2011-2016
37.	140801	INT	Electronics and Automated Physical Installations	AEER EUR-ACE®	2012-2017
38.	240501	INT	Chemical Technology of Modern Power Engineering Materials	AEER EUR-ACE®	2012-2017
39.	140404	INT	Nuclear Power Plants and Installations	AEER EUR-ACE®	2012-2017
40.	200100	SCD	Devices and Methods of Quality Control and Diagnostics	AEER EUR-ACE®	2012-2017
41.	200100	FCD	Measurement Devices and Technologies	AEER EUR-ACE®	2012-2017
42.	200100	FCD	Instrumentation Engineering	AEER EUR-ACE®	2012-2017
43.	200100	FCD	Devices and Methods of Quality Control and Diagnostics	AEER EUR-ACE®	2012-2017
44.	200100	SCD	Measurement Devices and Technologies of Nondestructive Testing	AEER EUR-ACE®	2012-2017
45.	240100	FCD	Chemical Engineering of Natural Power Sup-plies and Carbon-base Materials	AEER EUR-ACE®	2012-2017
46.	240100	FCD	Chemical Technology of Organic Substances	AEER EUR-ACE®	2012-2017
47.	240100	FCD	Chemical Technology of Inorganic Substances	AEER EUR-ACE®	2012-2017
48.	240100	FCD	Polymer Processing Technology	AEER EUR-ACE®	2012-2017
49.	240100	FCD	Technology of Refractory Non-Metal and Silicate Materials	AEER EUR-ACE®	2012-2017
50.	240100	SCD	Chemical Engineering of Refractory Non-Metal and Silicate Materials	AEER EUR-ACE®	2012-2017
51.	150100	SCD	Science and Technology of Nanomaterials and Coatings	AEER EUR-ACE®	2012-2017
52.	200400	FCD	Opto-Electronic Equipment and Systems	AEER EUR-ACE®	2012-2017
53.	22000	FCD	Geoecology	AEER EUR-ACE®	2012-2017
54.	201000	FCD	Biotechnical and Medical Devices and Systems	AEER EUR-ACE®	2012-2017
55.	140400	FCD	Electrical Drives and Automation	AEER EUR-ACE®	2014-2019
56.	140400	FCD	Protection Relay and Automation of Power Grids	AEER EUR-ACE®	2014-2019
57.	221400	FCD	Quality Management in Manufacturing and Technological Systems	AEER EUR-ACE®	2014-2019
58.	150100	FCD	Nanostructured Materials	AEER EUR-ACE®	2014-2019
59.	150100	FCD	Materials Science and Technologies in Me-chanical Engineering	AEER EUR-ACE®	2014-2019
60.	150100	SCD	Nanostructured Materials Tool Production	AEER EUR-ACE®	2014-2019

