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INTERDISCIPLINARITY IN ENGINEERING EDUCATION: GLOBAL TRENDS AND MANAGEMENT

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Dear readers!

The present issue of AEER journal is devoted to interdisciplinarity in engineering education.

Interdisciplinarity is a complicated notion which implies not only congregative character of activities performed to solve a particular task, but also the transfer of methods, ideas, and paradigms between different spheres (disciplines). Interdisciplinarity is essential when we use problem-based and practice-oriented approaches to solve scientific and engineering tasks, to overcome social, economic and political challenges. It is interdisciplinarity that makes it possible to obtain unique results, and even more, to set new goals, develop and implement competitive solutions, create and promote competitive products.

Interdisciplinarity as a trend in engineering education has been developing over the past decades. Today, interdisciplinary, as well as fundamentalism, internationalization, social responsibility, and sustainable development, is an urgent issue for most of the developed countries. The case in point here is project-based learning.

As a term, interdisciplinarity is described in numerous reports and overviews but often fails to be implemented in real education system. That was the reason to organize a network international conference devoted to interdisciplinarity in engineering education. The conference was initiated by AEER, Kazan National Research Technological University (rector G.S. D'yakonov; first vice-rector, member of the AEER Administrative Board, prof. V.G. Ivanov), and National Research Tomsk Polytechnic University (rector, vice-president of AEER, prof. P.S. Chubik). This initiative was eagerly supported by Gazprom (general sponsor), the Ministry of Education and Science of the RF, and the universities of Russia and Kazakhstan – Gubkin Russian State University of Oil and Gas (rector, vice-president of AEER, prof. V.G. Martynov), Don State Technical University (rector, member of the AEER Administrative Board, prof. B.Ch. Meskhi), Irkutsk National Research Technical University (rector, director of AEER Irkutsk Branch, prof. A.D. Afanas'ev), Saint-Petersburg State Electrotechnical University «LETI» (rector, member of the AEER Administrative Board, prof. V.M. Kutuzov), D. Serikbayev East Kazakhstan State Technical University (rector, prof. Zh. K. Shaimardanov).

The conference co-organizers were international organizations, which are the most authoritative in engineering education: the International Federation of Engineering Education Societies (IFEES), European Society for Engineering Education (SEFI), International Society for Engineering Education (IGIP).

http://aeer.ru/ru/conf_irkutsk.htm

The scope of the conference included a range of issues concerning implementation of interdisciplinarity in engineering education.

The most essential and successful cases of interdisciplinary principles implementation are as follows:

- interdisciplinary departments and laboratories (for instance, departments of manufacturing and medicine electronics, biophysics, the laboratory of computational linguistics, etc.);
- interdisciplinary courses ("Mathematical Methods in Economics", "Molecular Physiology", "Materials Science for Medicine");
- interdisciplinary research (for instance, automated control systems in social sphere, etc.).

Interdisciplinarity implemented in science, education, and engineering also implies training for work in interdisciplinary teams and on interdisciplinary projects, and these aspects used to be beyond the scope of experts' attention. Which competencies are essential for a university professor to provide the necessary training?

Which requirements should university top managers and heads of departments meet to implement such training?

Another important issue is how to recognize a prospective interdisciplinary project manager. What requirements should the manager meet? Which personal qualities should the manager possess? What are the criteria and tools to identify the professional with relevant competencies? How to ensure the development of such competencies?

Today, it is particularly important for students to participate in real interdisciplinary projects implemented by the prospective employers. How to ensure such participation?

To sum up, there are more questions than answers, and the above-mentioned international conference is supposed to clarify the situation and give necessary recommendations on the perspectives of interdisciplinary implementation in engineering education.

Some of the materials published in this issue were presented at the network international conference "SYNERGY". We hope they will not only help to find the answers, but will also initiate further research in this challenging field.

Editor-in-Chief, AEER President,
Prof. Yury P. Pokholkov

Contents

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Engineering Staff Development in Research University: Synergy of Traditions and Innovations

Kazan National Research Technological University
V.G. Ivanov, S.V. Barabanova, M.F. Galikhanov, L.T. Miftakhutdinova


V.G. Ivanov


S.V. Barabanova


M.F. Galikhanov


L.T. Miftakhutdinova

The paper deals with innovative processes in additional professional education for engineers. These processes are based on the modern state educational policy, new educational technologies, and multidisciplinary approach. The experience of KNRTU in designing continuing professional development programmes in cooperation with business partners is suggested as a positive model.

Key words: staff development, engineering education, state educational program, distance learning technologies.

Additional professional education and continuing professional development programmes for engineers are an effective model of cooperation between the state and private enterprises. Being an educational phenomenon, these programmes are supported by the government within the framework of new national policy in the sphere of engineering. It is a well-known fact that any educational system in Russia should be approved by the government and provided with administrative and/or financial support including that by regional authorities and business, as well as have legal backing in the form of federal laws and regulations [1]. In 2012, continuing professional development for engineers was supported by the President Programme of engineering staff training for 2012-2014 (hereinafter Programme P) [2], which was primarily focused on industrial enterprises staff.

Since 2013, many Russian industrial enterprises have chosen continuing professional development programmes within the framework of Programme P, as they possess a number of advantages. A case in point is cooperation between Kazan National Research Technological University (KNRTU) and the enterprises of Kamsky innovative cluster (KIC), the Republic of Tatarstan, the RF. The cooperation is secured by KIC Support Programme for 2013-2016 (Programme K) and federal budget funds [3].

The system of continuing professional development for engineering staff initiated at KNRTU is described in papers [4–6]. However, due to the programmes of governmental support, this system is being currently developed, which provides new material for research. The present paper deals with the programmes of additional professional education, their impact on educational activities at national higher education institutions (HEI) and their role in cooperation between HEIs and business sector.

Programme P became a key document, which affirmed inevitability, necessity, and efficiency of engineering elite education due to cooperative efforts of the national government, education, and business sectors. Two thirds of the programme costs were funded from the federal budget. 30% of the programme costs (or 50% of budget costs) were funded by the enterprises including the costs for business trips to the place of education. The programme consisted of lectures and practical classes (from 72 hours), final academic assessment, practical training in Russia (up to 50% of trainees) and abroad (up to 30% of trainees).

In 2014, the programme status changed and it got under the supervision of the Ministry of Education and Science of the RF (hereinafter Programme V) [7]. However, the programme structure remains the same –lectures and practical classes (72 hours), practical training at Russian enterprises and scientific centres (20% of students) and abroad (10%). However, the programme implementation is funded by the federal budget and business sector in equal shares.

As for the programme audience, it includes not only engineers, but also technical staff, i.e. mid-ranking personnel (in compliance with the Russian scale). Moreover, students doing Master's degree and post-graduate courses can participate in the programme as well. The academic staff providing the programme can participate in practical trainings.

The research conducted by the authors of the present paper since 2013 indicated positive changes in the system of continuing professional development provided at KNRTU, revealed the consistency of all four programmes (P, V, K, and G, which are to be described below) and identified the positive effect on university educational activities, which is caused by the programme implementation.

The university has participated in Programme P since 2013. Over two years, there have been 7 continuing professional development programmes implemented within the Programme framework. This allowed Programme teachers to improve their own professional qualification, obtain new experience at the leading international science and education centres and industrial enterprises, enhance educational technologies applied.

The programme implementation stipulated the development of new teaching approach since the programme trainees were qualified professionals, who wanted to learn new technologies or get new experience at another industrial enterprise or a leading international science and education centre. The customers were quite picky and estimated the proposed programmes in terms of professional competencies development and qualification acquisition. All the programmes were developed with due regard to the particularities of KNRTU education system to be further used for teaching KNRTU students as well.

In the course of the programme implementation it was found out that the university academic staff should also develop their professional competencies and skills to meet the current requirements of educational, scientific, and manufacturing sectors. Therefore, the university academic staff involved in the programme participated in the practical trainings that were organized for the programme trainees in Russia and abroad. At first, these trainings for academic staff were funded by the university.

New format of the programme caused a number of pedagogical challenges to be overcome. The programme allowed educating both engineers and technical staff (in separate groups). Development of flexible educational technologies made it possible for the programme trainees of different qualification levels to develop the required professional competencies.

The conducted research indicated the necessity for Programmes P and V outcomes assessment and monitoring on a nationwide scale. It stands to reason that the National Training Foundation issued a 60-page document prescribing the reporting procedure [8]. University autonomy should be in accord with the interests of the state, society, and corporate customers.

Having analyzed 18 education programmes elaborated at the university over the period 2013–2016 in compliance with the national policy for improving engineering education, we developed a guideline for designing continuing professional development programs, which can be used for the trainees of different qualification levels, based on the current professional standards, and allow developing the professional competencies in demand. The programme being partly funded by the corporate customers leads to contractual relationships, which will allow the programme implementation even without government financial support. This

positive experience boosted establishment of private-public partnerships in different Subjects of the RF.

As said above, there is Kamsky innovative cluster (KIC) in the Republic of Tatarstan, which includes many regional enterprises and works in industrial sectors of oil and gas refinery, petroleum chemistry, and automotive engineering. Innovation and education clusters play an important part in regional economic development and competitiveness improvement since they link all interested parties. The establishment of such clusters is stipulated by the urgent need in uniting different organizations based on a certain criterion to achieve particular goals. For example, Programme K aims at stimulating long-term demand for innovations at regional enterprises, which will contribute to their positioning on both domestic and global markets. Since the cluster's industrial priorities are petroleum chemistry and oil and gas refinery, KNRTU plays an important role in achieving the cluster's targets as it is one of the leading universities in this sphere on the regional, as well as national, scale. KNRTU is a leading university within the industrial scientific and educational cluster, which integrates elementary, secondary, higher, and additional professional education, on the one hand, and innovations, on the other hand, in the petroleum chemistry sector of the Republic of Tatarstan. For a long time, the university has maintained the attitude that it is for higher education university to be the basis for additional professional education, since such an organization has a great experience in student training and conducting research in the fields of chemistry, oil processing, petroleum chemistry, nanomaterials, etc.

It is a well-known fact that staff training and retraining are key factors to boost the development of the enterprise and industry in general. Project-based learning is an efficient technique to implement innovations. KIC development programme is peculiar since there is an opportunity to provide not only continuing professional development programs, but also the programmes of professional retraining for the enterprises within the cluster.

The foundation of Programme K rests on the educational courses of Programmes P and V: Programme K includes lectures and practical classes (72 hours), practical training at Russian enterprises and scientific centres (no less than 20% of students) and abroad (no less than 10%). The programme implementation is funded from the federal budget (90% within the framework of KIC support) and by the enterprises (10%).

Over the period 2013-2016, KNRTU has provided 7 education programmes for more than 200 professionals of KIC enterprises, with 2 of the programmes provided several times. One of the most in-demand programmes is "Modern polymer nanocomposites", which is not surprising. Firstly, polymer composites production and processing is the field most of KIC enterprises work in. Secondly, the programme "Modern polymer nanocomposites" was recognized as one of the best Russian education programmes in the course of Programme P implementation. Moreover, the programme is provided annually, which allows comparing programme outcomes and monitoring the number of trainees after programme reviews and modifications (for example, if it is necessary to develop innovative competences, which were not specified in education standards).

The practical training within this programme is provided at Federal state unitary enterprise "All-Russian Scientific Research Institute of Aviation Materials (VIAM)", State Research Centre of the RF (Moscow). It is noteworthy that VIAM is the main national centre of polymer materials study and application. As for international practical training, it was science and education centre «COMPOSITEC» (Savoie technolac), France.

All the programmes provided within the cluster were integrated since they were developed in compliance with the algorithm of additional education programme development and implementation, on the basis of national research university, and with due regard to the customer's requirements and real manufacturing demands [9,10]. As mentioned above, some additional education programmes for KIC enterprises staff were amended to be focused on innovation-related activities. We suppose that such programmes imply educational methods and techniques, which allow developing creative and challenge response skills, improving the ability of efficient individual and team work on hand-on projects, searching for adequate decisions under uncertainty and risks, interpreting the activity outcomes, and other component of innovation competency.

Since innovation competency implies well-developed comprehension and speculation skills, on the one hand, and the ability to modify and implement creative ideas, on the other hand, both aspects should be considered when developing innovation competency. It is necessary to stimulate subject's response to new things and events, as well as teach him/her how to operate creative activity outcomes – improve, adapt, implement, and disseminate [11].

To reach this goal, an interactive component of education was improved. Besides traditional forms of educational activities, there were trainings, master classes, "flipped classroom" with class discussions. The educational technologies applied allow grading and customizing the program, making it more flexible and responsive to trainees' need and enterprises' requirements: problem-, project- and module-based learning, cooperative education.

Based on the experience in teaching different enterprises staff, the initial module of most programmes is "Innovation and Teamwork (Training)". The module objective is to focus trainees on further education, create innovative and creative learning environment, stimulate motivation and understanding the necessity to develop innovation competency and implement innovation at the cluster enterprises.

Besides traditional lectures, the programme includes case-studies based on hand-on tasks and focused on identifying potential problems, business game on motivation, micro group work, discussions, etc.

An important tangible outcome of cooperation in developing innovative educational technologies is a bank of e-learning programs. This is attributed to the fact that KNRTU was approved as a corporate university of Gazprom and both organizations step up efforts in collaboration based on annual donation agreements (Programme G).

Over the period December, 2015 – April, 2016, a number of professional development programmes were designed: "Industrial Process Automation", "Corrosion and Pipeline Protection", "Metrology Support for Automation Equipment", "Compression Plant: Equipment Service and Maintenance". All programmes were supplied with e-learning materials arranged at specially designed information and education environment – E-Learning System, http://idpo.kstu.ru.

The content (educational materials and methodological support) was developed by 13 experts from leading universities and subsidiary companies of Gazprom. Some programmes were developed by one expert, while the others included several modules developed by 5-7 experts. As well as other above-mentioned programs, all the programmes developed for Gazprom are interdisciplinary ones.

12 subsidiary companies of Gazprom, from Krasnodar to Sakhalin, expressed their readiness to participate in the project. Those who tested the courses left their comments on the site. However, innovative e-learning technologies were not easy to use for the trainees: out of 83 participants, 13 did not start their work with e-learning resources and 6 failed to complete their studies.

To conclude, we would like to emphasize that the high quality of work performed by KNRTU over the period 2013–2014 was proved by the orders from partner enterprises for Programme V implemented in 2015. Regardless of economic downturn in 2016, the university got many orders for co-funded professional development programmes (Programmes K and G). The reason is not only the policy of import phase-out, but also the fact that the programmes are top ranked by the former trainees. The above-described programmes are unique since they are designed to meet the interests and opportunities of all stakeholders – the programmes are available for trainees of different professional background, based on cutting-edge educational technologies, and imply practical trainings at leading Russian and international education centres.

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Global Interdisciplinary Teams in Engineering Education

Instituto Superior de Engenharia do Porto (ISEP)
J.C. Quadrado
National Research Tomsk Polytechnic University
Association for Engineering Education of Russia
K.K. Tolkacheva

J.C. Quadrado

K.K. Tolkacheva

Multiple disciplines approach, which includes global enhanced interdisciplinarity, has been discussed in the engineering education context from the early 21st Century. There is very little disagreement about its importance for the engineers, the key question has been how to implement theory into practice both in the curriculum and in the actual learning enhancement phase. Both Problem-based learning and CDIO framework are constructivist learning approaches that emphasize these issues. In this paper, we discuss how to mitigate the social distance in these global education teams and therefore how it becomes the primary management challenge for the global interdisciplinary team leader. The management of the social distance is then paramount to identify and successfully improve the social distance. This approach reflects several components, namely, the structure, the process, the language, the identity, and the technology used.
A successful interdisciplinary and multidisciplinary teacher/learning depends on the general team dynamics. Several strategies to enhance interdisciplinary teams in engineering education are presented.

Key words: interdisciplinary teams, engineering education, management, team leader, social distance.

1. Context on global interdisciplinary teams

To succeed in the global economy today, more and more engineering companies are relying on a geographically dispersed workforce. They build teams that offer the best functional expertise from around the world, combined with deep, local knowledge of the most promising markets. They draw on the benefits of international diversity, bringing together people from many cultures with varied work experiences and different perspectives on strategic and organizational challenges. All this helps multinational companies compete in the current business environment [1].

But university managers who actually lead engineering faculties are usually not so focused in building global teams for engineering education unlike the existing focus to building global research teams [2]. Creating successful work groups is hard enough when everyone is local and people share the same office space. But when team members come from different countries and functional backgrounds and are working in different locations, communication can rapidly deteriorate, misunderstanding can ensue, and cooperation can degenerate into distrust. This is even more evident in the academic environment where the interdisciplinary team work is already very challenging.

One basic difference between global interdisciplinary teams that work and those that don't lies in the level of social distance – the degree of emotional connection among team members. When people on a team all work in the same place the level of social distance is usually low. Even if they come from different fields or backgrounds, people can interact formally and informally, align, and build trust [3]. They arrive at a common understanding of what certain behaviors mean, and they feel close and congenial, which fosters good teamwork. Coworkers who are geographically separated, however, can't easily connect and align, so they experience high levels of social distance and struggle to develop effective interactions. Mitigating social distance therefore becomes the primary management challenge for the global interdisciplinary team leader. The management of this social distance is then paramount to identify and successfully change the social distance. This approach should reflect several components, namely, the structure, the process, the language, the identity, and the technology – each of which can be a source of social distance (Fig.1.). In this paper we will describe some of the global enhanced teams' possible dysfunctions and describe how smart leaders can fix problems that occur – or prevent them from happening in the first place.

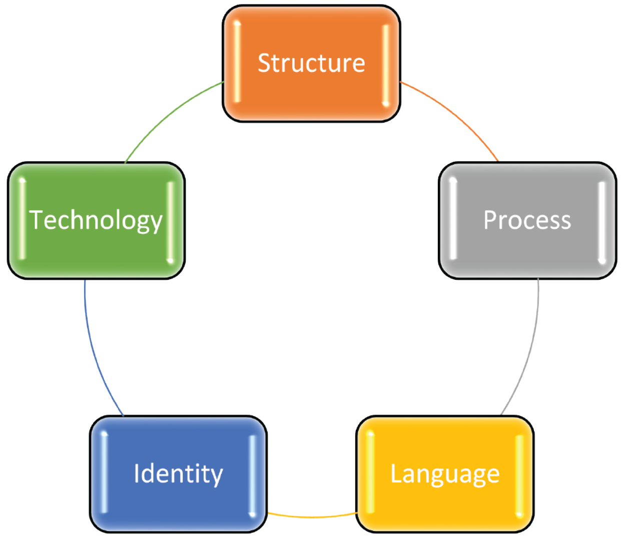
2. Structure and the Perception of Power

In the context of global interdisciplinary teams in engineering education, the structural factors determining social distance are the location and number of sites where team members are based and the number of educators who work at each site.

The fundamental issue here is the perception of power. If most team members are located in United States (US), for instance, with two or three in Russia and in Portugal, there may be a sense that the US members have more power. This imbalance sets up a negative dynamic. People in the larger (majority) group may feel resentment toward the minority group, believing that the latter will try to get away with contributing less than its fair share. Meanwhile, those in the minority group may believe that the majority is usurping what little power and voice they have.

To correct perceived power imbalances between different groups, a leader of a global enhanced interdisciplinary team needs to get three key messages across:

Fig. 1. Management of the social distance



who we are; what we do; and that I'm there for you (Fig. 2).

It is important that the answer to the who we are question is, that the the team is a single entity, even though individual members may be very different from one another. The leader should encourage sensitivity to differences but look for ways to bridge them and build unity. To bring people back together a leader for a global interdisciplinary team should create opportunities for employees to talk about their cultures, and instituted a zero-tolerance policy for displays of cultural insensitivity.

About the question of what we do, it is important to remind team members that they share a common purpose and to direct their energy toward team unit or the academic goals. The leader should periodically highlight how everyone's work fits into the course's overall strategy and advances its knowledge. For instance, during a weekly coordination conference call, a global team leader might review the group's performance relative to the academic objectives. The leader might also discuss the level of collective focus and sharpness the team needs in order to keep innovating.

About the question on if I'm there for you, team members located far from the leader require frequent contact with him or her. A brief phone call or e-mail can make all the difference in conveying that their contributions matter. The team appreciated his attention and became more cohesive as a result.

3. Process and the Importance of Empathy

It almost goes without saying that empathy helps reduce social distance. If colleagues can talk informally around a nice tea – whether about work or about personal matters – they are more likely to develop an empathy that helps them interact productively in more-formal contexts. Because geographically dispersed team members lack regular face time, they are less likely to have a sense of mutual understanding. To foster this, global team leaders need to make sure they build the following "deliberate moments" into the process for meeting virtually: feedback on routine interactions; unstructured time; and time to disagree.

3.1. Feedback on routine interactions

Face-to-face visits are one, but not the only, way to acquire learning about the impacts of set work routines. Remote team members can also use the phone, e-mail, or even videoconferencing to check in with one another and ask how the collaboration is going. The point is that leaders and members of global enhanced interdisciplinary teams must actively elicit

Fig. 2. Key messages

this kind of "reflected knowledge," or awareness of how others see them.

3.2. Unstructured time

Think back to your last face-to-face meeting. During the first few minutes before the official discussion began, what was the atmosphere like? Were people comparing notes on the weather, their kids, that new restaurant in a town? Unstructured communication like this is positive, even when people are spread all over the world, small talk is still a powerful way to promote trust. Especially during the first meetings, take the lead in initiating informal discussions about work and non-work matters that allow team members to get to know their distant counterparts.

3.3. Time to disagree

Leaders should encourage disagreement both about the team's tasks and about the process by which the tasks get done. The challenge, of course, is to take the heat out of the debate. Framing meetings as brainstorming opportunities lowers the risk that people will feel pressed to choose between sides. Instead, they will see an invitation to evaluate agenda items and contribute their ideas. As the leader, model the act of questioning to get to the heart of things. Solicit each team member's views on each topic you discuss, starting with those who have the least status or experience with the group so that they don't feel intimidated by others' comments. This may initially seem like a waste of time, but if you seek opinions up front, you may make better decisions and get buy-in from more people.

4. Language and the Fluency Gap

Good communication among coworkers drives effective knowledge sharing, decision making, coordination, and, ultimately, performance. But in global teams, varying levels of fluency with the chosen common language are inevitable – and likely to heighten social distance. The team members who can communicate best in the organization's lingua franca (usually English) often exert the most influence, while those who are less fluent often become inhibited and withdraw [4]. Mitigating these effects typically involves insisting that all team members respect three rules for communicating in meetings: dial down dominance; dial up engagement; and balance participation to ensure inclusion.

4.1. Dial down dominance

Strong speakers must agree to slow down their speaking pace and use fewer idioms, slang terms, local technical terms, and esoteric cultural references when addressing the group. They should limit the number of comments they make within a set time frame, depending on the pace of the meeting and the subject matter. They should actively seek confirmation that they've been understood, and they should practice active listening by rephrasing others' statements for clarification or emphasis.

4.2. Dial up engagement

Less fluent speakers should monitor the frequency of their responses in meetings to ensure that they are contributing. Don't let them use their own language and have a teammate translate, because that can alienate others. As with fluent speakers, team members who are less proficient in the language must always confirm that they have been understood. Similarly, when listening, they should be empowered to say they have not understood something. It can be tough for nonnative speakers to make this leap, yet doing so keeps them from being marginalized.