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
61.	150100	SCD	Computer Simulation of Material Production, Processing and Treatment	AEER EUR-ACE®	2014-2019
62.	130101	INT	Petroleum Geology	AEER EUR-ACE® WA	2014-2019
	National Research University «Belgorod State University»				
1.	210400	FCD	Telecommunications	AEER EUR-ACE®	2012-2017
2.	210406	INT	Communication Networks and Switching Systems	AEER EUR-ACE®	2012-2017
3.	210602	INT	Nanomaterials	AEER EUR-ACE®	2012-2017
	National University of Science and Technology «MISIS»				
1.	150101	INT	Metallurgy of Ferrous Metals	AEER	2004-2009
2.	150105	INT	Metal Science and Thermal Treatment of Metals	AEER	2004-2009
3.	150601	INT	Science and Technology of New Materials	AEER	2004-2009
4.	150400	FCD	Metallurgy of Ferrous Metals	AEER EUR-ACE®	2011-2016
5.	150400	FCD	Physical Metallurgy of Non-Ferrous, Rare-Earth and Precious Metals	AEER EUR-ACE®	2011-2016
6.	150400	FCD	Functional Materials and Coatings	AEER EUR-ACE®	2011-2016
7.	150400	FCD	Metal Forming	AEER EUR-ACE®	2011-2016
8.	11200	FCD	Physics of Condensed Matter	AEER EUR-ACE®	2012-2017
9.	150100	FCD	Materials Science and Engineering of Functional Materials for Nanoelectronics	AEER EUR-ACE®	2012-2017
10.	150400	FCD	Metallurgy of Non-ferrous, Rare and Precious Metals	AEER EUR-ACE®	2012-2017
11.	151000	FCD	Metallurgical Machines and Equipment	AEER EUR-ACE®	2012-2017
12.	210100	FCD	Semiconductor Devices for Micro- and Nanoelectronics	AEER EUR-ACE®	2012-2017
13.	210100	FCD	Materials and Technologies of Magnetoelectronics	AEER EUR-ACE®	2012-2017
14.	210100	FCD	Micro- and Nanotechnology Processes	AEER EUR-ACE®	2012-2017
15.	220700	FCD	Automated Systems in Manufacturing	AEER EUR-ACE®	2012-2017
16.	230100	FCD	Automated Systems	AEER EUR-ACE®	2012-2017
17.	150400	SCD	Metallurgy of Non-Ferrous and Precious Metals	AEER EUR-ACE®	2014-2019
18.	11200	SCD	Physics of Condensed Matter	AEER EUR-ACE®	2014-2019
19.	11200	SCD	Physics of Nanosystems	AEER EUR-ACE®	2014-2019
20.	210100	SCD	Materials and Technologies of Magnetoelectronics	AEER EUR-ACE®	2014-2019
21.	210100	SCD	Micro- and Nanotechnology Processes	AEER EUR-ACE®	2014-2019
	Novosibirsk State Technical University				
1.	150501	INT	Materials Science in Mechanical Engineering	AEER EUR-ACE®	2012-2017

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
	Ogarev Mordovia State University				
1.	151900	FCD	Mechanical Engineering Technology	AEER EUR-ACE®	2014-2019
2.	210100	FCD	Industrial Electronics	AEER EUR-ACE®	2014-2019
	Peoples' Friendship University of Russia				
1.	270100	SCD	Structural Theory and Engineering	AEER EUR-ACE®	2013-2018
2.	270100	SCD	River and Underground Hydraulic Engineering Works	AEER EUR-ACE®	2013-2018
3.	270100	SCD	Theory and Practice of Organizational, Technical and Economic Decisions in Building and Construction	AEER EUR-ACE®	2013-2018
4.	141100	SCD	Internal Combustion Engines	AEER EUR-ACE®	2013-2018
5.	141100	SCD	Steam- and Gas Turbine Plants and Engines	AEER EUR-ACE®	2013-2018
	Samara State Aerospace University				
1.	160301	INT	Aircraft Engines and Power Plants	AEER EUR-ACE®	2008-2013
2.	160802	INT	Spasecraft and Rocket Boosters	AEER EUR-ACE®	2008-2013
	Saint Petersburg Electrotechnical University "LETI"				
1.	220200	FCD	Automation and Control	AEER	2003-2008
2.	210100	FCD	Electronics and Microelectronics	AEER	2003-2008
3.	230100	FCD	Computer Science	AEER	2003-2008
4.	200300	FCD	Biomedical Engineering	AEER	2003-2008
5.	210400	FCD	Radio Electronic Systems	AEER EUR-ACE®	2014-2019
6.	210400	FCD	Radiotechnical Devices for Signal Transmission, Reception and Processing	AEER EUR-ACE®	2014-2019
7.	210400	FCD	Audiovision Equipment	AEER EUR-ACE®	2014-2019
8.	210100	FCD	Electronic Devices	AEER EUR-ACE®	2014-2019
9.	200100	FCD	Information and Measurement Technique and Technology	AEER EUR-ACE®	2014-2019
10.	200100		Laser Measurement and Navigation Systems	AEER EUR-ACE®	2014-2019
11.	200100		Devices and Methods of Monitoring of Quality and Diagnostics	AEER EUR-ACE®	2014-2019
12.	200100	SCD	Development of Distributed Software Systems	AEER EUR-ACE®	2014-2019
13.	10400	SCD	Mathematical Provisions and Software of Computers	AEER EUR-ACE®	2014-2019
	Siberian State Aerospace University				
1.	220100	FCD	System Analysis and Control	AEER EUR-ACE®	2011-2016
2.	230100	FCD	Computer Science and Computer Facilities	AEER EUR-ACE®	2011-2016
	Siberian Federal University				
1.	210200	SCD	Microwave Equipment and Antennas	AEER EUR-ACE®	2010-2015
2.	230100	SCD	High-Performance Computing Systems	AEER EUR-ACE®	2010-2015

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
	Stary Oskol Technological Institute named after A.A. Ugarov (branch of National University of Science and Technology «MISIS»)				
1.	150400	FCD	Metallurgy of Ferrous Metals	AEER EUR-ACE®	2012-2015
	Taganrog Institute of Technology of Southern Federal University				
1.	210100	FCD	Electronics and Microelectronics	AEER	2003-2008
2.	230100	FCD	Computer Science	AEER	2003-2008
3.	230100	FCD	Computer Science	AEER EUR-ACE®	2010-2015
4.	220200	FCD	Automation and Control	AEER EUR-ACE®	2010-2015
5.	210100	FCD	Electronics and Microelectronics	AEER EUR-ACE®	2012-2017
6.	200100	FCD	Equipment Engineering	AEER EUR-ACE®	2012-2017
	Tambov State Technical University				
1.	210201	INT	Design and Technology of Radioelectronic Devices	AEER	2006-2011
2.	140211	INT	Electrical Supply	AEER	2006-2011
	Togliatty State University				
1.	140211	INT	Electrical Supply	AEER EUR-ACE®	2009-2014
2.	150202	INT	Industrial Welding Technology and Equipment	AEER EUR-ACE®	2009-2014
3.	151002	INT	Mechanical Engineering Technology	AEER EUR-ACE®	2009-2014
	Tomsk State University of Control Systems and Radio Electronics				
1.	210100	FCD	Industrial electronics	AEER EUR-ACE®	2013-2018
2.	222000	FCD	Innovation Management in Electronic Engineering	AEER EUR-ACE®	2013-2018
	Trekhgorny Technological Institute				
1.	230101	INT	Computers, Systems and Networks	AEER	2004-2007
	Tyumen State Oil and Gas University				
1.	130501	INT	Design, Construction and Operation of Gas and Oil Pipelines and Storage Facilities	AEER	2006-2011
2.	130503	INT	Development and Exploitation of Oil and Gas Fields	AEER	2006-2011
3.	130504	INT	Oil and Gas Drilling	AEER	2006-2011
4.	190601	INT	Automobiles and Transportation Facilities	AEER	2007-2012
5.	190603	INT	Transport and technological machinery and equipment service (oil and gas production)	AEER	2007-2012
6.	190701	INT	Transportation organization and transport management (automobile transport)	AEER	2007-2012
7.	130602	INT	Oil and Gas Fields Machinery and Equipment	AEER EUR-ACE®	2008-2013
8.	150202	INT	Industrial Welding Technology and Equipment	AEER EUR-ACE®	2008-2011
9.	190205	INT	Lifting, Transportation Means and Road Machines	AEER EUR-ACE®	2008-2013
10.	240401	INT	Chemical Technology of Organic Substances	AEER EUR-ACE®	2009-2014
11.	240403	INT	Chemical Engineering of Natural Power Supplies and Carbon-base Materials	AEER EUR-ACE®	2009-2014
12.	240801	INT	Machines and Apparatus of Chemical Production	AEER EUR-ACE®	2009-2014