4.3. Balance participation to ensure inclusion

Getting commitments to good speaking behavior is the easy part; making the behavior happen will require active management. Global team leaders must keep track of who is and isn't contributing and deliberately solicit participation from less fluent speakers. Sometimes it may also be necessary to get dominant-language speakers to dial down to ensure that the proposals and perspectives of less fluent speakers are heard.

The leader could try as a tactic for his own team to create the "Rules of Engagement for Team Meetings".

5. Identity and the Mismatch of Perceptions

Globally enhanced interdisciplinary teams work, most smoothly, when members "get" where their colleagues are coming from. However, deciphering someone's identity and finding ways to relate is far from simple. People define themselves in terms of a multitude of variables – age, gender, nationality, ethnicity, religion, occupation, political ties, and so forth. And although behavior can be revealing, particular behaviors may signify different things depending on the individual's identity. Misunderstandings are a major source of social distance and distrust, and global team leaders have to raise everyone's awareness of them. This involves mutual learning and teaching [5].

When adapting to a new cultural environment, a savvy leader will avoid making assumptions about what behaviors mean. Take a step back, watch, and listen. For example, in America, someone who says, "Yes, I can do this" likely means she is willing and able to do what you asked. In India, however, the same statement may simply signal that she wants to try – not that she's confident of success. Before drawing conclusions, therefore, ask a lot of questions. In the example just described, you might probe to see if the team member anticipates any challenges or needs additional resources. Asking for this information may yield greater insight into how the person truly feels about accomplishing the task.

In this model, everyone is a teacher and a learner, which enables people to step out of their traditional roles. Team members take on more responsibility for the development of the team as a whole. Leaders learn to see themselves as unfinished and are thus more likely to adjust their style to reflect the team's needs. They instruct but they also facilitate, helping team members to parse their observations and understand one another's true identities.

6. Technology and the Connection Challenge

The modes of communication used by global interdisciplinary teams must be carefully considered, because the technologies can both reduce and increase social distance. Videoconferencing, for instance, allows rich communication in which both context and emotion can be perceived. E-mail offers greater ease and efficiency but lacks contextual cues. In making decisions about which technology to use, a leader must ask the following: Should communication be instant?

Teleconferencing and videoconferencing enable real-time (instant) conversations. E-mail and certain social media formats require users to wait for the other party to respond. Choosing between instant and delayed forms of communication can be especially challenging for global interdisciplinary teams.

Instant technologies are valuable when leaders need to persuade others to adopt their viewpoint. But if they simply want to share information, then delayed methods such as e-mail are simpler, more efficient, and less disruptive to people's lives. Leaders must also consider the team's interpersonal dynamics. If the team has a history of conflict, technology choices that limit the opportunities for real-time emotional exchanges may yield the best results.

7. Conclusions

Flexibility and appreciation for diversity are at the heart of managing a global interdisciplinary team. Leaders must expect problems and patterns to change or repeat themselves as teams shift, disband, and regroup. But there is at least one constant: To manage social distance effectively and maximize the talents and engagement of team members, leaders must stay attentive to all five dimensions presented. Decisions about structure create opportunities for good process, which can mitigate difficulties caused by language differences and identity issues. If leaders act on these fronts, while marshaling technology to improve communication among geographically dispersed colleagues, social distance is sure to shrink, not expand. When that happens, engineering education teams can become truly representative of the "global village" – not just because of their international makeup, but also because their members feel mutual trust and a sense of kinship. They can then embrace and practice the kind of innovative, respectful, and groundbreaking interactions that drive the best ideas forward, generating the new generation of global engineers.

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UDC 378

Engineers for interdisciplinary teams and projects: management of training process

National Research Tomsk Polytechnic University
Association for Engineering Education of Russia
Yu.P. Pokholkov

Yu.P. Pokholkov

The paper deals with the management issues of training specialists in the field of engineering and technology ready to work in interdisciplinary teams and projects. Interdisciplinarity in the engineering education is considered as a basis for critically new competitive engineering solutions. The indicators proving the presence of interdisciplinary management system at university are outlined. Based on the elaborated principles of interdisciplinary activities a set of required tools and elements to manage interdisciplinary training of engineers is presented.

Key words: interdisciplinarity, engineering education, indicators, principles and elements of interdisciplinary activities, management system, interdisciplinary teams and projects.

Competitiveness and economic security of any country is provided by natural, human, energy, material and non-material resources. There is a pattern indicating the relationship between economic competitiveness and volume of GDP per person [1]. The latter is associated with the level of wellbeing of the population (Fig.1).

These figures to a large extent depend on the quality of human capital, with such important characteristics as education of the population and its willingness to change in accordance with changing conditions of external and internal environment. Global challenges of the modern world - climate change, globalization, demographic situation, competition for resources, technological revolution, etc. – become powerful drivers for development of new trends in the social, economic, technical and political spheres. One of such trends in science, technology and education is interdisciplinarity, that can be determined as a "principle of organization of scientific knowledge, which opens wide possibilities of interaction of many disciplines in solving complex problems of nature and society" [2].

Definition of interdisciplinarity (multidisciplinarity, crossdisciplinarity, etc.) includes a transdisciplinary perspective as "a way to expand the scientific outlook considering any phenomenon outside the framework of any single scientific discipline" [3].

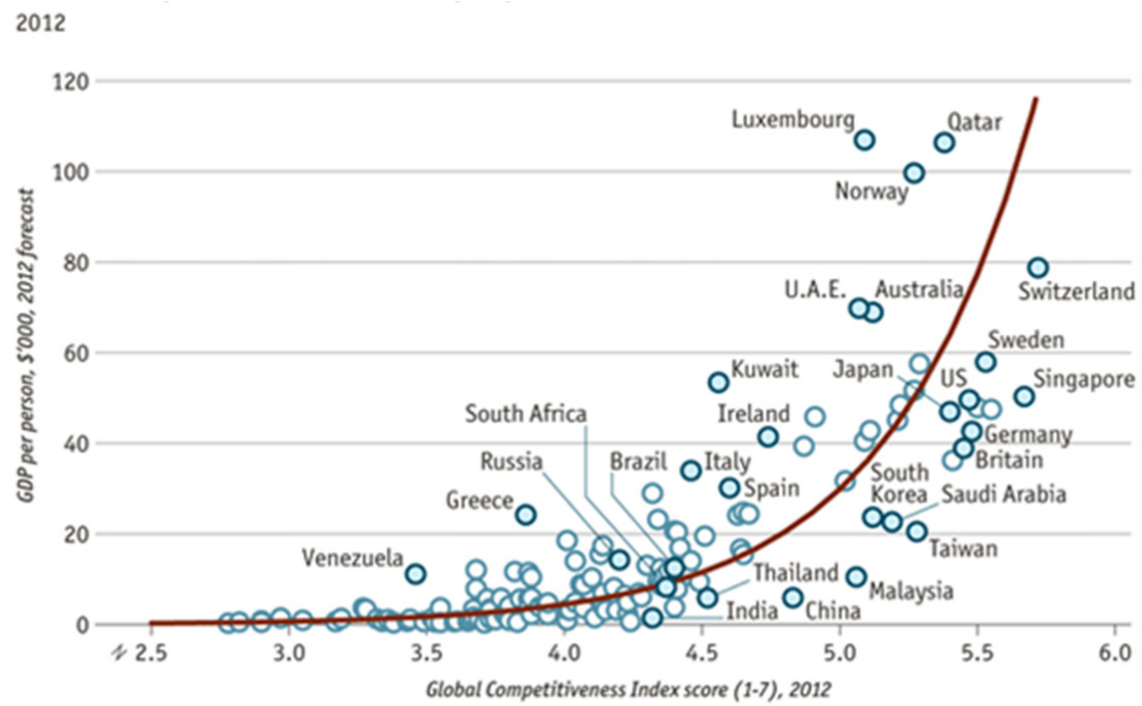
The idea of synthesis and integration of knowledge, that lies in the foundation of this principle probably have more than one millennium already [4].

A detailed analysis of the common terminology in this area can be found in studies completed by Akof L.R., Ausburg T., Bushkovskaya E.A., Jacobs H.H., Borland J.H. and others as well as in the proceedings of international conferences held in recent decades, including those held under UNESCO auspices [5,6,7,8,9,10,11].

Nicolás Lori, vice-president of the Association of Fulbright scholarship programme for Portugal (Fulbrighters Portugal), in his presentation made at the international conference "Management of interdisciplinary projects in engineering education: planning and execution" in Portugal, 2014, emphasized that "interdisciplinarity should not be:

- a group of people each an expert on everything;
- putting people from different expertise in the same place;

Fig. 1. Global competitiveness and GDP per person



Sources: World Economic Forum; IMF; *The Economist*

- creating the tools for everything that is needed in all fields,

but what interdisciplinarity should be is:

- establishment of communications that enable idea-filtering;
- idea-filtering creating information that is useful;
- allowing that useful information become institutional knowledge, which is the true wealth of any institution" [12].

From time to time the history of science, engineering and technology shows, as a consequence of interdisciplinarity, evident successes and breakthroughs that appear at the confluence of different disciplines, areas of activity or sciences. True evidence of this are the newly emerging successful scientific fields such as biophysics, bionics, medical electronics, geo-ecology, and many others.

In science, engineering and technology interdisciplinarity can ensure not only a competitive position of a team, country's economy in the international division of labor, but also helps to win the global competition in the relevant markets of the world, therefore, interdisciplinarity really becomes a source of wealth.

At the same time, we must distinguish between interdisciplinarity in its formal representation, when the result of the joint work of specialists in several research fields will be the sum of the result of their work, but also when, due to the synergistic effect, the result may be more significant. In other words, a result that can be obtained in this case can never be obtained as a result of the activity of one of the participants in an interdisciplinary team. Most often, this effect is achieved by means of mutual intersection and application of

methods, tools, approaches used by the representatives of different disciplines (science, trades), due to transdisciplinarity. Creating conditions for achieving synergistic effect is rather challenging but compulsory task in the organization of interdisciplinary activities. In this case we may expect to achieve fundamentally new scientific results, engineering and industrial products to ensure victory in the competition on the world markets. Precisely such understanding of interdisciplinarity has to be used as the basis to stimulate the work carried out by interdisciplinary teams and consortiums. A formal approach of regional and federal funds to encourage interdisciplinary work, when interdisciplinarity is considered as participation in the consortium of different scientific fields (branches, areas of activity) representatives, leads to the fact that applicants create as a formality interdisciplinary partnership in order to win and get the funding. In fact, this leads to unnecessary shift of funding towards such formal consortiums and underfunding of really promising projects, including monodisciplinary projects [13].

The results of interdisciplinary projects are determined by the level of staff involved in their implementation. Authors of interdisciplinary innovative ideas and hypotheses, managers and performers, all of them should have the required qualifications and competencies, that start to be developed at higher education institutions (HEI) and largely depends on the state of scientific and educational environment. Innovative approaches to engineering education include not only the tools and methods to improve the content of education and learning techniques but also the creation of specific environments at HEI, ensuring the formation of mindset, in particular in sustainable development and interdisciplinarity [14].

The current state of engineering education, according to the engineering education community, is not quite good (putting it mildly).

Thus, according to the website www.monster.co.uk

- "... 45% of US employers say that the lack of skills is the main reason for entry-level positions".

- "Only 42% of the world employers believe that graduates are adequately prepared to work".

- "Studies have shown that employers are ready to pay 22% higher wages for those who will have the necessary skills".

"... We do not have the jobs crisis, we have the skills crisis" [15].

The results of expert studies of the state of engineering education in Russia, carried out in 2010-2015 years by the members of the All-Russian nongovernment organization Association of Engineering Education of Russia (AEER) convincingly confirm this [16, 17]. Expert professional community considers as the main disadvantage of Russian engineering education the mismatch of engineers training at HEIs with the requirements of employers, which, in principle, is correlated with the data given in [15].

A more rigid evaluation of engineering education in Russia was given by Alexander Kuleshov, the SkolTech rector, Academician of Russian Academy of Science, within his lecture at governor's readings in Tyumen.

"... Modern engineer knows about the metal properties less than the blacksmith who forged the armor in the Middle Ages".

"... apparently Russian companies were not ready to progress. The problem is not only that we do not have tools or software. In some companies they have both. But there are no specialists who could translate into an electronic, understandable to modern machines form, existing in paper drawings and developments" [17].

Academician Kuleshov suggests "to eliminate the failure in engineering education, focusing on the intellectual good Russian genetics and foreign engineering staff".

The notion that "... foreigners will help us" is not new, and was declared in the last century in the famous work by Ilf and Petrov. Its implementation will certainly increase our chances to reduce the distance to the leaders, but we should not forget that leaders keep working and do not stand still.

However, it is clear that in the position of catching up the chances of winning the competition, are not high enough. We need solutions that will allow engineering education "overtaking without catching up".

One way out of this situation is the development of interdisciplinary research in engineering universities, the implementation of interdisciplinary engineering projects and training of professionals who will be able to work in these projects. The results of such projects and studies should lead to entirely new engineering solutions. And here, indeed, our undoubted competitive advantage will be "good Russian intellectual genetics", which was mentioned by the rector of SkolTech.

The process of preparation specialists to work in interdisciplinary projects and teams could and should be managed.

In recent decades a lot of research was dedicated to the problems of interdisciplinarity in education. In [19, 20, 21] and many others works the theory and practice of interdisciplinarity is discussed in detail, however, there is a little number works addressing the issue of the training specialists who are able to work effectively in interdisciplinary teams and lead them.

Management of any process means clearly stated goals, objectives, requires defining the role of the participants and creating conditions that promote the process and ensure its implementation.

Management of training professionals able to work successfully in interdisciplinary teams and participate in solving multidisciplinary issues requires understanding and formulating the basic principles of interdisciplinarity in engineering education, methods and management techniques, suitable for the task.

Talking about engineering education and leaving aside organization of interdisciplinary engineering projects implementing, we will focus on the features of the training specialists in the field of engineering and technology to work in interdisciplinary teams and projects. In order to understand whether the university environment permits to develop and manage interdisciplinarity it is needed to outline a number of direct and indirect features indicating the presence of such conditions in university.

With a certain degree of completeness, the list of features includes the following:

1. Interdisciplinary department (laboratory).

2. Participation in national and international interdisciplinary projects.

3. Group project based learning.

4. Following CDIO principles.

5. Educational programmes that provide training specialists of the future.

6. The system allows to receive two degrees in parallel.

7. Availability of infrastructure:

- The system of selection and training of the participants of interdisciplinary projects.
- Programmes for scientific and teaching staff professional qualification development in interdisciplinary fields.
- The system of selection and training leaders (managers) of interdisciplinary projects.
- Analysis of the domestic and global markets of interdisciplinary projects in science, technology and education.

Analysis of the presence in Russian universities of direct and indirect features indicating that there is a targeted management of training professionals to work in interdisciplinary teams and projects, shows:

1. Not often, but one can find currently running interdisciplinary departments, even in the leading universities of Russia (an average of no more than 5% of the total number of departments that may be enough for the organization of interdisciplinary research and training).

2. For the same group of Russian universities (not more than 60) it is quite common the participation of individuals and groups in carrying out interdisciplinary projects in framework of national and international programs. However, not much attention is paid to the main advantages of interdisciplinarity – synergy. The projects are implemented by representatives of different disciplines, but in majority of cases each of them completes task isolated within his/her specialty, not using or sharing information, methodology of other potential participants in the project.

3. Group project based learning (PBL) is becoming increasingly common in the HEI environment, as a basis for the development of practical-oriented and problem-oriented education. Group PBL is one of the most effective methods to develop competitive skills required by future professionals to work in interdisciplinary projects [22].

4. CDIO initiative have joined more than 100 universities around the world (30 countries) [23]. In Russia, 7 universities became pat of CDIO initiative, and the first to join was National Research Tomsk Polytechnic University.

The main focus in the organization of this work is to create favorable conditions for the formation of the graduates with critical and system (comprehensive) thinking, the development of competencies that enable them to adapt in educed time period to the real professional activity at enterprises. At the same time, the principles of CDIO Initiative is a good basis for the implementation of interdisciplinary projects and the opportunity to accumulate practical experience of focused teamwork.

5. Training specialists for the future still remains at the preparatory stage of discussion possible majors both in Russian and foreign engineering universities.

In particular there are some publications showing that main part of majors (educational areas) of training for the future are interdisciplinary [24].

For example like:

- system architects;
- evaluators of consequences;
- managers of corporate consumption;
- bio-waste optimizers;
- environmental minimizers;
- developers of secondary opportunities;
- specialists in organs 3D-printing;
- experts in 'Internet of Things' technologies;
- dismounting engineers;
- geo-engineers – specialists in weather control;
- forecasters earthquakes;
- engineers of heavy air;
- radical innovators (experts in the revitalizing, increasing memory capacity, architects of global systems, ejectors of gravity, robotic earthworms, etc.)

It is expected that highly demanded professionals will be those who acquire new skills, such as:

- the ability to make changes – "transiters";
- the ability to overcome a negative reaction to the new technology – "boomerangs";
- the ability to extend the life of "dying" technology – "ultimate runners";
- the ability to find the critical point of inflection in the system, to determine best time place and information required for introducing the changes – "inflectionists";
- our ability to tune elements of the system so as to obtain the best possible result "optimizers";

and others [24].

And:

"... - Cooperation (as a critical skill that should be integrated into the various aspects of the work and training).

- Thinking: critical, problem-oriented, system, cooperative and creative.

- Creative skills.

- Work in interdisciplinary environments + knowledge of the emerging universal "language of the concepts" (including systems engineering and economics)..." [25].

The development of educational areas of training of elite specialists for yet non-existent sectors of the economy, undoubtedly is an urgent task, requiring interdisciplinary and competent choice of strategy and management tactics.

6. Higher education degree in more than one field, to a certain extent, becomes the key competitive point for the specialist to be enrolled in interdisciplinary teams and projects.

The work to create conditions that allow students to get two degrees in the reduced period of training time, virtually is non-existent in the majority of Russian universities. However, the process is carried out spontaneously, at the request of students, who realized that availability to get different degrees allows to work in more than one profession field, is at least a solid competitive advantage.

The research of the demand for two Master degrees among undergraduate students of senior courses of the National Research Tomsk Polytechnic University conducted in 2016 showed that 79% would like to graduate from two programmes and get Master degrees in energy engineering and management. More than 90% of the students see themselves as future leaders of companies and enterprises.

7. Considering the elements and characteristics of the university infrastructure, which would provide the ability to manage training of specialists capable to work in interdisciplinary teams and projects, one should admit the lack of such infrastructure.

Basic principles of interdisciplinary activities

To develop a system in universities, providing training of specialists able to work in interdisciplinary teams and projects, requires the formulation of the basic principles of interdisciplinary activities, the definition of requirements to the participants of the interdisciplinary teams, formulation of a list of specific competences for these professionals, as well as the choice of methods, tools and relevant learning and teaching tools.

The basic principles of interdisciplinary activities may include:

1. The principle of "flight of ideas".
2. The principle of filtering ideas.
3. The system approach principle.
4. The principle of social responsibility.
5. The principle of synergy.
6. The principle of advanced development.

Each of these principles should be realized in holistic way following the determined sequence of actions that allow to develop an algorithm to manage educational process and training of specialists able to work successfully in interdisciplinary projects.

1. The principle of "flight of ideas" is realized through the development of the university environment (system of centers to generate new ideas, "ideadromes") for creativity and innovation, and the creation of conditions for selection and development of creative personalities.

2. The principle of "filtering of ideas" is implemented by the sequential actions with different focus groups, allowing to select the most effective and realizable idea for further processing and implementation.

3. The principle of "system" (holistic) approach is implemented taking into account the interests of all stakeholders, interaction between the individual elements of the project and their impact on the final result (outcome) of the project.

4. The principle of "social responsibility" involves the compulsory social assessment of the results of interdisciplinary project, including assessment of social impact of the project results, obtained in specific areas (disciplines).

5. The principle of "synergy" involves planning intended outcomes, which are impossible to achieve without the interaction of participants in the various spheres of activity (it is impossible to get such results thanks to the efforts of only one of participants of an interdisciplinary project).

6. The principle of "advanced development" is implemented due to planning and achieving of unique outcomes of interdisciplinary project, which does not have analogues in the world, and allowing to provide a new competitive place in the international division of labour.

The following list consists of naturally required, but probably not full enough elements to manage educational process and training of specialists able to work successfully in interdisciplinary projects and includes:

1. Methods and criteria for the selection of the Chief Engineers of Interdisciplinary Projects (generators of ideas, visionaries, inventors, who tend to have unconventional thinking, inspirers, charismatics, innovators, managers, systems analytics).
2. "Ideadromes" – conditions to ensure "flight of ideas", generation and selection of ideas, searching and choosing of participants.
3. Integrated educational programmes (training specialists for the future).
4. Effective learning and teaching tools.
5. System for selection of mentors (advisors) of interdisciplinary projects.
6. Training and competence development programmes for mentors.

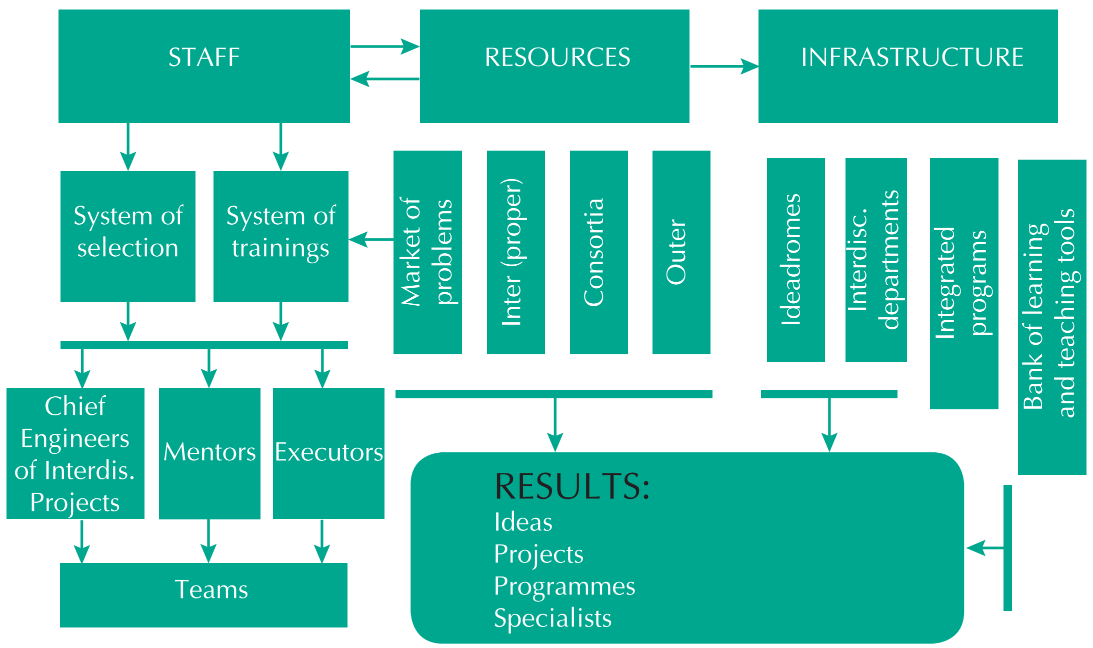
Analysis of the state of the problem, conditions, principles and organization issues to carry out interdisciplinary projects allows you to find approaches to the development of preliminary management system to train specialists able to work successfully in interdisciplinary projects.

A preliminary version of this system can be represented by the scheme given in Fig. 2.

Conclusion

Organization of implementation of effective interdisciplinary projects in science, engineering, technology or education requires not only the involvement of specialists from various fields of activity, but also planning a synergistic effect, as a kind of guarantee of obtaining fundamentally new solutions and results that, under certain circumstances,

Fig. 2. System approach to manage interdisciplinary activities at HEI



can ensure a victory in competition in the relevant markets. Training of leaders and specialists for such projects who are able to work effectively in interdisciplinary teams and projects - specific and not familiar task for modern engineering universities. Those learning and teaching tools that are used today, contents of educational programs, available infrastructure can hardly ensure the preparation of interdisciplinary projects leaders, professionals able to think free out of the box, to generate innovative interdisciplinary ideas and projects, efficiently organize interdisciplinary working teams. All activities of university teams in this area should be based on holistic understanding of the challenges they face, the ability to change in the right way the form and contents of engineering education, to create the necessary infrastructure, and crucially, the ability to change themselves. Training professionals able to work successfully in interdisciplinary teams and projects can and should be managed. In fact, this article is an attempt to draw attention and invitation for discussion on the indicated issues, which could result in very specific solutions that will prepare the advanced force of Russian engineers able to bring engineering in Russia at the forefront in the world.

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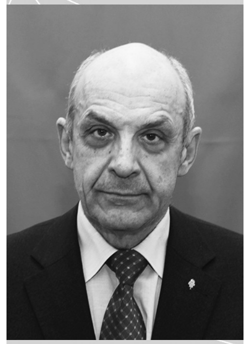
ENGINEERING EDUCATION 20'2016

V.M. Kutuzov

V.N. Pavlov



D.V. Puzankov

S.O. Shaposhnikov

Interdisciplinary Approach in Engineering Education in Terms of International Frameworks and Methodology

Saint Petersburg Electrotechnical University "LETI"
V.M. Kutuzov, V.N. Pavlov, D.V. Puzankov, S.O. Shaposhnikov

The article analyzes the standards and guidelines of international educational frameworks and initiatives in terms of interdisciplinarity of degree programmes in Engineering and Technology.

Key words: engineering education, interdisciplinary approach, implementation of degree programmes.

Introduction

The analysis of a great number of Russian and foreign studies concerning the attributes and competencies a graduate engineer should acquire has revealed importance of interdisciplinary approach among the key factors that ensure competitiveness of engineering graduates in labor market.

Traditionally, engineering education rests on Natural Sciences and Mathematics. Technologies usually evolve from simple structures to complex systems. This seems to be the case in development of information and communication technologies that play a significant role in our everyday life. However, there are certain limitations in engineering evolution from a purely technical point of view [1]. When designing new engineering products, it is of absolute importance to consider consumers' needs and interests. It is the needs analysis that allows creating more relevant and effective products, devices, and processes.

Interdisciplinary approach in engineering education

Interdisciplinary approach has been always considered a part of engineering activity. For example, microelectronics can hardly evolve without chemistry, physics, and other engineering disciplines. Such natural consumers' needs and expectations as simplicity, safety, cost-efficiency, usability, etc. force designers to search for new ideas within various disciplines.

Professional knowledge is always highly concentrated. With the increasing amount of knowledge, this fact seems to be rather natural. It means that the problems related to highly-specialized knowledge would be solved by standing out them from a wider context, even by separating them from general context. It is obvious that such an approach would never lead to comprehensive solutions which rest on the interdisciplinary approach.

Interdisciplinary approach in engineering education can be termed as a combination or interrelation of various sciences that are embodied in engineering training process. In reality, interdisciplinary approach is very often confused with multidisciplinarity when educators give students knowledge from various disciplines without making the link between them into a coordinated whole. Thus, interdisciplinary approach can be regarded as a natural training context in which boundaries between knowledge systems tend to be erased and new teaching paradigm is required.

In the 1970s the term interdisciplinarity or interdisciplinary approach was widely applied, however, the issue itself was not frequently addressed in the relevant research literature. The first work that provided definition of interdisciplinary approach was the article by Richard Meeth who defined "interdisciplinary" as "an attempt to integrate the contributions of several disciplines to a problem, issue, or theme from life" [2]. At about the same time, another American scholar Earl McGrath wrote: "the chief purpose of interdisciplinary work is to integrate relevant knowledge around a significant issue" [3, p. 7]. However, he also noted that "the largest percentage of interdisciplinary courses developed by the colleges involved no real merging of subject matter except in the catalog".

The first serious methodological work to reflect discussions of interdisciplinary approach in higher education was "Handbook on the Undergraduate Curriculum" by Arthur Levine [4] where an entire chapter was devoted to interdisciplinary studies. Arthur Levine defined interdisciplinary approach as "a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession" [4].

Gradually, educators started the process of moving discussions from definitions to practice. Among the next publications, the works by Allen F. Repko are the most notable. He discussed interdisciplinarity not only within educational context, but also within scientific one [5, 6].

It is worth noting that representatives of Russian High School also paid significant attention to interdisciplinary issues [7, 8 etc.]. However, like foriegn scholars, they concentrated on theoretical aspects rather than on methodological and practice-related issues.

Modern engineers are professionals whose activity directly influences the technological infrastructure of a society. The description of a modern engineer is given in National Guidelines for Engineering Education written and approved by Norwegian National Council for Technological Education [9]: "As an engineer you are able to use both your analytical and creative skills to solve socially valuable technological problems. You will have to work innovatively, structurally, and diligently. You have to analyze, generate solutions, assess, determine, execute, and report – be a good entrepreneur. In addition to natural science and technological subjects, your linguistic skills are important, both written and oral, both in Norwegian and in foreign languages. Interacting systems are essential to the modern society, and you must thus be skilled at working independently as well as in teams with engineers from your discipline and from others, professionals from other fields, and in interdisciplinary teams. As an engineer, you will work with people, you will have ethical and environmental responsibilities and you will have a significant impact on society".

European Qualification Framework

Recommendations on European Qualification Framework (EQF) [10] were approved by the European Parliament and the Council of Europe to provide information and facilitate comparison between different qualification systems of European countries. Thus, it aims to develop *lifelong learning* and facilitate mobility of workforce. The EQF provides a description of all types of qualifications (school compulsory education, higher education, and post-graduate study); three highest levels or cycles of the framework correspond to the Bachelor's degree, the Master's degree, and the Doctoral degree (or its equivalent).

The levels of EQF rest on the learning outcomes (knowledge, skills, competence) rather than the programme features (programme duration, type of educational institution, etc.).

Levels 6, 7 and 8 (higher education) offer the following learning outcomes:

- compliance with the labor market demands;
- training of active citizenship able to play an active role in democratic life;
- personal development;

- commitment to the development of new ideas and involvement in the most advanced frontier of a field of work or study.

Let us consider the above-mentioned learning outcomes in terms of interdisciplinary approach.

Compliance with the labor market demands is the most pressing issue of modern education. Many entrepreneurs complain that the current education systems of most European countries are not providing them with graduates possessing the required skills and competencies. Actually, it was one of the driving forces of the Bologna process. Besides, it also served as an impetus to development and implementation of practice-oriented approach in engineering education – CDIO [11, 12]. It is obvious that in the labor market success of engineering graduates does not only depend on their specific knowledge or skills, but also on the ability to predict the demands for certain new products and processes, work with regard to social and environmental requirements and regulations, demonstrate team building and communication skills. Thus, interdisciplinary skills and knowledge play a significant role in future success of a graduate.

Training of active citizenship able to play an active role in democratic life. Democracy is directly dependent on active involvement of educated citizens. Thus, education plays a key role in developing democratic culture. Active and responsible participation of citizens in social life and democratic development of the society requires people to have good knowledge in various fields and demonstrate the ability to think critically. This goal of higher education was mentioned in the Bologna Declaration and clarified in the Prague and Berlin communiqués.

Personal Development is one of the most obvious goals of any education, including higher education.

Commitment to the development of new ideas and involvement in the most advanced frontier of a field of work or study. To have access to the advanced knowledge within a wide range of disciplines is of great importance to any society. New challenges can only be addressed by the specialists who have obtained broad training in various fields of knowledge and are able to solve complex and interdisciplinary problems.

The learning outcomes of EQF cycle 1 (Bachelor's degree) do not include any interdisciplinary engineering skills and competences. For example, Bachelor's degree is awarded to a student who:

- «demonstrates advanced knowledge of *a field of work or study*, involving a critical understanding of theories and principles;
- is capable of collecting comprehensive, specialized, factual and theoretical knowledge *(usually within a field of work or study)* to make assumptions with respect to social, scientific, and ethical problems;
- is able to present information, ideas, problems and their solutions both to a specialist and ordinary audience;
- manages complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups» [10].

It is worth noting that interdisciplinarity is still implied in the above-mentioned learning outcomes, precisely, ability to work with regard to social and ethical problems directly indicates interdisciplinary skills and competence.

In contrast, the learning outcomes of EQF cycle 2 (Master's degree) include a wide range of engineering interdisciplinary skills and competences. Master' degree is awarded to a student who:

- "demonstrates highly specialized/or advanced knowledge (in comparison with the first cycle), some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research;
- possesses specialized problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and integrate *knowledge from different fields (interdisciplinary context)*;
- is capable of integrating knowledge, makes assumptions based on insufficient amount of information and with regard to the relevant *social and ethical requirements*;
- is able to present information, ideas, problems and their solutions both to a specialist and ordinary audience;
- demonstrates substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research" [10].

Thus, it can be stated that EQF cycle 2 (Master's degree) definitely indicates the importance of inter-disciplinary skills, knowledge, and competence.

ENQA Standards and Guidance

Standards and Guidelines for Quality Assurance in the European Higher Education Area [13] do not explicitly mention the necessity of interdisciplinary approach in Bachelor's degree and Master's degree training. However, the guideline to standard "Design and Approval of Programmes" indicates the following: "The education quality is assured due to the facts that programmes:

- are designed with overall programme objectives that are in line with the institutional strategy and have explicit intended learning outcomes;
- are subject to a formal institutional approval process;
- benefit from external expertise and reference points;
- are designed by involving students and other stakeholders in the work [13]".

Thus, those interdisciplinary learning outcomes (competences and skills) that are mentioned in EQF should be in line with the employers' needs and subject to continuous supervision and control.

To guarantee that the programmes are delivered in a way that students gain interdisciplinary knowledge and skills, universities should assure themselves of the competence of their teaching staff. Therefore, standard "Teaching Staff" prescribes: «Higher education institutions have primary responsibility for the quality of their staff and for providing them with a supportive environment that allows them to carry out their work effectively» [13]. The guidelines to this standard specify: «The teacher's role is essential in creating high quality student experience and enabling the acquisition of knowledge, competences and skills. Therefore, it is of great importance to recruit teachers who possess relevant knowledge and skills and are able to ensure qualitative training and give feedback on students' learning achievements" [13]. Hence, one of the most complicated tasks is to assure qualitative training of the teachers themselves who will be able to introduce not multidisciplinary, but interdisciplinary approach into education process.

CDIO Standards

CDIO Standards [11, 12] directly or indirectly cover the issue of interdisciplinarity in engineering education. As is known, CDIO Initiative is a unique approach to engineering education designated not only to provide students with deep theoretical and practical knowledge within the field of study, but also make them able to design and operate new products, processes, and systems in line with market demands and needs of society [12]. Being an educational framework, CDIO Standards are intended to facilitate developing such engineering programmes that would provide students both with knowledge required to design new products, processes, and systems, and communicational skills. It is obvious that such a goal can only be achieved by implementing interdisciplinary approach.

Thus, Standard 1. "The Context for engineering education" indicates: "A CDIO programme is based on the principle that product, process, and system lifecycle development and deployment are the appropriate context for engineering education" [12]. It is obvious that a model of the entire product, process, and system lifecycle requires interdisciplinary knowledge, i.e. from various study areas (engineering, ecology, economics, etc.).

Standard 2. "Learning Outcomes" outlines that "in addition to learning outcomes for technical disciplinary knowledge (Section 1), the CDIO Syllabus specifies learning outcomes as personal and interpersonal skills, and product, process, and system building" [12]. It is worth noting that personal learning outcomes focus on cognitive and emotional development of a student (engineering thinking and problem solving, experimentation and new knowledge acquisition, system thinking, creative thinking, critical thinking, and professional ethics), while interpersonal learning outcomes imply individual and group interactions in engineering activity (teamwork, leadership, professional communication, and knowledge of foreign languages).

It is essential that CDIO Initiative states that "an integrated curriculum includes learning experiences that lead to the acquisition of personal and interpersonal skills, and product, process, and system building skills, interwoven with the learning of disciplinary knowledge and its application in professional engineering. Disciplinary courses are mutually supporting when they make explicit connections among related and supporting content and learning outcomes. An explicit plan identifies ways in which the integration of skills and multidisciplinary connections are to be made, for example, by mapping the specified learning outcomes to courses and co-curricular activities that make up the curriculum" [12].

Standard 7 "Integrated Learning Experiences" details that "Integrated learning experiences are pedagogical approaches that foster the learning of disciplinary knowledge simultaneously with personal and interpersonal skills, and product, process, and system building skills". The Standard provides the example of implementing such an approach in engineering education: "Students might consider the analysis of a product, the design of the product, and the social responsibility of the designer of the product, all in one exercise" [12].

Another practical suggestion how to implement interdisciplinary approach is given in Standard 8: "Active learning in lecture-based courses can include such methods as partner and small-group discussions, demonstrations, debates, concept questions, and feedback from students about what they are learning. Active learning is considered experiential when students take on roles that simulate professional engineering practice, for example, design-implement projects, simulations, and case studies" [12].

Criteria of EUR-ACE engineering programme accreditation system

The criteria of EUR-ACE system developed by EUR-ACE system designed by the European Network for the Accreditation of Engineering Education ENAEE [14] is another framework that provides a set of requirements for the engineering programmes in terms of interdiscipinarity. Based on EUR-ACE criteria, accrediting agencies (members of ENAEE) have developed their own criteria for assessing quality of Bachelor's, Specialist's, and Master's degree engineering programmes in line with national higher professional education systems [15].

The introduction to the criteria for accreditation of Professional Bachelor's engineering programmes states: "Engineering problems should be solved on the basis of research literature review, analysis of normative documents, data bases, experiment results and involvement in real design of systems and technological processes, as well as with due regard to economical, ecological, and social limitations. Professional Bachelor degree graduate should demonstrate knowledge in Management *fundamentals* required for engineering activity; ability to work individually and as a team member; understanding of applicable materials and reports; ability to apply norms of engineering practice in their field of study" [15]. Criterion 2 (2.3) "Programme Content" details the requirements for Professional Bachelor's degree engineering programme: "The curriculum should contain disciplines and interdisciplinary modules that would provide graduates with professional and universal competences including personal and interpersonal skills and expertise in applying engineering systems and processes" [15]. Criterion 5 (5.1) "Preparation for Professional Activity" also specifies: "Practical engineering skills should be developed upon the completion of interdisciplinary modules and internships, defense of course and final graduation papers" [15]. Therefore, it is possible to make a conclusion that intersiciplinary approach in Professional Bachelor's degree training is basically aimed at integrating professional and special skills and competences.

Relating to the Academic Bachelor's degree programmes, interdisciplinary approach should not only contribute to integrating professional and special skills, but also deepen professional knowledge itself. Academic Bachelor's degree graduates should be ready for "complex engineering activity including complex problem solving related to investigations, analysis and design of processes and systems based on the fundamental knowledge of mathematics, natural sciences, and other disciplines within the field of study, as well as specialized knowledge and *interdisciplinary* competence" [15]. "Academic Bachelor's degree graduates should demonstrate ability to function as an individual and as a member of a team, possess leadership skills. He/she should be able to manage *interdisciplinary projects,* demonstrate knowledge and understanding of management, communicate clearly to specialist and non-specialist audiences" [15].

The interdisciplinary approach is more widely applied in Master's degree programmes. A graduate of Master's degree programme in Engineering and Technology should be able "to manage interdisciplinary projects, demonstrate knowledge and understanding of management, communicate clearly to specialist and non-specialist audiences" [15]. Engineering activity has significant influence on environment and society, and it always has strong social and environmental impacts. Therefore, Master's Degree graduate "should have an ability to manage complex technical or professional activities or projects with regard to legal and cultural issues, HSE requirements, taking responsibility for decision making" [15]. It is not a coincidence that criteria 2 (2.3) "Programme Content" specifies: "Curriculum should contain disciplines and interdisciplinary modules that would provide graduates with professional and universal competences including personal and interpersonal skills and expertise in applying engineering systems and processes" [15]. Then, Criterion 5 (5.1) "Preparation for Professional Activity" details: "Practical engineering skills should be developed upon the completion of interdisciplinary modules and internships, defense of course and final graduation papers" [15].

Conclusion

Based on the conducted research, it can be stated that interdisciplinary approach has taken many forms in various educational documents and frameworks. However, in reality interdisciplinarity is often confused with multidisciplinarity which could contribute to developing various graduates' skills and competences, but could hardly integrate knowledge and insights from many disciplines into a coordinated and coherent whole. Recently, universities have developed a great number of various education programmes which attractiveness in labor market and quality of education itself increase due to introducing into curriculum such disciplines as English for Specific Purposes, Management, Ecology, etc.

The analysis of various educational initiatives has revealed that implementation of interdisciplinary approach in engineering programmes necessitates the development of such an educational framework that would provide educators with the relevant methods, tools, and models for design of interdisciplinary engineering curricula regarding specific learning outcomes and ensure support for faculty members to improve their own competence in the interdisciplinary issues.

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I.N. Konyukhov

Possible Alternative of Interdisciplinary Learning in Russian Engineering Training System

Municipal state funded institution of additional education "Parus", Ufa city
I.N. Konyukhov

At present the Russian system of supplementary education for schoolchildren does not imply interdisciplinary learning. One of the alternatives of such learning is to develop supplementary education programmes for school age children that would involve diverse scientific and activity areas. Another challenge is to train instructors who would be able to implement such programs.

Key words: system of engineering staff training, additional education for schoolchildren.

While participating in the meeting of the President's Council in science and education on the 23rd June, 2014, the President of the RF, Mr. Vladimir Putin, paid special attention to the necessity for the professional education system to meet modern-day challenges, social and economic demands, and to facilitate the increase in competitiveness, technological upgrade, and labor productivity. Mr. Putin also noted that according to the survey conducted in 2013 among employers, the quality of graduates' training was graded 3.7 score on a five-point scale, and approximately 40% of employees, recent graduates, need additional professional training. In this regard, it is necessary to identify what jobs and specialties will be demanded by the regional production industries in 5-10, or even 20 years. It is a difficult challenge with the modern technologies progressing so rapidly. However, we should make an accurate prediction, paying special attention to the areas and activities that will determine or already determine the new technological stage [1].

To identify the tasks faced by the Russian education system, the Agency for Strategic Initiatives and Moscow School of Management SKOLKOVO conducted a survey to determine reality and prospects of staff training system for high-tech industries, which resulted in the Atlas of new jobs [2]. It includes 11 "trans-professional" skills, defined by employers as the most important ones for employees of the future. Two of them are as follows:

1. Interdisciplinary communication skills (to be aware of technology, processes and market in related and non-related industries).
2. Systems thinking (to identify and work with complex systems including systems engineering).

Taking into account all mentioned above, one of the tasks for the education system is to organize effective training within the framework of supplementary education of schoolchildren aimed at fostering multifaceted and comprehensive education that would ensure development of the "trans-professional" skills. However, the traditional way of individual training paths, which is used nowadays, have several disadvantages in terms of resolving the task:

1. There can be a problem of academic overload, since there is an increase in academic hours due to supplementary courses a pupil (student) should attend in addition to the basic secondary education.
2. A complex approach to creative problem-solving can hardly be achieved through traditional training carried out by instructors who make a specialty in a very specific area and, thus, viewing a problem in terms of this area.

Moreover, there is no training system for instructors of supplementary education in Russia to supply schoolchildren with multifaceted learning process.

To avoid the disadvantages mentioned above, it is necessary to use a scientifically-based background that is resulted from the research conducted under the supervision of Alexey Yu. Savin, an academician of European Academy of Natural Sciences (EANS), the head of the EANS department studying intellectual human resources, Doctor of technical science, and Doctor of philosophy. The research involves developing and testing programmes aimed at fostering intellectual human resources [3].

One of such programmes developed by Alexey Yu. Savin is called "Genius Russia" [4]. It is focused on multifaceted and comprehensive training to develop the abilities and skills that are required from engineers in high-tech industries.

The modern-day Russian education system does not imply a systemic training of teachers and instructors to ensure multifaceted education in multiple areas. It refers both to secondary and professional education systems of different levels. The whole education system is subject-based and specialty-based.

Thus, there is an urgent need for reconstruction of the Russian education system to meet the needs of the age, which can be achieved by introducing a training course of a new specialty: an instructor of multifaceted education programs. Such professionals should be trained for all education levels: from the secondary school to higher education institutions, PhD's and Doctor's degree programs.

To put into practice the programme "Genius Russia", Konyukhov I.N. developed and implements a programme of supplementary education "Samozvety Rossii" (Russian hard stones) in the framework of EANS research [5]. The programme is carried out in a municipal state funded institution of additional education "Parus", Ufa city. It aims at training schoolchildren aged 7-15 (three age groups) and developing their skills that may be required for further professional activity in high-tech and engineering industries. This programme of supplementary education involves three-year training, and is approved by the Institute of Education Development in the republic of Bashkortostan. The programme introduces the following modular-based activities: overcoming obstacles on a hiking route, decorative and applied arts, technical creativity, literary creative work, journalism, theater, (public performance, and project defenses), use of computer programmes (drawing programs, presentations, video editors, etc.), taking photo and video, mnemonics, activities to harmonize mental processes. All these activities are aimed at forwarding 9 out of 11 trans-professional prospective skills noted in the Atlas of new jobs.

The practical implementation of the programme can be as follows: children attend supplementary classes of one instructor who would offer them diverse activities integrated in one course. For example, hiking and regional study can be combined with drawing, literature, theatre, technical creativity, computer science and chess. The idea might look absurd. However, if we take a closer look, it is quite reasonable.

Thus, the idea of environmental protection becomes obvious every time we go out of town, on a hiking tour near city. The problem of rubbish dumps in forests and river banks cannot be solved only by writing slogans like "No litter". It can hardly teach children environmental awareness. A more efficient alternative is to show and teach them some ways of recycling. For example, plastic bottles can be used for different purposes. When making a plastic flower, a child will not only follow environmental behavior pattern, but also understand how to apply used things and materials in a different, non-standard way. Besides, it will also develop competencies in decorative and applied arts, and give practical life skills. Thus, there is a consistent link between several types of activities: hiking, environmental behavior, and decorative and applied arts.

While hiking or travelling out of city, children can observe a lot of unique natural phenomena, wonderful landscapes and views, which makes it quite reasonable to take a camera and take pictures and videos. On coming back, children make posters, edit the pictures and videos, and present them on some events or festivals accompanying them with a report or story. These activities need integrating a variety of skills both technical and creative. They foster development of literary, journalistic, presentation and computer skills that will be necessary for their future. This approach can also be applied in the activities related to theatre art. Children should be involved in every stage of the performance design and implementation: from a scenario and costume design to final performance.

The programme was tested during 2 years both in the city and in villages. The positive effect is proved by high performance of the children in various competitions of different levels (city, nationwide, and international).

Currently, such educational process is planned to be studied in the framework of an education system testing site founded by the Minor Academy of Science " Mental power of the future" and Education Academy of Russia. The research will start in 2016-2017 academic year in municipal state funded institution of additional education "Parus", Ufa city, with Savin A.Yu. consulting the study.