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
13.	280201	INT	Environmental control and rational use of natural resources	AEER EUR-ACE®	2010-2015
14.	280102	INT	Safety of technological processes and productions	AEER EUR-ACE®	2010-2015
15.	120302	INT	Land cadastre	AEER EUR-ACE®	2010-2015
	Tyumen State University of Architecture and Civil Engineering				
1.	270800	SCD	Water Supply and Sanitation	AEER EUR-ACE®	2013-2018
2.	270800	SCD	Industrial and Civil Construction	AEER EUR-ACE®	2013-2018
3.	280700	SCD	Safety of Technological Processes and Production	AEER EUR-ACE®	2013-2018
	Ural State Forest Engineering University				
1.	270205	INT	Automobile Roads and Aerodromes	AEER	2006-2011
	Ural Federal University				
1.	240302	INT	Technology of Electrochemical Productions	AEER EUR-ACE®	2008-2013
	Ufa State Aviation Technical University				
1.	280200	FCD	Environment Protection	AEER	2005-2010
2.	230100	FCD	Computer Science	AEER	2005-2010
3.	150501	INT	Material Science in Mechanical Engineering	AEER	2005-2010
4.	280200	SCD	Environment Protection	AEER EUR-ACE®	2008-2013
	Ufa State Petroleum Technological University				
1.	130504	INT	Oil and Gas Drilling	AEER EUR-ACE®	2007-2012
2.	130603	INT	Oil and Gas Processing Equipment	AEER EUR-ACE®	2007-2012
3.	150400	FCD	Processing Machinery and Equipment	AEER EUR-ACE®	2007-2012
4.	240100	FCD	Chemical Engineering and Biotechnology	AEER EUR-ACE®	2008-2013
5.	240403	INT	Chemical Engineering of Natural Power Supplies and Carbon-base Materials	AEER EUR-ACE®	2008-2013
6.	130602	INT	Oil and Gas Fields Machinery and Equipment	AEER EUR-ACE®	2008-2013
7.	130501	INT	Design, Construction and Operation of Gas and Oil Pipelines and Storage Facilities	AEER EUR-ACE®	2009-2014
8.	551830	SCD	Equipment Design Theory for Oil and Gas Processing, Petrochemical and Chemical Production	AEER EUR-ACE®	2010-2015
9.	551831	SCD	Technological Systems and Equipment Reliability	AEER EUR-ACE®	2010-2015
10.	550809	SCD	Chemical Engineering of Fuel and Gas	AEER EUR-ACE®	2010-2015
11.	270100	FCD	Building Construction	AEER EUR-ACE®	2011-2016
12.	550109	SCD	Building Construction	AEER EUR-ACE®	2011-2016
13.	131000	FCD	Petroleum Engineering	AEER EUR-ACE®	2013-2018
14.	151000	FCD	Production Machines and Equipment	AEER EUR-ACE®	2013-2018
	Vladimir State University named after Alexander and Nikolay Stoletovs				

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
1.	150900	FCD	Technology, Equipment and Automation of Mechanical Engineering Productions	AEER EUR-ACE®	2012-2017
2.	230100	FCD	Computer Science	AEER EUR-ACE®	2012-2017

List of Accredited Programs, Republic of Kazakhstan (as of 01.06.2014)