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The Engagement of Educational Process Into the Practical Activities as a Main Route for Development of Modern Engineering Education

Omsk State Technical University
V.V. Shalay, A.V. Kosykh, A.V. Myshlyavtsev, L.O. Shtripling


V.V. Shalay


A.V. Kosykh


A.V. Myshlyavtsev


L.O. Shtripling

The best practices and perspectives of practice-oriented education development are disclosed in the article.

Key words: educational standards, practice-oriented education, new model for organization of educational process.

The cornerstone in the assessment of learning outcomes, including their assessment in higher engineering education, is the issue of the quality of education.

Older generations, who received education in Soviet times, are overall satisfied with its quality and typically showcase it as a good example when speaking with the new generation. It most likely has some reasonable basis behind it. The system of higher education that existed at those times did not have such words as "competence-based approach", the descriptors "to know", "to be able to", "to possess", however the level of education of the majority of graduates was sufficient for the purpose of performing the required functions after a certain adaptation period. Moreover, their level of preparedness allowed them to step up the career ladder or change the sphere of activities more or less seamlessly.

How was it assured? There was an adequate approach to the development of typical curriculum, which joined the humanitarian (soft skills) component, the excessive fundamental basis and, in most cases, the insufficient professional training. The latter one could be considered insufficient due to the fact that, for instance, a mechanical engineering graduate usually was supposed to get the practical knowledge of all: the mechanical engineer, the technologist, the design engineer and the production manager. This insufficient professional training was smoothed by the 3-year "young engineer" status, which gave graduates an opportunity of receiving practical skills at their workplace; and the excess of fundamental education gave them solid basis for future professional growth.

Back then, there were no standards, but a set of disciplines, their content and volume for each major was formed by leading universities that had close ties with field-specific enterprises through developing typical curriculums. This system assured the required level of education for all specialists in the country. The government used to prepare specialists for its own industrial enterprises. The quality criterion was the assessment of graduate's capabilities at his/her workplace.

The drawbacks of such system could be underlined as follows: students did not always understand why they learned one or another course; typically, professors praised their own courses thinking that they are the core basis of specialists' education. However it all fell into right place – the knowledge received by learning the identified set of disciplines assured the evolvement of a graduate (specialist) and lied in the root of his/her further professional development.

Later on, the standards have been introduced and constantly changed: RF 1994, State Educational Standard (SES)-1, SES-2, Federal State Educational Standard (FSES) of Higher Professional Education, FSES of Higher Education. The appearance of the FSES-4 has been declared.

From the traditional 5-year education the majority of programmes transferred to the 4-year education; the concept of «young specialist» has dissolved. The economic factors pushed universities towards shortening lecture time, while not always increasing the intensiveness of the students' self-study.

At the same time, faculty pushed for saving the efficient set of disciplines and each department tried to save its workload at the expense of other departments, taking into account the fact that the overall workload has been cut.

Moreover, aiming to win the severe competitive war for enrollees many universities have taken the route of increasing the number of new majors, enlarging the educational profiles, which, in its turn, led to the appearance of artificially created courses with no required material, staff and methodological support, to the enlargement of study groups and to the increase of faculty workload. Overall, these factors have negatively affected the quality of education.

From the mid 90th and almost up to the 2010 all this was not important, since only few graduates actually ended up working at factories and the governmental control of the quality of education (except the thesis defense) was narrowed down to the control of residual knowledge on a number of courses, such as mathematics, economics, material science and other, the control of library fund compliance with the requirements, and – typically the most difficult one – the control of compliance with the licensed (not even officially ratified) indicator of the square meters per student.

The new times came. The engineers knowing brand new technologies and equipment became eagerly sought. However in the context of new economic conditions by far not all the enterprises are able to afford employing graduates and patiently waiting for them to become real "engineers". The graduates with sufficient practical background are in need, those, who can respond to the production issues without a long adaptation period.

The complicating factor is the reduction of the study period.

The only solution is to develop and deepen the direct links with the industrial enterprises by engaging the educational process into the production activity, attracting extra material, intellectual and other resources into the sphere of education, developing demonstrational platforms for modern technologies and equipment.

Omsk State Technical University (OmSTU) has taken this route.

On the first stage we focused on the creation of resource (innovational) centers [1, p. 145-146]. Their development has been financed by the Strategic Development Programme won by the OmSTU. By concentrating resources on obtaining new equipment for different specialties, the new quality of education has been assured. Based at the resource centers, the new production lines have been launched; students have been involved in the work processes; and research and development projects have been carried out. All of the resource centers are providing retraining and professional development programmes for production enterprises' employees. Overall, there are 18 resource centers at OmSTU.

However it had been noted in a short time that resource centers cannot provide mass education and are more suitable for training of custom-made specialists.

Since 2013, initiated by the Order of the Ministry of the Education and Science of the Russian Federation No. 958 of August 14, 2013, "On the endorsement of the procedure for the professional education organizations and the educational organizations of higher education to create departments and other structural divisions ensuring practical training of students based on the premises of external organizations that undertake activities in the field of corresponding educational program" OmSTU has created 16 industry-based departments on the premises of the largest enterprises of Omsk [1, p. 145-146].

Getting acquainted with the real production during the educational process, conducting course works and final theses on the industry-required themes under the supervision of specialists from the industry allowed to increase significantly the practical component of students' training and ease their adaptation to the work process after getting employed. Based on the requirements from the industry-based departments the curriculum has been modernized and the distributed internships, where students spend one day out of the study week working at the production units, have been introduced.

The university submits proposals and wins funding for joint projects together with the enterprises that allocate industry-based departments. One of such projects is the development of a system for professional training of specialists for military-industrial complex (MIC) in the framework of a call for supporting development programs. The project is "New workforce for MIC". It belongs to the Center for engineers training "Polyet" of the Production Association «Polyet» – a branch of the Khrunichev State Research and Production Space Center. The Center for engineers training, being a structural department of OmSTU, works for training highly qualified specialists in the field of design, production and operation of launch-rocket of the «Angara» series. The Center consists of 4 research, educational and production laboratories.

OmSTU is looking for other ways of increasing practical component of education. Analyzing best practices of training engineers at the leading technical universities of Russia and foreign countries there has been taken a decision to try out the system of training practice-oriented specialists based on the CDIO (Conceive, Design, Implement, Operate) Standards.

The analysis of the military industry requirements of the region, the material and technical equipment and the personnel of the university disclosed that CDIO Standards realization would be most efficient in the framework of Master programs.

The following Master programmes have been chosen as trial projects [2, p.103-104]:

- Design and optimization of power supply systems (13.04.02 "Electric Power Engineering and Electrical Engineering").
- Mechanics of small remotely piloted vehicles (15.04.03 "Applied Mechanics").
- Technological design for mechanical engineering production units (15.04.05 "Design and Technological Support for Mechanical Engineering Production").
- Design and structure of flight-vehicles (24.04.01 "Rocket Complexes and Astronautical Science").

The training process within all of these programmes is based on the existing resource centers.

In the framework of the international cooperation, OmSTU together with a consortium of HEIs and enterprises won a grant of the European Union programme supporting the modernization of higher education – TEMPUS program. The name of the project is "New model of the third cycle in engineering education due to Bologna Process in BY, RU, UA" (NETCENG).

The project is aimed at the development of experimental model for third cycle education (PhD, PostDoc) in the field of engineering disciplines in line with the norms and current recommendations of the Bologna process.

OmSTU is responsible for the development of an educational module on designing of a robotics on-board systems for automated maneuverable spacecrafts for solving the problem of docking with uncooperative objects of bulk space garbage, interorbital hauling, refueling of space propulsion systems on the orbit, replacement of on-board equipment, deorbitting, etc.

However everything described previously is only a modernization of the earlier existing system. And whatever the updates are applied to it, the system will not assure the former level of the quality of education.

There is an appraising need for fundamental changes that would inevitably lead to the changes in the structure of an HEI.

The background for future changes is presented further.

First of all, the words of the Minister for Education, D. Livanov, should be noted: "…in the upcoming years it is necessary to reconsider the educational standards that would be based on the professional standards; and the system for the assessment of educational programmes will be structured upon them" (TASS, May 28, 2015).

Further, the Government Executive Order of the Russian Federation No. 881-p of May 14, 2015, should be taken into account. It ratified a schedule-plan for a network of independent centers for the certification of professional qualifications.

Therefore, the transition towards professional standards application is inevitable, and after receiving diplomas of higher education graduates will have to go through an evaluation process, where their level of professional competences' acquisition will be checked. This evaluation will not include asking graduates to take integrals, but will assess their level of knowledge, attitudes and professional skills for conduction of work functions.

This leads to the conclusion that we need to transfer to a different set of educational principles, where the result of education is a competence acquired not formally, but truly. This will be achieved by moving towards the modular principle and omitting some disciplines. At the same time, the module can be not only interdisciplinary, but also inter-department.

A strong need for discarding disciplinary design of curriculum and transiting towards the modular principle of design is already stated in the FSES of Higher Education. Thus, for instance, the major 15.03.05 – "Design and Technological Support for Mechanical Engineering Production" for project design activities has no ground for including such disciplines, as "Theoretical mechanics", "Theory of mechanisms and machines", "Material resistance" in its curriculum. Those are the disciplines that used to lie in the essence of any mechanical engineer's education. The closest two competences (general professional competence 5 and professional competence 5) require for a student to be able to design and develop technical documentation and to draw up and finalize project designs. But that does not mean that a graduate has to know the laws of kinematics and strength calculations. A graduate actually should know them, but not in the context of highly theoretic disciplines. He/she should rather learn them within a unified module, where one of the parts would be devoted to the engineering methods of strength calculations (not of all the possible situations, but in application to the constructions being developed within the educational process).

Having said this, it should be taken into account that for different groups of enterprises the technological component of the educational process may vary according to the development strategy of an enterprise, its attitude towards introducing new technologies and project solution.

Interesting conclusions can be drawn from the comparison of professional competences introduced by FSES of Higher Education and the work activities according to the professional standard, for instance, of a rocket design engineering graduate (Table 1).

Federal State Educational Standard of Higher Education indicates that a graduate of a Bachelor programme should have fostered competences complying with the position of a chief design engineer, i.e. the ability and readiness to analyze the current state of space-rocket technology (professional competence-5 (PC-5), to design space-rocket technology (PC-2), to define work specification for designing systems of space-rocket technology (PC-3). But it is impossible to assure these competences' formation within the theoretical education of neither 4 years, nor even 10 years. The analysis of curriculums indicates their overload with various diversified disciplines, which are unnecessary on this stage.

A corresponding professional standard refers to the graduate's ability to collect materials following the task leader's order, to prepare detailed description of an existing

Table 1.

FSES of Higher Education (24.03.01 "Rocket Complexes and Astronautical Science", Type of activity – project designing)	**FSES-4 (Specialty group 25 "Space-Rocket Production") 25.045 – Design engineer for rocket production**
Professional competences	Work activities
(PC-1) ability and readiness to participate in the analysis of the overall state of space-rocket technology, its different subsections and development of a modern constructions and technology basis	2. Collection of materials for projects of design and calculation documentation on space-rocket technology and its components
(PC-2) ability and readiness to conduct technical design of space-rocket components with application of solid modelling in line with the Unified system for design documentation based on modern computer technologies with an aim to determine parameters of volumetric and mass characteristics of products included in the space-rocket complex	1. Preparation of design documentation on existing developments, conduction of preliminary calculations of space-rocket technology and its components
(PC-3) ability and readiness to participate in development of technical tasks for the design of systems, mechanisms and component units, that are included in the designed products for space-rocket complex, as well as its technological support	3. Arranging adjustments to the design documentation on space-rocket technology and its components

assembly drawing, and correct the drawing after receiving remarks.

The principle is simple: graduate is supposed to enter work environment and start immediately conducting his/her tasks (received according to the qualification) professionally. In the case that a specialist has a need for professional development, there is an opportunity to apply for a Master program, a PhD program, a programme of the system of retraining and professional development.

Omsk State Technical University among another 10 Russian universities became the winner of the project "Flagship university".

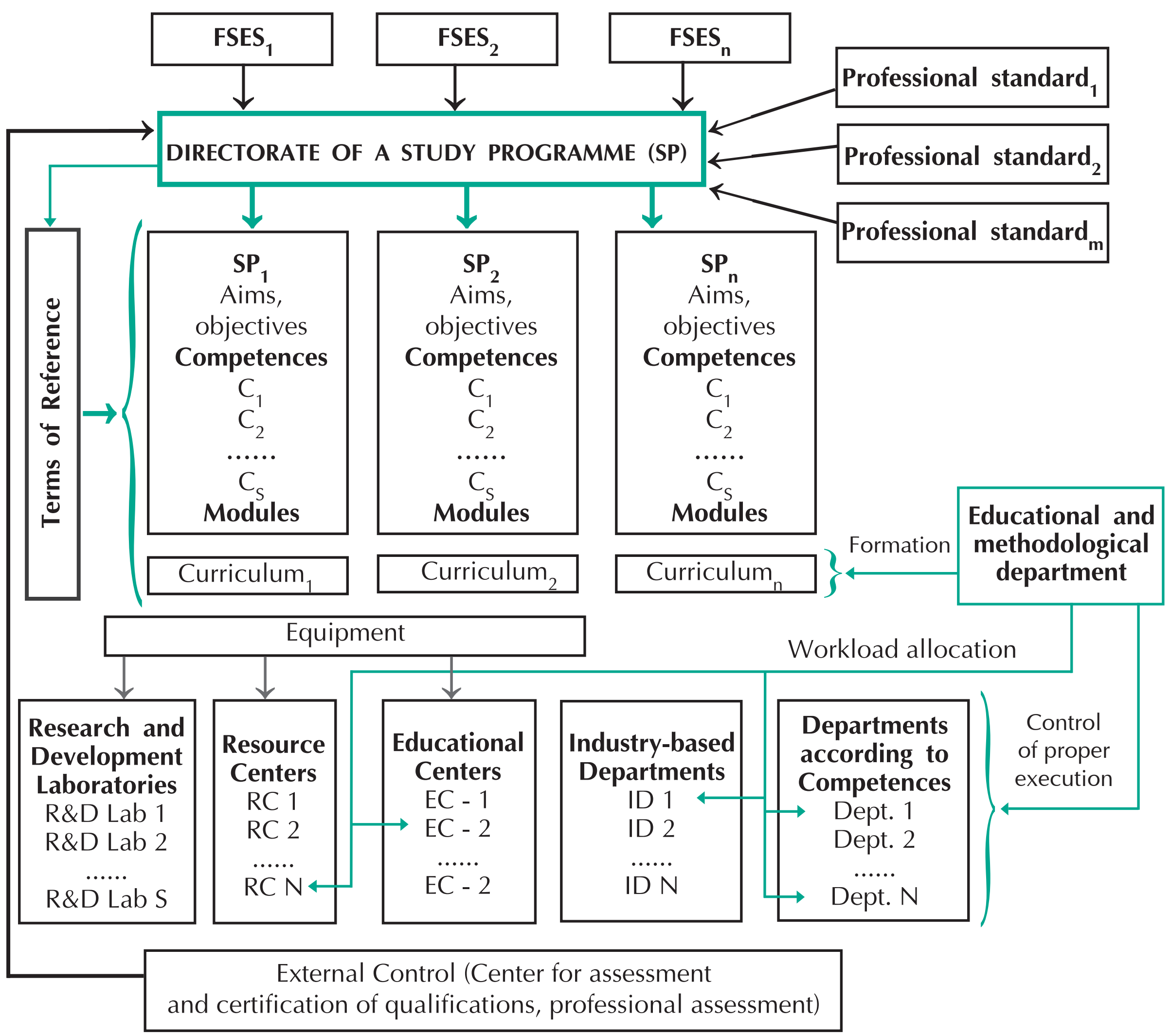
According to the Programme for development of flagship universities the modernization of management system of OmSTU includes the development and implementation of a new organizational model of the university. The distinctions of a new model of educational process organization are (Fig. 1):

- Transition to the formation of departments according to competences.
- Different system of formation, realization and monitoring of the study program's results.

The key role here is played by the directorate of each study program, who have to consider the needs of employers through professional standards, the requirements of the FSES, as well as the opportunities of all of the university's structural departments: research and development laboratories, resource and educational centers, industry-based departments or departments, responsible for the formation of one or another competence.

There is a great work ahead of us.

Fig. 1. Model for organization of educational process



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Interdisciplinary Approach and Interactive Self-Learning

Kazan National Research Technological University
R.Z. Bogoudinova, I.M. Gorodetskaya

R.Z. Bogoudinova

I.M. Gorodetskaya

The paper considers theoretical and methodological bases for interdisciplinary approach to interactive self-learning and principles of academic process organization via interactive learning techniques.

Key words: interdisciplinarity, self-education, interactive self-learning, nature-aligned learning.

In modern post-industrial society, education is a kind of anthropological and social project planning. The foundation of adequate education rests on the social project implying correlation between an individual's ideals and social structure. In social perspective, education fulfils an important function of socialization – an individual acquires knowledge and develops relevant skills, as well as learn social standards and values which stipulate successful life and development in a given society over a definite period of historical time. As for static societies, education is transmission of knowledge, and self-education is a kind of traditional practice. In dynamic societies, which are focused on development, education deals with ideas and practices which have neither become traditional nor been regarded as social and practical standards. Such education implies testing and research, as well as new practices implemented by their creators – fresh graduates. Therefore, education becomes an institution which secures activity development [1].

Education, even reduced to simple acquisition of knowledge in a certain sphere, has impact on an individuals' worldview. Being a complex system itself, the personality is a component of another system – social group, which, in its turn, is included in the system of social relationships. Education deals with psychology and considers existence as polysystemic, with due regard to the integrity of human qualities and particular characteristics. Therefore, the systemic approach to the analysis of education and self-education is the most adequate one. In philosophy, system is "a totality of elements correlated and interconnected with each other to make a unity" [2, p. 584]. The notions and principles of the systemic approach are as follows: unity, links, structure and organization, a number of levels and their hierarchy, management, target and target behavior, self-organization, performance, and development [3]. Systemic integration of new knowledge into the world model is only possible via interdisciplinary links. The interdisciplinary approach to education allows developing the level of thinking and forming holistic worldview. This approach is also contributive to improve professional, worldview, communicative, and cross-cultural competencies. It is a well-known fact that scientific and technological breakthroughs occur through crossing boundaries in science, as a result of integrated research [4].

The system of today's education is focused on new achievement, which can be proved by the correlation of knowledge and skills within educational process. Knowledge is currently losing its fundamental status since today it is easily available while the methodology is becoming disputable. What society today needs more than anything is skills, and they are intensively developing and increasing in number [5]. Under these conditions, the disciplinary structure of educational process is inadequate since it is focused on transmitting knowledge and formalized assessment. Interdisciplinarity, which implies systemic integration of acquired knowledge into the individual's worldview, allows transforming abstract information into applicable skills and competencies.

It is important to note that a student may play different parts depending on the stage of the educational process, however, self-learning, self-organization, and self-management take priority over other educational activities. Didactic systems and technologies developed by experts should encourage self-education, i.e. contribute to acquisition of knowledge in general or in a particular field.

Self-education is an intrinsic mechanism of any educational process. Without being interested and determined, the student fails to reach the expected learning outcomes, whatever the didactic forms are. Self-education is even more significant when the education makes a shift from transmitting knowledge to project-based learning, i.e. dealing with non-standard situations and solving complicated and hand-on tasks, which used to be neglected. Dealing with hand-on tasks (especially in engineering) stipulates interdisciplinary approach, since real life goes beyond the framework of a particular discipline and necessitates taking into account a wide range of factors: technological, scientific, social, ecological, etc. There are no "correct" answers, therefore, traditional transmitting channels fail to work (for example, the situation when the teacher works with the audience in class).

The significant role that self-learning plays in education is undisputable. All teachers agree on the point that professional communication with colleagues is essential to efficiently perform professional activities. Student's academic success and other students' respect are only possible beyond the classroom, and self-study encourage students to conduct scientific and creative research.

"Development and education cannot be gifted or passed. Everyone who wants to learn something should step up efforts to reach his or her aim. The only thing which can be obtained from outside is impulse...

Therefore, independence is a tool and an outcome of education" [5].

Education at any level, i.e. acquisition of knowledge, can be provided only via self-learning. This is a fundamental didactic principle, which the foundation of education rests on, and it is adequate to develop any didactic and/or educational system.

Today, there are no doubts that education is a complex process depending on an individual's psychology and his/her ability to self-learning. In compliance with this general didactic principle, knowledge, unlike an object, can never be passed (or gifted, or sold, etc.) from one individual to the other without participation in educational process or unless the "recipient" comprehends and processes the knowledge provided. This knowledge can only be acquired by means of the recipient's intellectual efforts and via interiorization, i.e. incorporation of knowledge into one's mind and inner life [6].

It is only self-learning that allows acquiring practical knowledge, developing creative abilities and practical skills. There is no educational process if a student does not take an active part, no matter how active the teachers and parents are.

As a result, we have a model of self-education and self-monitoring, which allow adjusting the educational process to reach the expected learning outcomes with due regard to interdisciplinary links and cooperation between educator and student.

The didactic system of interactive self-learning implies that the interactive self-learning model is intensively used at a certain stage of educational process.

The method and model of interactive self-learning aim to develop nature-aligned and individual-focused method and model of self-learning which make professional education available and ensure that:

- the quality and level of education correspond to the student's educational background and potential (IQ, basic training, etc.);
- educational process is efficient due to being based on the mechanism of self-development, self-education, and improved ability to learn.

Interactive self-learning is a method and model of self-education based on interaction and cooperation between the educator and students, with timely feedbacks and monitoring of nature-aligned and individual-focused self-learning [7].

In the course of our research, we determined the major principles to design the system of interactive self-education and self-learning for higher professional education. These principles are as follows:

1. Self-learning and self-management are predominant over the other types of educational activities.

2. Nature-aligned learning is ensured through the method and model of self-learning, in which learning in predominant over teaching and the educator's part is to contribute to effective learning.

3. Interdisciplinarity is supposed to develop a way of thinking, which implies multi-faceted approach and the discipline taken as a system comprising a bulk of connected components and being itself an element of the metasystem, namely, the knowledge about the world and particular phenomena. This approach is implemented through setting hand-on tasks which necessitate considering many different factors and finding solutions beyond the framework of a particular discipline.

4. The educator's contribution to effective learning, i.e. comprehension and speculating on the information received, is provided via specially designed, adapted, and appropriately structured interactive self-learning tools.

5. The measure to secure the efficiency of self-learning is implementation of multi-level monitoring (entry, interim, final).

6. Self-management mechanism being a part of the didactic system of interactive self-learning induces self-development and self-education, with the educational process nurturing intelligence and shifting priorities from teaching to educating.

7. In compliance with the concept of activity-based learning, practical activities are predominant within educational process and provide fundamental knowledge to be obtained. In combination with improved comprehension of educational materials, it boosts self-learning.

The intensive development of IT systems in Russia, and in Russian education, in particular, facilitates interactive e-learning via implementation of cutting-edge digital and information technologies.

The didactic system of interactive self-learning for professional education stipulates implementation of e-learning, as well as the design of open e-learning resource.

The system of interactive e-learning developed with due regard to the principle of interdisciplinarity allows:

- achieving the expected learning outcomes in group learning environment;
- implementing technologies into educational process, which, in its turn, ensures achievement of expected learning outcomes;
- reducing the number of poor results (or even avoiding any) at the end of the academic term;
- providing high quality professional training within short period of time due to the reduced number of lectures, activity-based learning, and integrated classes;
- improving the potential for continuous professional development via self-development and self-education, which is stipulated by well-developed learning skills.

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Interdisciplinary Interaction in ISO 9001-2015 Standards

National Research University of Electronic Technology MIET
M.V. Akulyenok

M.V. Akulyenok

The article is devoted to the analysis of quality management system of interdisciplinary interaction and trends in university QMS improvement in accordance with the requirements of the new implemented edition of International ISO 9000 standards, in particular, the requirement for risk management.

Key words: quality management system, interdisciplinary interaction, risk management, positive and negative risks.

Significant innovation potential and highly negative risks of interdisciplinary interaction further the pressing need in considering the International ISO 9001-2015 standard requirements [1], in particular, risk management.

It should be noted that the quality management system (QMS) has been formally implemented into most universities and, in most cases, it lacks high effectiveness. At the same time, the unreasonably imposed scope of documentation does not improve the quality of education. Only a few universities have succeeded in fulfilling the requirements stated in the earlier standard edition, i.e. implementation of approach process into the T&E activity and, thus, achieve effective QMS. Adopted and implemented on November,1, 2015, the newly edited standards GOST R ISO 9000-2015 and GOST R ISO 9001-2015[1,2] specified two aspects: firstly, solving the more complicated problems within specified transition period to September, 2015; and secondly, implementing the developed requirements to improve the education programme (EP) quality at a totally new level.

Management risks in the QMS structure, being included in the new ISO 9001-2015 standard edition, could be the response to the dynamic external and internal realities of this or that university. Under conditions of unpredictable changing, constant opportunities and challenges, high risk and subjectivity in evaluating an organization status and its surroundings, probability to achieve the stated goals, the approaches that are applied in high school management require improvement, i.e. implementing the process of management risk. Basically, risk management, within QMS of any company, is a development tool providing the transfer to a more qualitatively conceptual level "preventive action" and relevant documentation procedures, which have been excluded from the described standard requirements.

In accordance with the existing regulatory documents [1-5], the operational definition could be: **risk is the consequence of an uncertainty action on achieving specified goals. "Consequence of uncertainty action"** is any inclination from expected result and/or event, both positive and negative (i.e. not only emerging possibilities but also risks with negative consequences). "Uncertainty" is complete and/or partial absence of information and/or knowledge needed to understand the events, their consequences and probabilities.

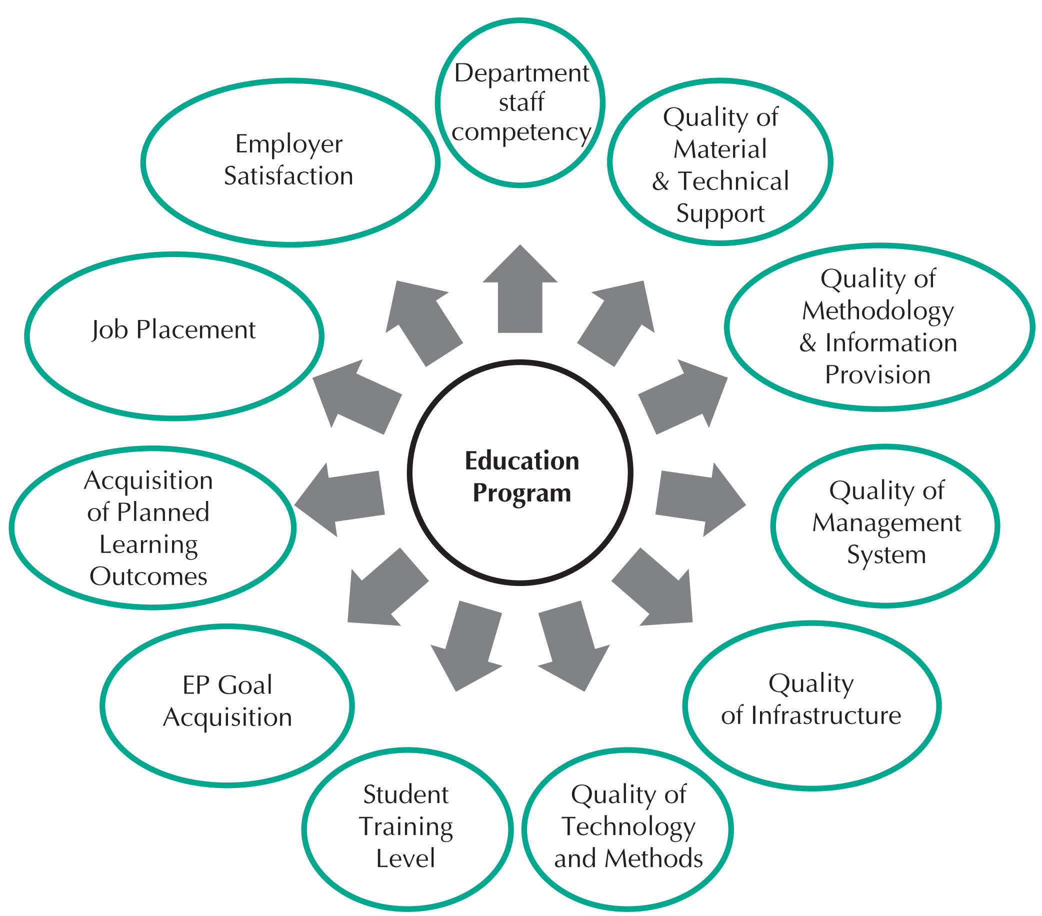
In this case, goals as desired result, presently absent, are in good agreement not only with the concept "goal in quality, but also exactly reflect its specific nature "education programme goals". The education programme path from the stated goal and planned learning outcomes to goal acquisition is long. It is inevitable that this path itself involves the influence of varied risks. In this case, the application of risk management methods would be very useful. This in itself is necessary for interdisciplinary programmes as the uncertainty source "intensity" and further possible synergy effect and insurmountable difficulties increase with the intensity and depth of interdisciplinary interaction (from two disciplines to specialties, majors and/or fundamentals [6, 7, 8]).

Principally, decreasing risk of EP quality should be taken into consideration in the risk analysis of EP during its planning and development, including the determination of the goals and learning outcomes [9, 10]. Despite the multi-concept of the term "education quality" (ref. Example [11]), described risk is often considered to be (fig.1):

- no achievement of education programme goals;
- noncompliance of requirements for graduates according to FSES HE;
- learning outcomes noncompliance to planned ones;
- inability to entirely identify and implement employer's requirements;
- no target-focused training;
- noncompliance of staff training to State Accreditation criteria;
- impossible job placement;
- necessary professional retraining;
- etc.

During EP planning and development

Fig. 1. Basic aspects of the concept "education quality"



(according to §6.1 GOST R ISO 9001-2015) and its further implementation, risk management implies:

- determining the context of the education programme (external and internal realities);
- identifying the risks, including their detection and description;
- quantitative evaluation and comparative analysis of risks;
- actions on risks (management decision making, for example, reducing the probability of unfavorable results and minimization of possible losses).

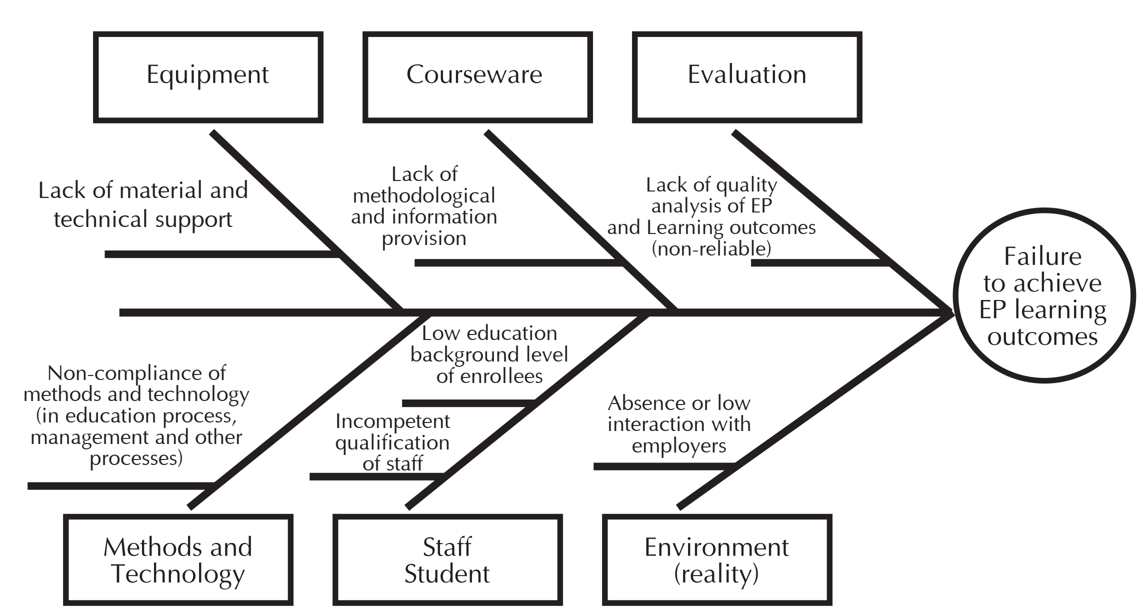
As well as constant information sharing with interested parties and monitoring designed measures and EP implementation throughout the process. This involves not only the analysis of occurring changes and newly emerging risks, but also the evaluation of the effective action on the risks. Systematic approach in identifying and evaluating risks involves the structured process based on the corresponding elements through the specific methods [3-5].

Identification (detection and description of risks) includes cause-effect analysis. In this case the risks involving goal acquisition and planned EP learning outcomes could and should be analyzed. For example, the EP learning outcomes noncompliance to the planned ones (or low EP effectiveness) could be connected with a series of reasons, a few of which are illustrated in the cause-effect diagram (fig. 2). To identify the factors affecting the achievement of planned learning outcomes, the universal "5M" tool analogue (man-machines-materials-methods-milieu), adapted to the T&E activities, was applied.

Interdisciplinary education programmes embrace not only the above-mentioned factors, but also a wide range of additional factors associated with the result interaction, which, in its turn, influence the possible synergy effect. Thus, the following reasons for noncompliance of interdisciplinary education programme learning outcomes to planned ones could be included in this risk list:

- slight interaction within the internal university reality, for example, ineffective (or unmanageable)

Fig. 2. Achieved and expected learning outcomes: reasons for non-conformity



interaction between department staff and lack of university administration support;

- slight interaction with the external reality: for example, ineffective (or unmanageable) interaction between enterprise- employers and interested parties.

Functional risk management implementation into planning and development of EP furthers:

- implement focused-risk definition of EP goals and learning outcomes;
- improve effective academic-teaching staff interaction within internal university reality, as well as university department-employer interaction and university-graduate interaction;
- perform operative monitoring, constantly observing the risks that could emerge both at the EP stage of planning and designing and during its implementation.

There is one more positive aspect – informal risk management implementation could possibly solve the problem of university QMS. i.e. document management optimization through risk-oriented identification of necessary and unnecessary documents within the framework of both QMS and EP management.

Consistent interdisciplinary interaction and interdisciplinary EP risk analysis would involve the following: promoting interdisciplinary education programme goal achievement, developing and integrating risk management into the QMS structure, updating university QMSs in compliance with the new GOST R ISO 9001-2015 requirements and improving EP management efficiency.

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R. Martínez-López


M. Reznichenko


C. Yot


C. Marcelo

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Inventory of Activities of Learning Technologies at University: Cross-Cultural Adaptation in the National Context of Russia

Samara National Research University
University of Seville (Spain)
R. Martínez-López
Samara National Research University
M. Reznichenko
University of Seville (Spain)
C. Yot, C. Marcelo

This research estimates the adequacy of translation and adaptation of the Inventory of Activities of Learning Technologies at the University (IAATU) in the national context of Russia. The IAATU is proved to be internally consistent and well comprehended.

Key words: competencies, University teachers, technology based learning activities, confidence, instrument, cross-cultural, Russia.

Introduction

UNESCO ICT competency framework for teachers (UNESCO, 2011) emphasizes that it is not enough for teachers to have Technology Information and Communication (ICT) competencies and be able to teach them to their students. Evaluation of professional competence is performed by comparing the obtained results with some norms and averages, as well as with the results of previous diagnosis to identify the nature of the advance in the development and professional growth of a teacher and leader (Simonov, 2010). In addition, the fact of having extensive skills in ICT use has not been linked to their use in academic activities: the abilities developed through using the computer do not seem to be transferred – or at least not to the degree expected – to learning (Romero, Guitert, Sangra, & Bullen, 2013). According to Marcelo & Yot (2015), to incorporate technologies into their teaching, teachers need to design teaching-learning experiences based on three interrelated TPACK components. These are the content to be taught (content knowledge), the pedagogical model upon which teaching is based (pedagogical knowledge), and the technological resources that teachers select at a given moment (technological knowledge).

This subject is considered to be an important research issue, since adopting a new type of learning requires a specific study on whether the audience and the teachers are ready for new forms of education. It is impossible to introduce new technologies if the target audience is not ready to absorb the information presented by new methods (Yanuschik, Pakhomova, & Batbold, 2015). In fact, it is necessary to understand how technology is taught and implemented in order to improve the developed competency and the technology used in learning (Lemon & Garvis, 2016). Over the last years, researchers have made efforts to identify the competencies that prospective teachers need in relation to technology (Lee & Lee, 2014; Valtonen, Kukkonen, Kontkanen, Sormunen, Dillon, & Sointu, 2015; van den Beemt & Diepstraten, 2015), and ICT instruments have been developed in order to assess the effective strategies to prepare prospective teachers for technology integration (Tondeur, van Braak, Siddiq, & Scherer, 2015; Arki, Kiss, & Gastelш, 2015; Tondeur, Aesaert, Pynoo, Braak, Fraeyman & Erstad, 2015).

Although there are several studies on teacher competencies in the context of Russia (Drovnikov, Vazieva, Khakimova, & Konyushenko, 2016; Mokshina, 2015; Mirzagitova & Akhmetov, 2015; Erganova & Shutova, 2014); there is a lack of knowledge related to this approach, particularly in Russia. One possible strategy to cover up the lack of knowledge is to validate a Russian version of the IAATU (Marcelo, Yot, & Mayor, 2015). To adapt a questionnaire with documented validity rather than to create a new one is recommended (Beaton, Bombardier, Guillemin, & Ferraz, 2000; DeVellis, 2003; Lovelace & Brickman, 2013) under the condition that the construct exists in the target culture and the existing instrument measures it appropriately (Epstein, Santo, & Guillemin, 2015). This instrument may help to understand how effectively university teachers in the context of Russia use the technology in the learning design.

The IAATU was developed focusing on the didactic aspect and represents the design of learning activities enriched with technologies. In the course of the research the authors analyzed how different digital technologies are integrated into the classrooms of the Andalusian universities. Since the level of technology integration in learning sequences is known (Marcelo, Yot & Mayor, 2015), the Cronbach's alpha coefficient for the IAATU is 0.958. It has 38 items distributed among 1 to 6 on a double Likert-type scale. One refers to the frequency with which it is used (usage level) with internal consistency measured using Cronbach's alpha coefficient of 0.912, while the other refers to the degree to which the teacher feels confident when using the activity (confidence level), Cronbach's alpha = 0.937.

According to Hsu (2011), the activities the teachers suggest to the students are influenced by their own usage of ICTs. Recently, the relationship between teachers' own ICT practices and the type of ICT activities they assign to students has been examined. The research outcomes indicate that teachers' technology integration practice could determine their knowledge in technology integration to a large extent (Chuang, Weng, & Huang, 2015). Therefore, there are variations in the educational use of digital technology by teachers. These patterns of ICT use emerge from the frequency of use (the amount of times they use it) and by the nature of the activity (the type of tasks and grouping when working with ICTs in the classroom) (Area-Moreira, Hern6ndez-Rivero, & Sosa-Alonso, 2016).

Confidence is considered a strong predictor of teachers' technology use (Wozney, Venkatesh, & Abrami, 2006). One of the explanations for the gap between what teachers know and what they do relates to their confidence, or self-efficacy, for performing the task successfully (Ertmer & Ottenbreit-Leftwich, 2010). In terms of digital technology, recent empirical studies show how self-efficacy can determine the level of teacher confidence and competence to engage with a task (Lemon & Garvis, 2016).

The IAATU use the taxonomy of Conole (2007) to classify the various types of technology-based learning activities. The taxonomy of Conole & Fill (2005) attempts to consider all aspects and factors involved in developing a learning activity, from the pedagogical context, in which the activity occurs, to the nature and types of tasks undertaken by the learner. This taxonomy classifies types of the learning activities used to achieve the intended learning outcomes into six areas: assimilative tasks, information handling, adaptive, communicative, productive, and experiential.

The original study included 291 Andalusia teachers. The IAATU was subject to a validation process by experts and sixteen university lecturers from various universities and fields of knowledge. It is noteworthy that there was statistically significant concordance among the values assigned to the various items.

Speaking about the global educational practices, the authors of the Russian education modernization strategy argue that competences are of integrative nature and, therefore, suggest an innovative vector of educational practice development. Currently, the competency-based approach tends to be more holistic in terms of its structure (Erganova & Shutova, 2014). According to Mokshina (2015), one of the important issues of the would-be teacher training in Russia is the lack of their practical preparation for professional activities. Despite this study's findings, little is known about what technologies do Russian teachers use in their teaching design, in particular, those that are related to learning activities. The IAATU is useful to analyze how different digital technologies are integrated into the classrooms of the Russian universities and can also be used as an instrument to identify what type of learning activities based on technologies university teachers design in Russia.

An objective measure applicable to a university level will offer a start point to explore a multidimensional research on the developing teachers' professional skills and competencies in Russia. There were two research objectives: the main one was to adapt and validate the IAATU in the national context of Russia, and the second objective was investigate how intensively the technology is used to design the teaching-learning process in relation to teacher's confidence.

Sample

The pilot-test (i.e. the Russian version of the IAATU) was conducted as an online survey from February to April. The sample included 103 responders, 52.4 % of them being female and 47.6 % male. 43.7% of the respondents were in the age group of 31-40, 17.5% under 31 and 9.7% over 61. The teachers of Samara National Research University (Russia) made up 44.7%.

Methods

As the evidence for the best method for cross-cultural adaptation of questionnaires is lacking, and back translation may not be mandatory (Epstein et al., 2015), the research involved individuals fluent in both English and Russian, as well as the committee to review the translation from English into Russian (Geisinger, 1994). The adaptation process described below was used as the most appropriate in the context of the questionnaire of interest (Epstein et al., 2015). When the author's permission to adapt the IAATU within the Russian national context was received, the instrument was translated from English into Russian by a bilingual person, with Russian as mother tongue. Then the expert group consisting of three professionals specializing in technology education discussed the translated concepts in order to find the cross-cultural equivalents (Beaton et al., 2000). The content was validated by the expert group. Once the pre-final version was ready, it was administered through an online questionnaire. A link with the questionnaire (http://goo.gl/forms/otScqvE7WE) was sent by email, explaining the purpose of the study. This pilot study was conducted to strengthen both the semantic and content equivalence of the IAATU. Following guidelines for cultural adaptation of instruments (Hambleton & Patsula, 1999) the pilot version was administered first to 40 teachers to assess their understanding and the feasibility of administration. In relation to content validity, some stylistic changes were made by the expert group between the phases of translation and the pilot-test. With the author's consent, Likert-type scale was adapted to 1 to 5. The general structure of the instrument was preserved and adapted with great care to ensure the best properties possible (Epstein et al., 2015).

The IAATU with 38 items developed by Marcelo et al., (2015) includes initial questions to collect demographic information such as: sex, age, university, field of knowledge and professional category, and specific items related to learning activity types: assimilative, information management, communicative, productive, experiential and evaluative, asking their level of agreement with each statement, and suggestions to be considered. Providing an estimate of the internal consistency of each Likert scale increased confidence that items on each scale were measuring something similar (Lovelace & Brickman, 2013).

Nonparametric techniques, Mann-Whitney and Kruskal-Wallis tests, were applied to analyze possible changes in teacher's gender or age in relation to usage and self-confidence level. To measure the strength of association between two ranked variables – the level of use of different learning activities and self-confidence, the Spearman's rank-order correlation was used.

The data were analyzed by using IBM SPSS Statistics, and univariate descriptive statistics were used to describe the sample characteristics and frequency of learning technology use. The reliability estimation method Cronbach's alpha was used to ensure internal consistency (Field, 2009; van der Palm, van der Ark, & Sijtsma, 2014) for the scales of level of use (0.916) and self-confidence (0.939), with a value above 0.957 showing very good reliability and internal consistency of the scale, which meets the criteria of reliability.

Results

According to the level of use (Cronbach's alpAccording to the level of use (Cronbach's alpha=0.916), three groups of learning activities are identified in relation to the mean: low level (mean 1-2.5), medium level (2.5- 3.5) and high level (3.5-5). The two technology based learning activities used are of assimilative type, i.e. promoting the transfer of knowledge from the teacher to the student: (1) In my class I use presentations created using a computer programme (PowerPoint, Prezi, Impress, etc.) to show students concepts and ideas regarding subject content (3.68) and (3) During my presentations for the students, I show simulations, demonstrations or examples based on digital resources, either my own, or available on the web, to clarify concepts and ideas (3.59).

As for the other activities, another three items are frequently incorporated into teaching (M > 3.5): Information management, (10) I teach students to verify whether the information obtained is true or the information sources found when searching the Internet are reliable. (4.17); Communicative, (16) I develop online tutorials by means of various communication tools (email, videoconference, messenger, chat, etc.) to respond to student's queries or doubts. (4.32) and Productive, (23) I encourage students to present their results in a creative manner, using presentation infographics, presentations, concept maps, etc. (3.87). The five items show high level of confidence over 3.5, however, items 10 and 23 have the highest level: 4.22 and 4.31, respectively.

The experiential type of activities (creating educational environment simulating the reality) have a low level of use ($M \le 2.5$) with the exception of (13) I design practical case studies, using digital resources (videos, presentations, specific software, etc.), so that students can apply the theory learned to practice: 3.37 (medium level $M<3.5$).

Practically all of the evaluative activities (aiming at evaluating student's learning) are characterized by low level of use ($M \le 2.5$), except for item (35) I use anti-plagiarism software when assessing students' papers to guarantee that these are original works (3.38) (medium level of use $M<3.5$).

Within the scope of the research, there were 103 teachers involved (the national academic staff in miniature), the null hypothesis suggested was that there is no association between the use of learning activity and self-confidence ($r = 0$). Statistical significance, set $\alpha \le 0.05$, indicates that the null hypothesis can be rejected. A statistically significant Spearman rank-order correlation means that if the null hypothesis is true, the probability of occasional strong connection between the use of a learning activity and self-confidence (rho coefficient 0.01) is less than 5%.

Considering the value of r indicating the type and importance of the linear association (Table 1), we know, first, that the relationship in all cases is positive (an increase in self-confidence level takes place with an increase in the level of use and vice-versa). Secondly, the association is moderate ($0.30 \le | r | \le 0.70$) for items 1, 2, 3, 4, 5, 8, 10, 11, 14, 16, 18, 20, 25, 33, and 34, while for the rest of the items the correlation is strong ($| r | > 0.70$).