	D. Serikbayev East Kazakhstan State Technical University (Ust-Kamenogorsk, Republic of Kazakhstan)				
1.	50703	FCD	Information Systems	AEER EUR-ACE®	2011-2016
2.	50713	FCD	Transport, Transport Facilities and Technology	AEER EUR-ACE®	2011-2016
	L.N. Gumilyov Eurasian National University (Astana, Republic of Kazakhstan)				
1.	50702	FCD	Automation and Control	AEER EUR-ACE®	2011-2016
2.	50732	FCD	Standardization, Metrology and Certification	AEER EUR-ACE®	2011-2016
3.	50901	FCD	Organization of Transportation, Traffic and Operation	AEER EUR-ACE®	2011-2016
4.	6N0702	SCD	Automation and Control	AEER EUR-ACE®	2011-2016
5.	6N0732	SCD	Standardization, Metrology and Certification	AEER EUR-ACE®	2011-2016
6.	6N0901	SCD	Organization of Transportation, Traffic and Operation	AEER EUR-ACE®	2011-2016
	Innovative University of Eurasia (Pavlodar, Republic of Kazakhstan)				
1.	50701	FCD	Biotechnology	AEER EUR-ACE®	2010-2015
2.	50718	FCD	Electrical Power Engineering	AEER EUR-ACE®	2010-2015
	Kazakh National Technical University named after K.I. Satpaev (Almaty, Republic of Kazakhstan)				
1.	50704	FCD	Computer Science and Software	AEER EUR-ACE®	2010-2015
2.	50711	FCD	Geodesy and Cartography	AEER EUR-ACE®	2010-2015
3.	50712	FCD	Mechanical Engineering	AEER EUR-ACE®	2010-2015
4.	50718	FCD	Electrical Power Engineering	AEER EUR-ACE®	2010-2015
5.	50723	FCD	Technical Physics	AEER EUR-ACE®	2010-2013
6.	50713	FCD	Transport, Transport Facilities and Technology	AEER EUR-ACE®	2011-2016
7.	50716	FCD	Instrumentation Engineering	AEER EUR-ACE®	2011-2016
8.	50719	FCD	Radio Engineering, Electronics and Telecom-munications	AEER EUR-ACE®	2011-2016
9.	50720	FCD	Chemical Technology of Inorganic Substances	AEER EUR-ACE®	2011-2016
10.	50721	FCD	Chemical Technology of Organic Substances	AEER EUR-ACE®	2011-2016
11.	50722	FCD	Printing	AEER EUR-ACE®	2011-2016
12.	50724	FCD	Processing Machinery and Equipment	AEER EUR-ACE®	2011-2016
13.	50729	FCD	Construction	AEER EUR-ACE®	2011-2016

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
14.	50731	FCD	Life Safety and Environmental Protection	AEER EUR-ACE®	2011-2016
15.	50732	FCD	Standardization, Metrology and Certification	AEER EUR-ACE®	2011-2016
	Karaganda State Technical University (Karaganda, Republic of Kazakhstan)				
1.	50702	FCD	Automation and Control	AEER EUR-ACE®	2010-2015
2.	50707	FCD	Mining Engineering	AEER EUR-ACE®	2010-2015
3.	50709	FCD	Metallurgy	AEER EUR-ACE®	2010-2015
4.	50712	FCD	Mechanical Engineering	AEER EUR-ACE®	2010-2015
5.	50713	FCD	Transport, Transport Facilities and Technology	AEER EUR-ACE®	2010-2015
	Kostanay Engineering and Pedagogical University (Kostanay, Republic of Kazakhstan)				
1.	50713	FCD	Transport, Transport Equipment and Technology	AEER EUR-ACE®	2011-2016
2.	50732	FCD	Standardization, Metrology and Certification	AEER EUR-ACE®	2011-2016
	Semey State University named after Shakarim (Semey, Republic of Kazakhstan)				
1.	50727	FCD	Food Technology	AEER EUR-ACE®	2010-2015
2.	50724	FCD	Processing Machinery and Equipment	AEER EUR-ACE®	2010-2015

List of Accredited Secondary Professional Education Programs (as of 01.06.2014)

	Tomsk Polytechnic College				
1.	131003	T	Oil and Gas Drilling	AEER	2014-2019
	Tomsk Industrial College				
1.	140448	T	Technical Operation and Maintenance of Electrical and Electromechanical Equipment	AEER	2014-2019
	Tomsk College of Information Technologies				
1.	230115	T	Computer Systems Programming	AEER	2014-2019

Dear Colleagues!