Based on the results obtained in Kruskal-Wallis Test0, it can be asserted that there are significant differences in the level of self-confidence depending on the age. The p-value of less than 0.5 leads to rejection of the null hypothesis for the variables "age" and "self-confidence" in items 11, 17, 21, 22, and 34. As for the activities of learning technologies in use and the variable of age, significant differences were found in items (11) I use concept maps created with specific software (MindManagers, CmapTools, etc.) to help students understand the structure and relationship between subject concepts (0.25) and (17) I facilitate interaction with students outside the classroom by means of cellphone applications such as WhatsApp, Line, Twitter, Facebook, etc. to motivate exchange of information, resolution of doubts (0.02).

Mann–Whitney U tests were conducted to compare differences between gender and self-confidence. Difference was found between men and women in items 2, 8, 11, 14, 20, 23, 25, 33, 34, 37. As for the activities of learning technologies, significant differences were found in items 10, 13, 18, 19, 21, 23, 25, 35, and 37 depending on gender.

Limitations

The sample size in the present study (N = 103) might be considered to be low (Tabachnick & Fidell, 2007; Field, 2009). Communality values in the present study were above 0.5, therefore, a sample size between 100 and 200 is sufficient (Field, 2009). Moreover, a small sample is commonly understood as any sample that includes 30 or fewer items, whereas a large sample is one in which the number of items is more than 30 (Kothari, 2004). Nevertheless, it is important to note that generalizations of findings should be made with caution. In further research it would be desirable to replicate the study with different samples in other subjects, disciplines, and/or other universities in order to obtain results that can be generalized and allow us to determine the reliability and validity of the IAATU in a diverse range of samples.

Although the expert group participated in the survey, there still were some ambiguities in the meaning of concepts in the translated version, which is evident from the teachers' comments. Back-translation ensures that the instrument is the same in the two languages, and assessment of internal consistency indicates reliability of the target language version (Maneesriwongul & Dixon, 2004). Studies comparing methods suggest that the back-translation should not be mandatory but can be useful as a communication tool with the author of the original questionnaire (Epstein et al., 2015).

Temporal stability should be analyzed through the retest method based on the measurements obtained by the application of the IAATU in the same group of respondents with one-month interval between tests (Beaton et al., 2000). Although the participants in the pilot test also had an opportunity to give their comments in the questionnaire, verbatim transcription reflecting conventional content analysis was missing (Hsieh & Shannon, 2005). Moreover, each respondent of the pre-test was not interviewed to probe about what he or she thought was meant by each questionnaire item and the chosen response (Beaton et al., 2000).

To overcome the possibility of biasness of the results, future work should include an offline questionnaire in the sample collection (Teo, 2000). As technology integration practice is subject to change, future research should adopt longitudinal design to collect data across time.

Conclusions

Based on the analysis of the data obtained, we can conclude that there is relationship between self-confidence and intensity of use of the learning activities technology by the teachers. This finding is consistent with the findings of Marcelo et al. (2015) and the validity of IAATU. Intensity of use of learning activity depends on teacher's self-confidence. The results of this study showed that the probability of using learning activity technologies is much higher if the teacher feels confident in using them.

The results of this research indicate that the teacher's confidence has a strong impact on the intensity of technology use (Wozney et al., 2006) and conform with the outcomes of the other empirical research (Lemon & Garvis, 2016; Greener & Wakefield, 2015; Bennett, 2014). Ertmer & Ottenbreit-leftwich (2010) suggest that an increase in teacher's

Table 1. Correlation coefficient Spearman Rho for different items

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9
Coefficient	0.522	0.598	0.561	0.676	0.661	0.769	0.704	0.308	0.762
Sig. (bil)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Item10	Item 11	Item 12	Item 13	Item14	Item 15	Item 16	Item 17	Item 18
Coefficient	0.641	0.586	0.830	0.754	0.686	0.784	0.695	0.840	0.688
Sig. (bil)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Item 19	Item 20	Item 21	Item22	Item 23	Item 24	Item 25	Item 26	Item 27
Coefficient	0.777	0.576	0.807	0.843	0.742	0.730	0.643	0.803	0.795
Sig. (bil)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Item 28	Item 29	Item 30	Item 31	Item 32	Item 33	Item 34	Item 35	Item 36
Coefficient	0.746	0.779	0.742	0.724	0.765	0.655	0.594	0.859	0.792
Sig. (bil)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Item 37	Item 38							
Coefficient	0.758	0.862							
Sig. (bil)	0.000	0.000							

confidence is connected with achievement of expected learning outcomes. However, more evidence is necessary to better understand this process.

Learning activities based on technology is a resource-intensive learning strategy that requires reliable and valid evaluation tools to measure effectiveness of the educational process. Due to the fact that testing for validity is an ongoing process, the properties of the IAATU should be further validated in different cultural contexts. The present results must be considered as a contribution to this process.

As a starting point of a multidimensional approach, this research describes the different ways the teachers use technology in educational purposes, and also offers an instrument adapted in the national context of Russia for future research. This study is expected to shed light on developing teachers' professional skills and competencies in Russian universities.

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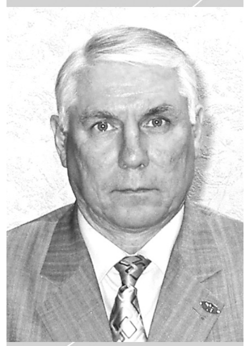
Computer Applications in Engineering Education: New Opportunities in Training Engineers for Creative Economy

Kazan Federal University
I.V. Makarova, R.G. Khabibullin
PTC "KAMAZ"
A.M. Ushenin, S.A. Mikheeva, V.S. Karabtsev


I.V. Makarova


R.G. Khabibullin


A.M. Ushenin

The article addresses the issue of ensuring qualitative training of specialists for mechanical engineering and road-and-transport complex. To increase the competitiveness of the personnel, a new education pattern is proposed. It has been revealed that introduction of a system approach in engineering training makes it possible to handle the problems in training engineers able to design, manufacture, and maintain complex machines and equipment.

Key words: engineering education, computer technology, education system, engineer's competence, specialist's profile.

Introduction

The problems of the 21st century caused by depletion of natural resources and environmental hazards stipulated the changes in the existing employment structure, i.e. old and traditional jobs disappear, while new jobs emerge. On the one hand, a fast-growing economy is in a constant need for all-rounded quality personnel capable of resolving increasingly challenging tasks. In this respect, the role of an engineer who is able to design, operate and maintain complex machines, as well as create new materials and develop new technologies, is becoming more prominent. On the other hand, there is a massive inertia in the education system, which should be overcome in order to ensure qualitative training. It is one of the greatest challenges facing modern education system, and it can be addressed only by implementing systemic strategy that would make it possible to combine new opportunities offered by up-to-date technologies and positive experience gained by engineering universities all over the world. Such a strategy would ensure stability of the education system and its continuous improvement and revision to meet the needs of the real economy. Training of engineers capable of resolving modern tasks should be based on the innovative learning strategies. In addition, the programmes themselves should be designed with regard to the modern advancements in science and technology. It is important to improve the system of so-called "advanced education" aimed at training engineers of the future.

Problems and contradictions in business and education

The competences of a specialist are basically discussed in two contexts: as learning outcomes of a definite programme and as a qualification description which helps companies select the candidates for the vacancies they have. Further, they educate their own employees. In companies, the qualification of a specialist is described on the basis of the competence model. According to the education standard, competences are defined regarding the industry a graduate is going to work in. As, on the one hand, engineering activity is becoming more and more diverse and, on the other hand, the companies want to

ENGINEERING EDUCATION 20'2016

employ the specialist for definite work, the contradiction between education goals and business arises. Besides, today one should speak of so-called "global competences".

To handle these contradictions, it is essential to introduce a systemic approach in the education system. As the balance between supply and demand for engineers with a definite set of competences is defined by the labor market, it is the labor market that can make a link between education and industry. Such a mutual cooperation would contribute to the stability of both the education system and industrial sector. However, for business representatives and educators it is essential to develop a single understanding of the competence model and learning outcomes. The challenges arise when one is trying to formalize the assessment system of specialist's competences. The traditional system of education and professional standardization do not include the description of competences which directly influence the success of a company: decision making, agreement achievement, responsibility, etc. Based on the standard assessment tools, it is possible to determine the level of competence and professionalism in a definite field of study, but it is impossible to predict whether this specialist will be effective or not for the company. For this purpose, the competence model is required.

Competence-based management is a unique approach towards human resources management, with three main competences being emphasized: educational-cognitive – abilities to perceive, set goals, plan, analyze, speculate, control oneself, solve problems and address the tasks, etc.; informative – ability to search, select, process, analyze, and interpret information; communicative – ability to interact, to work in a team, and perform various social functions, etc.

The mission of an engineer of the future is to create more stable and fairer world. As engineers bear collective responsibility for improving living conditions of people worldwide, they must think and act globally. Such complicated tasks force educators to revise the current education system. According to the research literature, "global competence" of an engineer is discussed in three basic aspects. Firstly, an engineer not only has to be involved in product design and manufacture, but also he/she is responsible for market promotion, operation, maintenance, and utilization. Therefore, engineers should have interdisciplinary knowledge, especially, in the fields which are traditionally related to the engineering activity: global socio-economic and political systems, international trade and markets, ecological systems, research and technological innovations. Secondly, it is the ability to work in a team, communicate and collaborate in a global frame. Multinational team is more likely to be effective and innovative. Thirdly, for engineers it is essential to be able to live and work comfortably in multinational engineering environment. Involvement in multinational projects requires being able to demonstrate strong language and communication skills.

Another challenge to be addressed is declining interest in engineering education among young people, especially, when it entails involvement in knowledge-intensive activity. There are various ways to increase motivation: to launch career guidance programs, to define and develop potential abilities, and to enhance prestige of engineering activity. Relating to the above-mentioned tasks and challenges, one should consider computer technologies as a tool of all participants of the education process. They can be applied to design learning content and learning environment, solve the assigned problems, foster teacher-student communication, develop professional competences, and assess learning achievements and training quality.

Results and discussion

To make vehicles more effective, cost-efficient and eco-friendly during production, operation, maintenance, and utilization stages is one of the most pressing


S.A. Mikheeva


V.S. Karabtsev

problems that faces motor-vehicle industry. In addition, an engineer should have intensive knowledge in digital modeling of automobiles, vehicle maintenance, and intelligent transportation systems. Cooperating with "KAMAZ" and other companies engaged in transport, logistics, maintenance, and safety management, we have gained extensive experience in training engineers for the Research and Design Centers.

Considering the above-mentioned challenges, the first stage was dedicated to goal setting and identifying the ways to achieve them. Precisely, we systemized the tasks to be solved by engineers at their work places. In addition, to define the most important competences for graduates to make a successful career, the representatives of partner-companies were interviewed. The outputs of the survey were analyzed and categorized (Tab. 1).

To adjust professional standards to education ones, first of all, we defined the courses which are required for all engineering programmes and concern all stages of automobile lifecycle (the first module – General Sciences); secondly, we define the courses which are specific for each occupation (the second module – Professional). Then, the curricula were designed, with the key competences corresponding to the professional standards of motor-vehicle industry being specified. The courses aimed at shaping required competences were introduced in the corresponding engineering programmes with regard to future occupation in the relevant company. The peculiarity of the proposed pattern is due to the fact that students gradually become involved into the professional environment, precisely, they do internships during the first years of education, then, they have an opportunity to work as engineers and continue their education. In this case, they have access to vast information resources of the companies, learning content of the corporate university, and software support required for project execution. Thus, the courses of the first module are completed at university, while the courses of the second module are completed at the corresponding workplaces. This allows educators to solve the problem of "sharing" management functions by two LMS (learning management system) [1]. The second stage involved design of learning content, selection of appropriate teaching strategies and software to ensure qualitative education. At the third stage, the efficiency of the proposed education pattern was tested. For this purpose, experimental student groups were made up. They were taught within the proposed education pattern, with special emphasis being made on computer application.

Computer as learning environment

As the current education system should be effective in teaching creative and initiative personalities who demonstrate cognitive flexibility and complex problem solving, it is essential to turn from reproductive approach in education to creative learning and innovative teaching. In this regard, importance of computer is indisputable as it allows learners to shape the required skills and competences independently by means of the relevant learning content. Daniel Araya noted that global network capitalism is a network model that involves democratization of education, development of horizontal links on a global scale, rise of self-discipline and interaction. It is this model that would define the education system of the future (Araya D., 2010) [2]. John Seely Brown [3] stated that the obligatory content of education programme should correlate to the basic competences, while additional aspects ("open" component) to be covered over the programme completion should be defined by the learners themselves according to the opportunities provided by the learning platforms.

Application of a computer in designing learning environment allows educators to settle a number of contradictions. The first contradiction arises due to the need, on the one hand, to minimize the length

Table 1. Results of (Partner-Companies) Engineers Survey

Group	Competences	Companies' activities		
		1*	2**	3***
Technical	Fundamental knowledge	90	60	72
	Engineering knowledge	90	56	78
	Application IT in professional problem solving	70	60	65
	Understanding of product life cycle and its stages	90	48	63
Personal	Creative and critical thinking	80	45	60
	Initiative	90	85	80
	Commitment to continuous self-development	90	90	90
	Ability to set goals and plan career	95	94	90
	Ethics and responsibility	98	95	95
Professional	Engineering thinking	98	56	68
	Ability to resolve professional tasks	95	95	92
	Systems thinking	95	48	71
	Ability to search and analyze information	95	85	80
	Knowledge of trends in engineering	98	60	70
Interpersonal and communi-cational	Ability to work in a team	80	90	90
	Business communication	90	75	85
	Foreign languages	90	70	70
	Ability to work effectively	95	95	95

Basic company's activity: 1* – Design and Manufacture of Vehicles and Automobile Intelligent Systems; 2** – Transportation and Logistics Management Systems; 3*** – Transportation Management and Safety.

of university attendance and, on the other hand, provide qualitative training in terms of acquired knowledge and competences. The second contradiction is stipulated by the need for maintaining high level of staff teaching skills and increasing faculty workload caused by constant revision of the learning content.

To settle the above-mentioned contradictions, the single unified learning environment, preferably supported by business, is required. This allows all programme stakeholders to combine their efforts in designing curricula and ensuring qualitative training. In this case, the concept of E-Learning 2.0 itself changes: «Motivation – purpose – tools – implementation».

In our opinion, engineering education should teach students how to define a problem and find the most appropriate way to solve it. That is what such courses as "Introduction to Engineering Activity", "Fundamentals of Product Design", and "Methods of Engineering Problem-Solving" are devoted to, as they familiarize students with the real-world examples of engineering problem-solving.

Computer as means of communication

Being able to communicate and work with people is still one of the most important competence, especially in engineering. Most skills and competences that are essential for sustainable development of the society can be developed only in a teamwork pattern. In addition, a deep insight into the media tools and technologies is also essential, since, in this case, engineering graduates are no longer just consumers of media products but producers who are able to think critically and help people raise their awareness about manipulation techniques (especially in advertising and PR) and make their own opinions about the reality.

The management of the global companies believes that competitiveness in the labor market is determined not only by proficiency level, but also by the ability to solve problems in a bilingual environment that stipulates human interaction by means of information technologies. Therefore, knowledge of foreign language is an essential component of successful professional career as it has already become a valuable tool for communication within the current information space. This fact urges educators to revise foreign language training of engineering graduates. Teaching foreign languages by means of computer software significantly improves the training process itself, as, unlike traditional teaching technologies, the use of computer ensures high information capacity and student independent work, stimulates students' cognitive activity and motivation, and provides them with valuable communication experience.

Thus, engineering programmes include such courses as "Intercultural Communication", "Translator in the Field of Professional Communication". Students are taught in the special language labs where they can practise and hone their communication skills. Participation in various international education projects (CDIO, Formula-student) provides students with an ideal opportunity to communicate with their counterparts all over the world.

Computer – virtual and augmented reality

Adequate information perception is a basis for its further analysis and decision making. As an engineer has to deal with complex systems, the systems of virtual (VR) and augmented reality (AR) are of great importance during the training process and further professional career. As stated [4], the advantages of AR use in education has become a point of attention of many specialists. However, there is an opinion [5] that educators should work together with researchers in order to design AR interfaces. According to [6, 7], one of the main advantages of AR is significant savings in time required for material revision, since students have an opportunity to learn independently. In addition, these technologies have a double effect: they allow teachers to increase efficiency of lab assignments and stimulate students' motivation. Students who participate in such projects as "virtual automobile", "virtual manufacture" have an opportunity not only to get insight into the complex engineering systems and logics of real technological processes, but also to acquire knowledge in system design and optimization.

Computer – tool for professional task solving

Being a part of professional competence, informative competence covers a number of specific issues related to the level of computerization within the definite professional domain. Besides, a specialist should have commitment to continuous development both in the professional sphere and related fields. Informative component of the professional competence should be developed upon the completion of a number of courses, internships and by participation in designed and real work-related activities that imitate real professional tasks. As employers want new hires to have knowledge in IT, the courses should be designed so that students have an opportunity to work with the software packages and mathematical models used for problem solving within the chosen professional domain.

Thus, students in various Design and Technology programmes (automobile manufacturing, engine technology) focus on the design of automobile systems. Therefore, students gain a deeper insight into 3D-modeling, simulation, and engineering analysis by means of Siemens PLM. The students who deal with design of smart control electronic systems enrich their experience of using Siemens NX, e-Series. The students in Automobile Manufacture Technology programme who are planning to work in the technological center study Plant Simulation and Tecnomatix (with modules Jack and Human Performance), which allows resolving ergonomic issues and enhancing technological processes by means of virtual models. Students employed in the field of Logistics and Operations Management study the theory of vehicle and transportation systems management, optimization methods in logistics and telematics, GIS via MiniTab, PTV Vision (VISSIM, VISUM), ArcGIS, MapInfo.

Computer – tool for assessing quality of engineering training

The shift to the test-based knowledge assessment system, increasing number of universities that are not able to ensure qualitative education are the basic challenges that are common to many countries. The formal indicators do not present fairly the condition of education system. However, the discussed learning environment and control systems allow students to assess their knowledge by themselves. The teaching staff can easily use computer tests for interim assessment, students' knowledge estimation, and grade-rating system. In addition, it is possible to calculate the time that a student spent on completing each module and revise the courses based on the obtained data.

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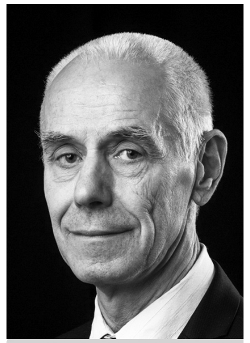
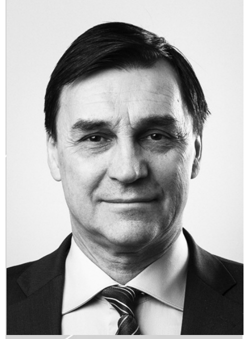


I.R. Kuznetsov



V.N. Malyshev

M.E. Shevchenko

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A System of Integrated Field-Oriented Training of Specialists Based on Innovative Research and Developments

Saint Petersburg Electrotechnical University "LETI"
I.R. Kuznetsov, V.N. Malyshev, M.E. Shevchenko
Scientific Research Institute Vector
O.G. Petkau, A.Yu. Tarakanov

The article presents innovative university strategy for solving scientific and practical problems and training of field-oriented specialists for science and industry focused on the development of an advanced interdisciplinary training of specialists and modernization of educational environment in the field of advanced radioelectronic measures, as well as on an efficient commercialization of scientific research and developments.

Key words: interdisciplinarity, field-oriented training, semi-active radiolocation, academic mobility.

The further presented concept of solving scientific and practical problems and training of field-oriented specialists for science and industry is aimed at the development of an advanced interdisciplinary training of specialists and modernization of educational environment in the field of advanced radioelectronic measures, as well as at efficient commercialization of scientific research and developments.

Assurance of advanced interdisciplinary training is based on attraction of intellectual and infrastructural resources both of a university and of a wide network of partners – research centers and scientific institutions. One of the dominant technologies is learning through research and participation in real-market developments (both at HEI's scientific centers and industry-based departments).

In the framework of a cluster for radioelectronics, professional equipment development, communication tools and infotelecommunications the key areas for developing cooperation between industry and Saint Petersburg Electrotechnical University "LETI" (SPb ETU "LETI") in scientific and educational fields are the following:

- Development of a targeted work order for specialists.
- Active career-guidance.
- Compliance of the list of Master programmes and their contents.
- Fostering of students' professional competences within Bachelor and Master programs.
- Execution of joint (network) study programs.
- Joint targeted training in the interest of military-industrial complex.
- Joint training of PhD students.
- Vocational education (for students and specialists).
- Joint programmes for professional development (Presidential Program);
- Professional accreditation of study programs.
- Scientific research and development projects.

Collaboration of universities and industrial enterprises is aimed at solving practice-oriented educational, scientific and technological problems in exploitation of advanced technologies in radioelectronics that respond to the Grand Challenges of Sustainable Development. Among the problems to solve are exploitation of St. Petersburg scientific capabilities, launching and promotion of innovative products on new markets, contribution to export, human

O.G. Petkau

A.Yu. Tarakanov

resourcing of innovative development of St. Petersburg economy, training and professional development of specialists for scientific and high-tech industries, fostering the integration of science, education and industry for commercialization of innovations.

A suitable example could be one of the oldest radio engineering enterprises – JSC "Research Institute "Vector" (founded in 1908, is a part of JSC "Radio Engineering Corporation "Vega") that has been successful in working for the defense industry.

JSC "Research Institute "Vector" carries out the orders of the Russian Federal Ministries for conducting research, design and development of tools for the following fields of radio engineering and radio electronics:

- Electromagnetic propagation physics with respect to various natural and artificial geophysical factors (earthquakes, storms, eclipses, etc.).
- Radio perception on communication hubs, integration of portable and stationary communication hubs.
- Monitoring of electromagnetic interference, direction finding and locating its sources, processing received signals in their stationary, mobile, marine, aero space and portative execution.
- Sonic monitoring.
- Testing radio electronic devices at all frequency intervals.
- Practical application of electronic devices for economic and technical monitoring, medical diagnostics and other.
- Microminiaturization of radio electronic device components.

SPb ETU "LETI" has developed an ongoing programme "Strategic partnership" that aims to assure high quality of professional training for specialists based on the integrative cooperation of university and interested enterprises and organizations (university's strategic partners) by consolidating the intellectual potential, material, financial and corporate resources [1].

SPb ETU "LETI" cooperates with more than 40 largest enterprises of the North-East region of the country, such as JSC "Research Institute "Vector", Group of industrial companies "TIRA" Corporation", JSC RIPR, JSC MART, JSC "NPO Radar MMS", CJSC "Kozitskiy Plant", JSC "Svetlana", JSC "Avant-garde", JSC "Concern "Okeanpribor", JSC "State Research Center for the Russian Federation Concern CSRI "Electropribor", JSC "Power Machines", JSC "REP Holding", the Institute of Applied Astronomy of the Russian Academy of Sciences, the Ioffe Institute and others. Among the international partners of SPSETU there are 18 large industrial enterprises, 7 science and research centers and institutes, and 65 universities from 35 countries. A specific system for field-oriented training has been created. Within this system the organizational and methodological guidance materials have been developed and tested for the joint (university-enterprise) scientific and research projects on development of science-driven high-tech products; professional developments of enterprises' staff and university faculty; Bachelor, Master and PnD students' internships; and targeted training of young specialists for enterprises [2]. Thus, JSC "Vostok" successfully employs a significant number of LETI graduates and holds all types of LETI students' internships. The enterprise forms groups of 12 to 15 students for Bachelor and Master targeted engineering training annually.

With the direct involvement of SPb ETU "LETI" and JSC "Vostok" a programme (the "20/80 Program") for training, retraining and professional development of workforce for the high-tech industries has been developed and executed from 2007. The aim of the programme was to support St. Petersburg large and medium enterprises that conduct training of their specialists and targeted education of students at field-oriented HEIs through providing grants for 80% of the total costs for training, retraining and professional development programs. During 2007-2011 several dozens of St. Petersburg enterprises, organizations and technical HEIs have participated in this program. More than a thousand specialists and students have been trained within the program. Due to the rise of the program's popularity a new

Programme for training, retraining and professional development of workforce for industry of Saint Petersburg has been launched from 2012 to 2015 by the Order of the Economic Development, Industrial Policy and Trade Committee No. 177-p of Feb-ruary 15, 2012. The programme was launched as a sequel to the previous "20/80 Program" and set strict criteria for selection of enterprises and organizations, as well as determined interconnections between all the stakeholders of the training process. The prerogative right for participation in the Programme was given to the enterprises and organizations of the military-industrial complex that have high-profile government contracts.

Best practice of executing municipal professional development programmes of workforce for high-tech industries have been taken into account when developing a Presidential Programme for professional development of engineering workforce for 2012-2014 and a State institutionalized programme "Professional development of engineering and technical workforce for 2015-2016", in which SPb ETU "LETI" and JSC "Research Institute "Vector" have taken active parts.

In the framework of the municipal programme for training and retraining of workforce for high-tech industries of Saint Petersburg, training and retraining of workforce is conducted under the request from enterprises. Within only the last three years different types of retraining programmes at SPb ETU "LETI" have been attended by more than 270 people. At the same time, the SPb ETU "LETI" faculty members get trained by attending professional development programmes on the premises of St. Petersburg enterprises.

In 2015, SPb ETU "LETI" won the third place among engineering universities in the Rating of HEIs' relevance (demand for their graduates) conducted by the "Social Navigator" of the International Information Agency "Russia Today" in cooperation with the Center for Labor Market Research (http://vid1.rian.ru/ig/ratings/Rating_uni_2015_Engin.htm). Overall there were 463 state, corporate, municipal and private HEIs from 80 constituent entities of the Russian Federation included in the Rating. All featured HEIs had conducted professional training on educational and vocational study programmes of higher education during 2014. Among the HEIs there were 87 classical universities, 140 technical universities, 56 agricultural HEIs, 61 HEIs from the sphere of management, 72 Social Sciences HEIs and 47 medical HEIs.

An important part of the innovation strategy for solving scientific and applied problems and field-oriented training of workforce for science and industry is the cooperation between JSC "Research Institute "Vector" and SPb ETU "LETI" in the fields of scientific research and development, as well as the conduction of methodical scientific research for the enhancement of specialists' education.

Cooperation between JSC "Research Institute "Vector" and SPb ETU "LETI" in the framework of the Strategic Partnership Agreement includes the development of prospective plans, execution of joint meetings of scientific and technical councils, and, based on these events, the selection of precise objectives and forms for organization of research and developments.

This approach allowed executing a number of large-scale projects, as well as a significant number of initiative works. Thus, in the framework of realization of the Saint Petersburg Government Decree No. 928 of August 30, 2012, "On amendments of the Saint Petersburg Government Decree No. 835 of June 28, 2011, and the 2012 procedure for granting subsidies for execution of events in the framework of the Comprehensive Programme "Science. Industry. Innovations" in Saint Petersburg during 2012-2015" the competition has been won by a scientific research programme "Development of a passive radiotechnical control system for metropolitan air environment by means of radio emission of digital video and radio broadcasting" (code "Metropolitan") in total of 30 million rubles. What is meant here is the scientific development of a system that solves core issues of radiolocation – detection of targets and determination of their coordinates by signals of the digital video and radio broadcasting. The objects of the research are semi-active radar systems – direction of radio radar, joining methods and means for detection of targets and determination of their coordinates by using signals of external sources.

In 2014 SPb ETU "LETI" and JSC "Research Institute "Vector" won the competition for working in the framework of projects on the development of high-tech production in line with the Russian Federation Governmental Decree No. 218 of April 09, 2010, on "Development of a passive coherent location complex for protection of critical facilities". The aim of the project is to develop a batch production of passive coherent location complex for protection of critical facilities notable for its enhanced exploitation and functional characteristics.

The system of semi-active radiolocation (PARLS) that uses illumination signals of external objects (such as broadcasting video and radio centers, basic stations of mobile systems, etc.) is considered today as prospective measure for determination and trajectory guidance of radiosilent terrestrial, offshore and aerial objects [3]. A semi-active radiolocation has a num-ber of advantages: lower production, arrangement and exploitation costs, a lack of need for frequency allotment, a lack of harmful environmental impact and a lack of disturbance for other radio engineering devices, as well as its furtivity. The features of the system for semi-active radio location determine a high potential of their implementation for protection of critical facilities, monitoring of perimeters and territories, including creation of low-altitude radar field. A wide spread occurrence of modern digital broadcasting and telecommunication systems provides PARLS with efficient illumination signals with good correlation characteristics, which allow receiving the needed technical specifications in a wide variety of application conditions.

A comprehensive approach to the development of these systems requires the involvement of specialists from different fields of knowledge and ensures the basis for interdisciplinary training of students based on joint innovative research and developments. Therefore, on the second Master cycle of education students are invited to choose an enterprise for their practice-oriented work and conduction of certain components of their curriculum. Student's independent work outside of the in-class learning is a necessary component of training Master students – qualified specialists that attend innovation programmes and are capable of solving, individually or in groups, various professional scientific, engineering and social problems using creative methods, able to apply to the practice the latest developments of progress in science and technology, able to adapt quickly to the changing economic conditions. Students' scientific and research work in a semester is seen as a constant independent work of a Master student on each of the four study semesters, which is not directly connected with the courses of the curriculum (the learning process of the latter includes their own specific forms of Master students' independent work) [4]. In line with the interdisciplinary projects, industrial and technological internships, design and engineering internships, as well as preparation of Master thesis, the scientific and research work in a semester is a component of Master student's independent work outside of the curriculum courses.

Cooperative activity of the SPb ETU "LETI" and industrial enterprises is executed in the framework of Strategic Partnership Agreements that incline mutually beneficial development in scientific, educational and innovation areas. Only the Faculty of Radio Engineering and Telecommunications of the SPb ETU "LETI" itself guides cooperation with leading enterprises of the region on 14 Strategic Partnership Agreements. The structure of the Faculty includes 5 industry-based departments (on the premises of JSC "Research Institute "Vector", JSC "NPO Radar MMS", the Institute of Applied Astronomy of the Russian Academy of Sciences, Institute of Silicate Chemistry of RAS, Television Research Institute), as well as a number of joint scientific research divisions.

The most severe tension around the issue of field-oriented training of specialists for modernization and development of the real economy is allocated at the administrative bodies of the industrially developed regions. St. Petersburg has approved and executed a Comprehensive Programme "Science. Industry. Innovations" for 2012-2015 (approved by the Saint Petersburg Government Decree No. 835 of June 28, 2011). The basis of this programme is a cluster model for the development of industry in St. Petersburg that unites highly essential enterprises and organizations.

Starting from 2009, SPb ETU "LETI" and JSC "Research Institute "Vector" have been actively involved in the execution of study programmes for academic mobility of students and faculty. The Government of Saint Petersburg (The Committee on Science and Higher Education) provides financial support to the HEIs taking part in the programmes for academic mobility of students and faculty from other HEIs according to their level of participation in the programs. Academic mobility can be executed in a form of students' participation in the following programs: network (joint) study programmes (NSP); exchange programs; programmes for short-term partial education; traineeships or internships; summer schools.

At the same year, SPSETU has started executing a project on organization of development and experimental approbation of a project on academic mobility enhancement for students, PhD students and faculty of HEIs that conduct training of workforce for industries securing modernization and technological development of Russian Federation economy. Study programmes (modules) have to correspond to one of the prioritized areas of modernization and technological development of Russian economy: energy efficiency, nuclear technologies, space technologies and telecommunications, medical technologies and pharmaceuticals; strategic information technologies and software.

Starting from the fall of 2014, SPSETU together with JSC "Research Institute "Vector" and JSC "NPO Radar MMS" execute two projects: "Training of highly qualified specialists in the field of special radio electronics systems" and "Training of qualified specialists in the field of Super-High Frequency systems, ultrabroadband radiolocation and radio contact" in the framework of performance of the open public tender terms for providing support for programmes on workforce training system development for military-industrial complex at educational organizations of higher education under the jurisdiction of the Ministry of Education and Science of the Russian Federation (minutes of the tender commission meeting No. AK-158/05pr of September 19, 2014, and No. AC-68/05pr of September 25, 2014).

From 2012, the Ministry of Education and Science of the Russian Federation has organized the work in line with the Presidential Programme for professional development of engineering workforce for 2012-2014, approved by the Order of the President of the Russian Federation No. 594 of May 07, 2012. Based on the evaluation of the Presidential Program's productiveness, it has been decided to continue it in the form of an institutionalized targeted programme "Professional development of engineering and technical workforce for 2015-2016", approved by the Order of the Ministry of Education and Science of the Russian Federation No. 490 of May 12, 2015.

An important component of specialists' training assessment is the professional accreditation of HEI's study programs, which for engineering majors is carried out by the Association for Engineering Education of Russia. SPb ETU "LETI" has already received the EUR-ACE label for its 34 study programmes that are being executed from 2014 to 2020.

In the courtesy of the network cooperation development between the university and scientific and educational organizations, enterprises of high-tech fields of economy, SPb ETU "LETI" has modernized and developed a professional environment that allows to generate, apply and disseminate knowledge on prioritized areas of modernization and technological development of the university, which is highly demanded by the society and the government.

In a close cooperation with potential employers the interdisciplinary study programmes have been developed and executed. The innovative Master programmes with industry-targeted component are set atop. Based on them the programmes for vocational education, professional development and retraining are executed in a modular format. A joint training of PhD students is being developed. Joint systematic execution of methodical science and research work allows a constant targeted modernization of educational process's forms and contents both in the interest of enterprises and with a focus on an advanced development of interdisciplinary training of workforce and modernization of teaching and learning methods in the field of advanced radio electronics.

A longstanding fruitful cooperation between SPb ETU "LETI" and enterprises in the spheres of scientific research and development assures the development of interdisciplinary training of workforce and modernization of educational environment in the field of prospective radio electronic devices, as well as an efficient commercialization of R&D results. Such cooperation is a good example of development and consecutive exploitation of innovation strategy for solving interdisciplinary scientific and applied problems and targeted training of specialists for science and industry.

The outputs contribute to the development of scientific potential and innovative infrastructure of St. Petersburg, launching and promotion of innovation products on new markets and contribution to export, as well as the human resourcing of the St. Petersburg economy's innovative development, the training and professional development of workforce for science and high-tech production industries, the development of integration processes in industry, science and education for commercialization of innovations, and the support of clusters' development in Saint Petersburg.

When working on the article the results of the design and development project "Development of a passive coherent locational complex for protection of critical facilities" have been used. The project is conducted by SPb ETU "LETI" under the agreement with JSC "Vostok" in the framework of a Comprehensive Project on development of high-tech production and is financed by the Ministry of Education and Science of the Russian Federation (RF Government Decree No. 218 of April 09, 2010).

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A.G. Zakharova


K.O. Ponomareva

UDC 378

Synergy of Educational Cluster Development in the Framework of a University Supplementary Professional Education

National Research Tomsk Polytechnic University
A.G. Zakharova, K.O. Ponomareva

The article deals with advantages of cluster additional vocational education. Synergetic effect is considered in the development of programme cluster in the framework of additional vocational education in a university. A strategy in programme cluster development is suggested using scenario development based on "neosystem approach".

Key words: additional vocational education, educational cluster, a cluster of additional professional education programs, synergies interdisciplinarity, innovation, benchmarking.

Transformations taking place in our country have promoted modernization of education providing qualitative development of human potential, which is largely defined by the change in content and quality of education including additional vocational one. The system of additional vocational education is rather a dynamic system of perspective development of a person possessing potential creativity and fulfilling herself /himself by means of definite competencies, its social and professional mobility.

At present, in the system of additional vocational education (AVE), educational clusters are rapidly being developed. They are intended to train highly-qualified and competitive specialists possessing professional independency. The qualitative characteristic of the new stage in a university's development is an educational cluster, in which all structural elements are transformed, their interconnections and features are clearly observed in innovations of education process.

Innovation as an important feature of new economy is, first of all, revealed in the ability to transfer knowledge (the result of research and educational activity) into development of new products, projects, processes, and services. In the system of additional vocational education, new uniform consistent curricula are developed to train specialists at all levels.

The advantage of the cluster approach consists of development of learning goals by learners themselves – "knowledge in action". AVE course participants are in the condition of specific project innovative activity. Learning is based on training personnel capable of managing the processes in an education institution, region, country, and the world.

"Cluster" is a strand, chain or connector that is capable of being an organizing or integrating principle. M. Porter defines cluster in the following way: "it is a cross-industry network confined by the system of reproduction communication of enterprises located in the same site and united by technological innovations". He introduces a concept of communication as a system-generating principle of synergetic relations. Within the cluster there is a growth in employment, investments, and accelerated distribution of advanced innovative technologies in economy. One of the main conditions for cluster development is an extensive network of additional vocational education. Development of educational clusters contributes to implementing the strategy of a university's or a region's innovative development.

Considering a cluster in the university environment, it is, first of all, worth paying attention to a cluster structure. Cluster is based on interactions built upon formation of links among different departments of an organization. Closeness of cluster elements allows increasing the effect of synergy. Development of cluster implies formation of horizontal and vertical links based on synergy, i.e. all elements in the structure would function on the basis of cooperation. Hence, the cluster is the highest form of organization in mutual development of all elements. Educational cluster is a combination of interconnected enterprises of vocational education united on the grounds of industrial profile and partnership relations with other industry players.

Development of curricula cluster is conditioned by necessity of integrating all disciplines and business projects in a definite sphere, fundamental research and modern project system of new educational products, their production and implementation in the university AVE based on interdisciplinary and transdisciplinary approaches. Integration of technology and knowledge transfer cycles originates developing curricula cluster which unites several groundbreaking educational products in its structure. Transfer to cluster is connected, first of all, with development of integration processes in learning individualization based on transformation and replacement by new innovative techniques of exsiting AVE curricula.

The foundation of curricula cluster development is, first of all, integration of different education programs, among which there is synergy; secondly, innovative pedagogical technologies based on humanitarian paradigm and new principles of education system in the sphere of additional education, using the "life-long learning" rule in the new systems of practice and activity. Curricula cluster is developed to accumulate new trends in AVE university system by means of arrangement of educational grounds, involvement of leading researchers and specialists from business communities to university; In this case, there is an intensive knowledge circulation (fundamental, engineering, technological, humanitarian, natural-science, economic), which is a foundation for curricula cluster management using complex practice-oriented knowledge and humanitarian theories based on subject-subject relations. From this point of view, curricula cluster development implies mutual organization of engineering, natural-science, humanities and spheres. The developed curricula cluster is efficient in education institution only that adopts new and new innovative and differentiated scheme of activities, such as a university.

When developing curricula cluster, synergy is manifested in the following forms presented by I. Ansoff [3, p. 18-20]:

- sales synergy of post-diploma education product;
- operating synergy in collaborative learning in the specialists' network structure;
- management synergy;
- investment synergy in innovation transfer projection within the cluster.

In the process of curricula cluster formation a student is integrated into positive stage-by-stage development by means of:

- development of guaranteed consumption of post-diploma educational products around the system;
- formation of new infrastructure; development of structural mega curricula cluster (interdisciplinary projects);
- initiation of contractual relationships and building contracts with immediate consumers of post-diploma education product, for example, education management or local business community, which, in their turn, guarantee the consumption of education products.

Curricula clusters are to meet the following requirments: to have a basic resource of developed and existing curricula; have some identical curricula based on module approach and connected between each other; be attractive to customers [2, p. 48-50].

The criteria of curricula cluster priority are as follows: in terms of curricula cluster potential (current curricula and their number); in terms of infrastructure (specialized education); in terms of curricula cluster culture at a given moment (level of interaction / building relationships between the curricula, AVE departments, motivation of parties involved programmes of additional vocational training, potential leaders of university's AVE system, leading highly demand curricula based on qualitative and quantitative indicators).

A significant factor for successful development of curricula cluster is sustainable development strategy formed on multi-factor basis of final education product and modelled by us using the following components [4, p. 3-5]:

- benchmarking of curricula cluster as a a comparison of advanced domestic and foreign research technologies or some varaible experimental programs;
- development of coordination and cooperation plan within the curricula cluster to increase competitiveness of final education products;
- customer focus on educational products;
- selection of curricula cluster's name, its brand;
- increase in the number of stakehoplders and specialists involved in cluster initiatives.

As K.L. Komarov states [1, p. 52-54], benchmarking is not limited to the study in experience of competitors and world leaders. This method is to be one of the key components in continuous improvement of any activity since benchmarking is a regularly performed comparison of activity elements with similar elements of a more successful activity at macro- and microlevels.

Let us consider the types of scientific criteria for benchmarking, i.e. comparison of the level of potential market creativity in terms of the following parameters:

- psycological readiness for European standards of post-diploma educational services;
- requirements of the RF Ministry of Education and Science for definite level of additional vocational re-training.

The preventive consistency of benchmarking is defined as a multifaceted approach to long-term marketing forecast of future consumers' preferences for post-diploma education product.

Cluster structure allows differentiating programmes and developing infrastructure via [5, p. 23-24]:

- specialization in basic majors of university;
- structuring the university inner networks where interaction between AVE structure occurs on the basis of interdisciplinary and competence-oriented approaches;
- research and development of large projects within a university, cooperation with government and public institutions, business community (order of a definite curriculum);
- competent and effective management and education marketing;
- university teaching staff's motivation;
- access to financial flows, development of proactive business activity of AVE departments.

In our opinion, the objectives of university higher management are to be analysis, long-term forecasting, evaluation of produced synergy in AVE curricula cluster to plan long-term solutions on their further application, extension of curricula cluster complex multiplying the AVE programme potential demanded by education service market and local labor market.

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UDC 378.1

V.M. Kutuzov

N.V. Lysenko

Fostering Professional Competences within Integrated Engineering Education Programs

Saint Petersburg Electrotechnical University "LETI"
V.M. Kutuzov, N.V. Lysenko

The article discloses special aspects of specialists' cycle education. The requirements of employers towards HEI graduates' competences are presented. Types of Centers for Competences executing integrated educational programmes are described.

Key words: integrated educational program, graduates' competences, interdisciplinarity.

Main international trends in the development of engineering education lie in the realization of the following principles:

- Interdisciplinarity (integrativeness).
- Informational openness.
- Mobility and variability.
- Internationalization.
- Network cooperation.
- Distance learning.
- Integration of science, industry and society.
- Life-Long Learning.

At the same time, engineering education should be:

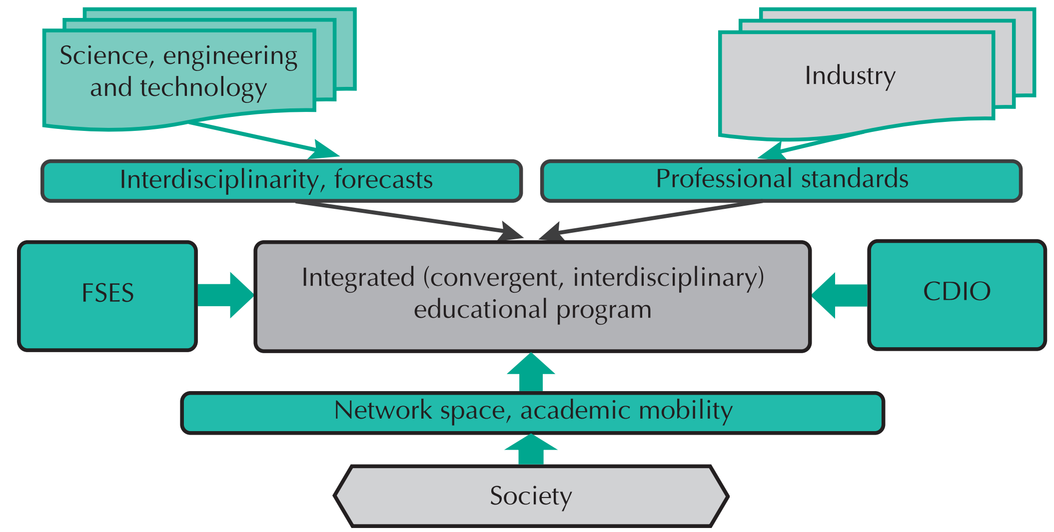
- **forward-looking and advanced** with regard to the dynamically changing engineering and technology;
- **interactive** – allowing students and teaching staff to acquire professional competences of independent exploration, receiving and application of new knowledge within the educational process;
- **integrative** – based on the principles of network cooperation, the integration between different fields of science and technology, and the potential of all the educational process stakeholders.

Realization of these ideas is only possible by means of introducing to the educational process the integrated (interdisciplinary) educational programs, whose content is based on the forecasts in science, engineering and technology, the requirements of professional standards, society and current Federal State Educational Standards – FSES (Fig. 1).

The key problem of realization of the current Federal State Educational Standard lies in the following: Bachelor programmes that imply professional activity after receiving the diploma have to have a very prominent practice-oriented character. At the same time, Bachelors willing to continue their successful education at a Master level, have to receive deep fundamental training both generally (physics, math, chemistry) and professionally (in line with the major).

The Saint Petersburg Electrotecnical University "LETI" (SPb ETU "LETI") has a cycle education scheme that provides fundamental background in the framework of unified training in line with the major during the first 2–3 years, and then an opportunity to choose one or another educational profile (specialization) within Bachelor studies after an initial acquaintance with student's possible future professional activities at strategic partner enterprises. After finishing Bachelor education the most prepared graduates, who have succeeded in competitive selection, choose a Master educational program. Their Master education lasts for 2 years in line with the programs, whose contents are approved by employers and reflect modern requirements of labor market, as well as top-rated achievements in one or another field of engineering and technology.

Fig 1. Integrated educational program



For SPb ETU the Master cycle of education is the top-priority educational cycle. The number of budgetary (state-financed) places for Master students is no less than 60% of the number of first-year Bachelor students.

Realization of the cycle training assures a real possibility for flexible adaptation of the study programs' content, selection of an individual learning path, early career-guidance for students. At the same time, a certain updating of the educational process infrastructure is expected to take place, which is be aimed at providing immediate access for each student to the up-to-date knowledge databases, technologies and achievements in science and engineering. The key role in this case is played by an early (almost at the first study year) career-guidance for students, which is provided with the help and direct involvement of employers – university's strategic partners.

The procedure for creating and updating educational programmes of Master level and Bachelor profiles (specializations) anticipates the involvement of employers (strategic partners) in the process of fostering required graduates' professional competences, the development of educational content and employers direct involvement in the programs' realization.