Association for Engineering Education of Russia invites all universities to participate in the non-governmental-professional accreditation of engineering education programs. This non-governmental-professional accreditation in engineering and technology is a process to improve the quality of engineering education in accordance to the global standards, and to obtain acknowledgement in the professional engineering community for high-qualified professional engineering training.

Such accreditation of engineering education programs provides the opportunity to obtain an independent evaluation of the quality of the university's education programs and recommendations for their further improvement; to assert one's high-professional engineer training level and, thus, enhancing the competitiveness of engineer-graduates in the domestic and global labor market.

The graduates of such accredited engineering education programs can receive the profession degree EUR ING "European Engineer" in the future.

Association of Engineering Education is the only agency in Russia that has the qualifications to certify EUR-ACE. Accredited programs are included in the AEER accreditation program register, as well as, the European register of accredited engineering programs.

All necessary information can be found on the following website:

Accreditation Center AEER www.ac-race.ru.

Contact details:

Tel. (3822) 41-70-09

Tel\Fax (3822) 42-14-78

e-mail: ac@ac-raee.ru

Address: P.O. BOX 119454 Moscow, Russia

78 Vernadsky Prospect, Building №7

Correspondence address: P.O. BOX 634050 Tomsk, Russia

30 Lenin Prospect, Room 328

ARTICLE SUBMISSION GUIDELINES

General requirements:

Authors are requested to submit the text in electronic form. It is important that the file is completed using Microsoft Word software and saved in the native format of the wordprocessor .doc extension. For the file name, please, use author's family name (for example, Petrov.doc)

Page Setup:

Paper size: A4 Margins: top & bottom – 30 mm; left – 22 mm, right – 28 mm

Text Format:

Number all pages; place the number in the bottom right hand corner of the page. Use 1.3 – line space within the paper.

Font size:

Times New Roman, 14 pt.

Paper Length:

6-10 pages, including all tables, figures and notes.

Article structure:

title, Last name Name of authors, organization, e-mail address, abstract, key words, main text, references, epigraph can be added.

Abstract:

A concise and factual abstract is required (of no more than 40-50 words). The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented in Russian, before the main text and after the title of the article.

Key words:

Immediately after the abstract, provide a maximum of 7 keywords

Illustration guidelines:

It is recommended that you use tiff files for illustrations such as photographs, charts, graphs, drawings (no less than 300 dpi).

References:

The list of Literature Cited should be included after the final section of the main article body. References should be arranged in the same order as they appear in the article. All references listed must be cited in the text. State Standard style must be followed for the references. For citing please indicate the reference number and page numbers in brackets (for example, [3, p. 14-16]).

Author's CV:

A brief author's CV should be presented in a separate file (for example, Petrov_cv.doc):

- Full name of the author
- Academic degree, title, current position, organization
- In case of PhD student: university, department information is required
- List honorary titles in the professional field (for example, Honorary worker of higher professional education of Russian Federation)
- Contact information: full address, telephone, fax, cell phone, e-mail

Editorial board has been forming a part of the journal called "Our authors". We kindly ask all authors to send in a separate file one 3x4 cm size color photograph (no less than 300 dpi, TIF format) for example (Petrov.tif).

Moreover, all articles must be accompanied by a separate file in English (for example, Petrov_eng.doc) including the following information:

- title of the article,
- abstract,
- author's full name,
- organization, position hold,
- e-mail address.

Editorial board,
"Engineering Education" Journal

ENGINEERING EDUCATION

Esponsible for the release:
S.V. Rozhkova
Editorial office address:
7 building, 78, Vernadskogo Prospect,
Moscow, 119454, RUSSIA

Telephone/Fax: +7 (499) 7395928,
E-mail: aeer@list.ru

Full-text e-journal:
www.aeer.ru

© Association for Engineering
Education of Russia, 2013
Design © 2013 dart-com