Modern professional standards require fostering unordinary graduates' competences as the following ones:

- an ability to depict a scientific world view adequately relating to the modern level of knowledge and based on the known fundamental principles, laws and methods of natural sciences, information and mathematical theories, understanding of the scientific and social essence of problems that occur in professional activities;
- an ability to find organizational and managerial solutions to abnormal managerial situations at small groups of people and readiness to take the responsibility for them;
- an ability to recognize social significance of one's future profession, to have high level of motivation for conducting professional activity, to strive for personal growth, enhancement of one's qualification and mastership, to critically evaluate own strengths and weaknesses, set paths and chose means for reinforcing strengths and dissolving weaknesses;

- an ability to collect, process, analyze and structure scientific and technical information in the field of audiovisual engineering, to apply the developments of domestic and foreign science, engineering and technology, to apply modern programme software for development and editing of images and technical drawings, to prepare design and engineering documentation, to conduct feasibility studies for instruments' and systems' projects.

It should be noted that in the professional standards professional competences are described indirectly through working functions, working actions, knowledge and skills (Fig. 2).

Development of a unified informational space assures a distributed network system of cooperation between the university and its strategic partners, Russian and foreign universities, research organizations, i.e. assures the realization of integrated educational programs.

Network cooperation has the following advantages:

- Reacting more rapidly to the external and internal changes due to its ability to reconfigure and attract new participants.
- Focusing activities on the prioritized fields of educational clusters' development.
- Attracting best partners with particular advantages for cooperation.
- Exchanging unique knowledge.
- Creating a "network society".

University designs and develops integrated educational programmes as means for fostering professional competences. Focusing on that, and in order to enlarge the prospective functional opportunities of the university, it provides access to the scientific and educational resources, including access to unique equipment and programme systems of Centers for Competences, Centers for Prototyping and Centers for Engineering Competences, as well as an opportunity for on-sight communication of educational process participants (Fig. 3).

According to the term, Center for competences is a specific structural unit of an organization, whose function is to control key fields of action by collecting corresponding knowledge and finding ways to apply it in a maximum efficient way.

The role of the Center for competences is to assure integration of knowledge and processes, to give all the interested parties

Fig 2. Structure of a professional standard

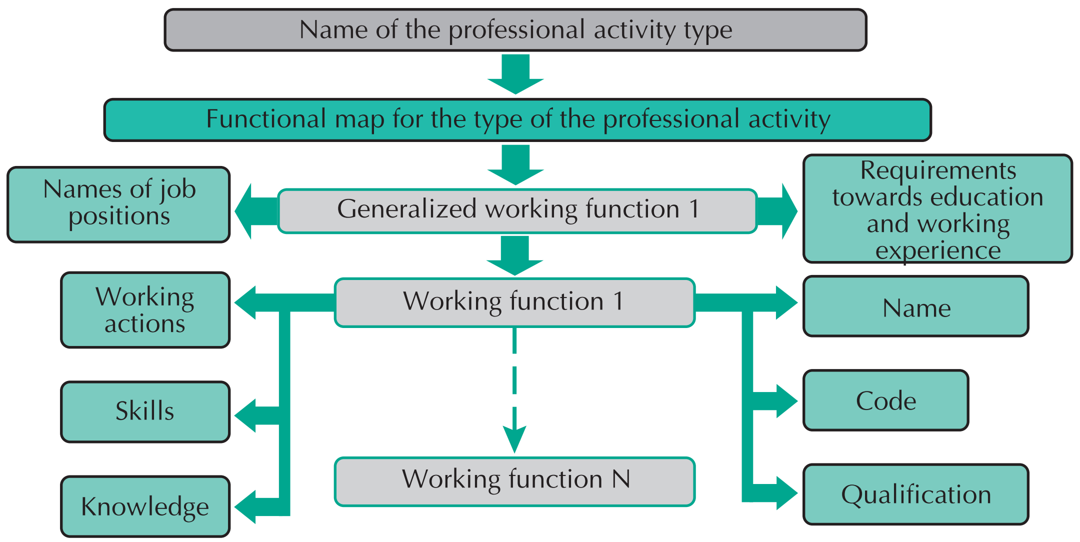
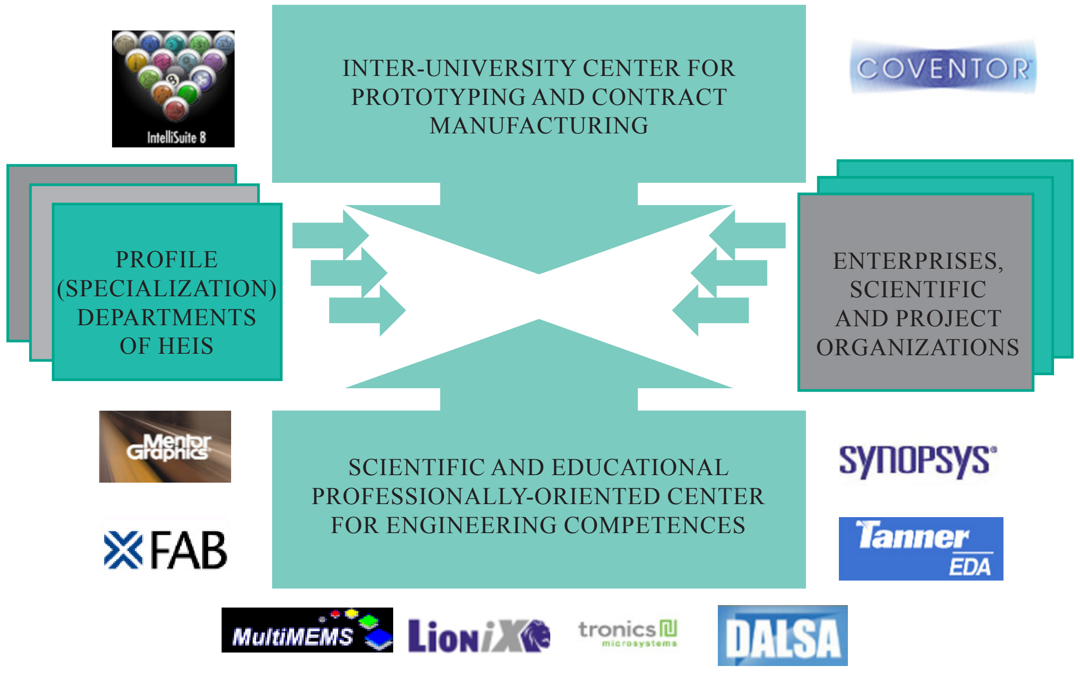


Fig. 3. Professional competence development at centers for engineering competences, prototyping and contract manufacturing



(faculty, top-management, students, and employers) access to the resources and to create an efficient way for communicating. In other words, the Center for Competences works in a way to assure the possibility for operative communication with each other and to receive all the information needed for efficient performance.

The practice shows that there are several types of Centers for Competences that differ according to their key objective:

1. A Center for Competences that works on collecting examples of excellent performance. The main "subjects of interest" of such Center are the so-called best practices that have been performed on one of the core areas of action of an HEI. The Center works on identifying and systemizing such practices, as well as on developing corresponding standards and implementing the received expertise generally.

2. A Center for Competences that aims at development of technological standards. The knowledge acquired by this Center is commonly of the engineering sphere, particularly referring to the development of software, technologies, and equipment. The main objective is to standardize processes, to develop a unified technological platform and interlinked data banks.

3. A Center for Competences that maintains numerous projects and initiatives relating to knowledge management, for instance, staff training on new products and services, assessment of applied technologies, etc.

4. A Center for Competences that supports the overall integration of processes and data for the whole organization. Its aim is to assure staff's global knowledge exchange on a corporate level and recirculation of this knowledge.

Today the humanity is on the edge of a wide spread occurrence of the so-called 6th technological wave [1, 2, pp. 159–166], the essential aspects of which are the following fields of science, engineering and technology:

- Nanoelectronics.
- Molecular and Nanophotonics.
- Nanomaterials and Nanostructured Surfaces.
- Nanosystems Engineering.
- Biotechnologies.
- Information Technologies.
- Cognitive Sciences.
- Social Sciences and Humanities/
- Nano-, Bio-, Info- and Cognitive technologies' convergence (the so-called NBICS-convergence).

The key aspects of the 6^{th} technological wave are the Nanotechnologies and Cell Technologies. According to the prognosis, the main advantage of this wave comparing to the previous one would be a radical decrease of production's power and material consumption and designing of materials and organisms with tailor-made properties.

It is evident that only the development and execution of the integrated (interdisciplinary) educational programmes will allow the formation of professional competences needed by a modern specialist.

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Interdisciplinarity in Education: Education Programmme Design

Kazan National Research Technological University
L.V. Redin, V.G. Ivanov

L.V. Redin

V.G. Ivanov

The significance of interdisciplinarity in education under the condition of sharp growth in patent activity in developed countries and the increased role of intellectual property items in modern economy are shown. Inderdisciplinarity is based on the network relations among the studied disciplines. Goal, content, and trends in interdisciplinarity are presented in the system of re-training, staff development, and Bachelor's training.

Key words: interdisciplinarity of education, methodology, network, thinking, innovation.

"Systems cannot be controlled,
but they can be created and redone"
D.L. Meadows [1, p. 274]

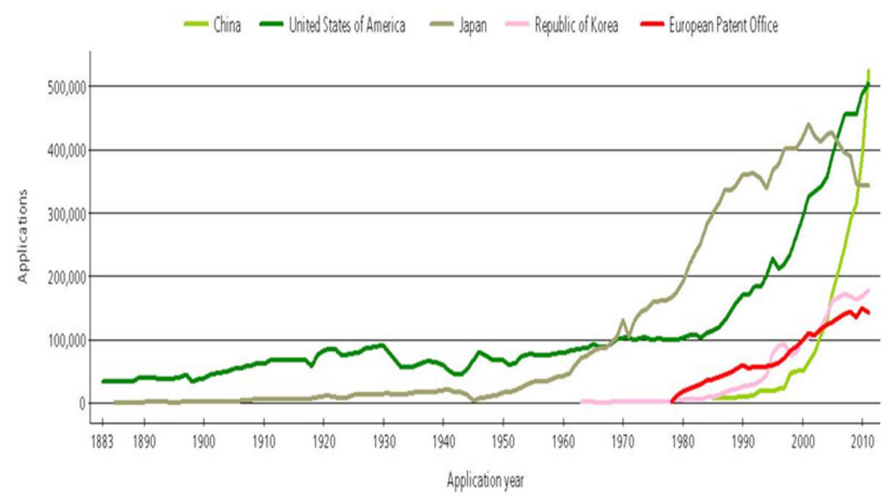
One of the major modern peculiarities is conditioned by changes in development of social-economic civilization model stipulated by transition from consumer economy and trade in resources, commodities, and services to the society based on knowledge and the priority of knowledge economy (innovative economy).

At present, innovations are introduced in all spheres of life: science, engineering, industry, education, business, and everyday life in the form of new tools and labour conditions, new technological aspects of production, new products and services, new research-production methods, new values, concepts, ways of understanding, complications, and improvements in quality of informative-structural-functional means of organization-management solutions. In general, innovations are conditioned by information technologies that cover all spheres of human life and have a tendency to double capacity within a year – exponential growth (technological singularity, "phase transition") [2].

In this case, the consciousness intensity and trade volume of intellectual property assets rise sharply, first of all, in advanced world powers (USA, China, Japan). Patent activity of leading economic countries is shown in Fig. 1. As seen from the figure below, the advanced countries in the sphere of patent activity have some inflection points in the historical flashback after which there is a sharp acceleration in dynamics of invention applications (Japan – 1950-70; USA – 1985-90; China – 1995-2000).

Rapid growth of patent activity is conditioned by approved national strategy of research-innovative-technological breakthrough due to which a new post-industrial foundation for the country's development is established. State and public innovative-investment resources are concentrated in the strategic spheres providing dissemination of high research and technology knowledge over the whole economic system of the country. It is evident that the sharp growth in patent activity, along with transformations in economic sphere, is connected with changes in education paradigm, as well as development and implementation of innovative educational programmes to foster the commitment to inventive and innovative activities in the participants of economic process. For instance, in the USA in 1990 the programme of formation and development of creative qualities and inventive thinking was adopted, its initiator being the US PATENT and Trademark Office (USPTO) [4]. In

Fig. 1. Dynamics of invention application in the leading countries [3, p. 47].



Japan, in its turn, the universities do not train focused specialists («specialist»), but those of the higher level of generalization («generalist») [5, p. 43]. Over 2003-2014 in China the number of invention applications increased 8 times and since 2011 China has been steadily ranked at the top in terms of this indicator. Particularly, China intensified the modification of innovative strategy, acceleration of patent activity, and attention to investments in high-tech technologies after WTO accession in 2001 [6].

Hence, there is a demand for not just knowledge economy, but "new knowledge economy" [5, p. 42] and additional creative-thinking innovative competencies. Development of "new knowledge economy" and creative-thinking-innovative competencies is a process related not only to and not so much the sphere of economy itself, but also and even more extensively and deeper covers state building (policy), science, education, and culture. In this case, innovations are not only involved in the sphere of economy, science, and technology, but also related to new concepts, values, new policy, strategies, and ways of thinking.

Therefore, a society of competitive structure needs personnel ready and capable of inventory, innovative-managerial and rationalization activity, possessing inter-disciplinary knowledge and tools of generating a reliable and effective solution with high level of novelty (patentability), innovativeness (social-commercial efficiency), reliability and responsibility, and strategies in development of invention "resource" in the professional sphere.

In this case, interdisciplinarity is a presentation of definite disciplines, their structures, and contents, specific methods at the level of integration (general unity) as a structuring single, particular, general one based on integration of semantic and axiological criteria. The basis of learning process interdisciplinarity is not in opposition of definite disciplines, but in their juxtaposition and interconnection of content, methods, etc. Interdisciplinarity is not a reflection of subjects or methods by science; it is inclusion of knowledge of subjects and methods of every science into united-integrated scientific world image. This integration requires system incorporation on the basis of common methods and tasks [7].

Interdisciplinarity of learning process includes multidisciplinarity, convergence of knowledge and divergence of opportunities, intensifies juxtaposition of natural, engineering, technological, social-economic sciences and humanities, spheres of culture and spiritual concepts, in this way having a dialectic-synergetic influence on drastic changes in culture, economy, engineering and technology, spiritual life, promoting development of educational integrative programmes to increase their ideality. Interdisciplinarity of education minimizes the knowledge (methodologization) within one discipline, but, at the same time, discovers it in a new perspective, maximizing it in other disciplines (multidisciplinarity). Interdisciplinarity provides information-knowledge conductivity of educational environment, its transparency, continuity, consistency, and compatibility. In the process of education interdisciplinarity the task is set to develop isomorphism of semantic thinking structures in different disciplines. It contributes to mutual understanding by the experts in different scientific fields and opens the floodgates for metadisciplinarity and transdisciplinarity [8-10].

Under such conditions, theoretical knowledge plays a particular role (in contrast to industrial society where empirical approach prevailed) providing intellectual technologies and intellectual organizations. It is explained by the fact that information is not creative power if it fails to be meaningful, realized, comprehensive, minimized to theoretical concept, i.e. it has not become structural knowledge yet, i.e. based on methodology. Hence, the major productive force of the modern society becomes a subjective factor depending on level of human development, human thinking, human place and role in social-business system, conditions of interaction with Nature.

Thus, there is a necessity, a demand for new research-engineering, educational, and social-economic paradigm, new methods, the elements of which are:

- holistic approach, principle of all-encompassing unity;
- environmental awareness (in ideological aspect);
- harmony in interaction of a man, machine, object, information, and nature;
- principle of system synergy, principle of refilling;
- self-organization (self-regulation, self-discovery, reflection);
- systematic thinking;
- metasystematic thinking;
- logical principle of included fourth (metasystem, trans-dimentions);
- openness (continuity, consistency, commensurability);
- interactions, but not struggle;
- ecological-aesthetic-economic principles, eco-design;
- dialectic synergy of freedom, debt, justice, and responsibility;
- new consumption and production models;
- cooperation (solidarity, collaboration, additionality, replenishment, respect, tolerance), but not competition;
- temporal unity (principles of actualization, history, futurism);
- dialectic-synergy of the unity, whole, and completeness.

To achieve this goal, one needs, first of all, interdisciplinarity of learning process focused on human consciousness development and the level of staff's moral, social-economic, professional experience (competencies). There is a need for not only professional training of prospective engineer, but also formation of integral, cultural personality capable of living in harmony in the world, society, in time and in its entirety (concepts of «"I", "Other", "We", temporal unity).

To train the staff for "economy of new knowledge" and creative-thinking-innovative competencies at the department of engineering pedagogy and psychology, Kazan National Research Technological University (KNRTU), one of the article authors developed the pedagogic system including:

- staff development at the enterprises and institutions based on the programme "Training for inventory and innovative activities: bases for enterprises' competitiveness and innovative development";
- retraining of pedagogical staff in the Volga and Ural regions using the programme "Pedagogy of high school";
- training in the system of academic and applied baccalaureate (full and part-time forms) on the major 44.03.04 – "Professional training", profile – Chemical production.

The basis of the given pedagogical system consists in authors' concept of integrative metasystem innovative thinking method (IMITM) [11-14], focused on knowledge convergence, training staff competent in pedagogic, engineering, psychological, creative, and economic sciences. In this case, the interdisciplinary approach is intentionally applied to retrain and develop staff, to train future specialists by means of knowledge and skill transfer that allows them to be competitive in the contemporary labour market.

The staff development programme is intended for experts of management, engineering, patent, production, economic, marketing, commercial services as well as service of enterprise quality and standardization focused on inventory and innovative activity at enterprise and increase in efficiency and reliability of solutions for non-standard problems made by administration at different organization levels.

The staff development programme is implemented in the form of courses of different levels:

I level – theoretical course of inventory methods (IMITM) with visual examples and research-engineering creative methods.

II level – extension of knowledge and skill in theoretical course and application of research-engineering creative methods by means of solution of appropriate problems.

III level – problem solution under teacher's supervision formulated by a student independently on the basis of problem-based situations in his/her professional sphere.

IV level – tutorial instructions on definite problem-based professional situations.

V level – training for teaching in innovative (inventory) activities.

The programme of teaching staff development includes the following disciplines united by uniform methods and concepts:

- "Methods of creative activity".
- "Innovations in professional sphere".
- "Culture of logic thinking".
- "Methods of research-engineering creativity".
- "Methods and technologies of competence development".
- "Psychology in engineering".
- "Design in specialists' training system".
- "Professional aesthetics and ethics".

The bachelor programme was developed in accordance with the Federal State Educational Standard [15] based on the regional educational component focused on development of commitment to use new knowledge and creative thinking-innovative competencies and includes the following disciplines:

- Psychology of intellectual activity.
- Professional aesthetics.
- Legal bases of education.
- Results of intellectual activity.
- Management of intellectual activity.
- TIPS-pedagogy.
- Methods of creativity.
- Heuristic methods of thinking.
- Bases of inventory activity.
- Engineering aesthetics and design.
- Innovations in education.
- Project in education.
- Forecasting in education.
- Professional psychology and ethics.
- Knowledge management.
- Marketing and management.
- Bases of consumer culture.
- Bases of practical rhetoric and debates.
- Qualimetry in education.
- Bases of scientific methods in education.

In this case, interdisciplinarity of education is based on network interaction of studied disciplines. It is pedagogical integration in the complex of natural, engineering, technological, mathematical, social-economic, legal, philosophic, and humanitarian knowledge. Besides, multidisciplinarity of education develops a uniform, integrated, dynamically interactive, recursive-continual, dialectic-synergetic, fractal-holographic existence image and relevant mode (modality) of student thinking. Education multi-disciplinarity (its content and structure) may be referred to the category defining quality of education and personal culture in post-industrial period. Improvement and extension of education due to its interdisciplinarity introduces the relevant content of invariant part of learning process which is so necessary in modern innovative conditions, when one should response to new social challenges, new technologies, and new markets quickly and adequately, making decisions in the unbalanced condition of uncertainty keeping balance of mobility and stability. At the same time, transition to interdisciplinarity of education is neither technological nor conceptual one. It is the problem of values, rational will, and choice.

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Development of Specialists' Training Environment for Interdisciplinary Research Projects Using RASA Center in Tomsk as an Example

National Research Tomsk Polytechnic University
Yu.Sh. Sirazitdinova, O.O. Bugayeva

Yu.Sh. Sirazitdinova

O.O. Bugayeva

At present, the Russian system of higher professional education stands at a pivotal moment. Challenges of globalization and international competition for talented specialists pose new problems for the Russian universities. The article considers experience of Tomsk Polytechnic University in development of environment for training students in interdisciplinary research projects in collaboration with leading scientists and research-educational centers.

Key words: university management, international research collaborations management, research environment development, interdisciplinary research projects, training research staff.

To respond to the international trends and temps of development in 2013 a project of increasing Russian universities' competitiveness was created for the leading world research-educational centers – Project 5-100[1]. The basic goal of the Project is "to enhance the capacity of research potential of the Russian universities, strengthen their competitiveness in the global market of educational services"[2]. By 2020 five leading universities of the country are to be included in TOP-100 world universities list according to the QS international rating[3].

What does the university competitiveness in the world educational market consist of? According to the QS rating methods a university position in the world market is determined by the values of six indicators with different share[4]: Academic reputation – 40%, reputation among employers – 10%, the ration of students' number to the number of research-teaching staff (RTS) – 20%, citation per one RTS – 20%, share of foreign RTS – 5%, share of foreign students – 5%.

Hence, the universities-Project participators develop the strategy of the indicator achievement in their "road maps" to be ranked upward in the QS rating and increase competitiveness in the global market of educational services. It is just globalization that is one of the prerequisites of the Project development: "If we do not have globally competitive universities, talented specialists will go abroad to study and live there. But if there were some competitive universities, would the most people stay here?"[5].

According to the data of 2012 in the period from 1989 to 2004 about 25 thousand researchers left Russia, 30

[1] Ukaz № 599 Prezidenta Rossiiskoi Federatsii «O merakh po realizatsii gosudarstvennoi politiki v oblasti obrazovaniya i nauki» [The Order № 599 by the President of the Russian Federation on the Measures of Implementing the Government Policy in the Sphere of Education and Science] (in Russ.).

[2] O Proekte.5-100 [About Project 5-100], Available at: http://5top100.ru/about/more-about/

[3] Official site of QS Top Universities, Available at: http://www.topuniversities.com/

[4] Methodology of QS Top Universities, Available at: http://www.topuniversities.com/university-rankings-articles/world-university-rankings/qs-world-university-rankings-methodology

[5] Iz interv'yu rektora Tomskogo politekhnicheskogo universiteta P.S. Chubika zhurnalu «Ekspert» [From the interview of Tomsk Polytechnic University rector P.S. Chubik to Expert journal, Available at: http://news.tpu.ru/actual/2013/11/11/20625/?title=universitety_konkuriruyut_za_umy&print=1

thousand researchers work on temporary contracts abroad [1]. Based on the latest research, of all Russian students learning abroad only quarter of them plan to return, but 45% are going to stay there, but with the possibility to contact with countrymen [2]. Hence, creation of attractive environment for talented young men is one of the key problems for the Russian universities and the country in general.

The universities-Project 5-100 participators developed unique strategies to place the top positions in the international ratings based on their unique competencies and resources, history and traditions. Thus, National Research Tomsk Polytechnic University, one of the leading participators of Project 5-100, defines its strategic goal as: "Development of TPU as a research university – one of the world leaders in the sphere of resource-efficient technologies solving the global problems of humanity on the way towards sustainable development". Among the key tasks of TPU there is "development of research at the international level; globally competitive engineering education; strategic partnership with academic and business communities, training and involvement of students, researchers, and teachers; transformation of the university into that of mostly Master-Postgraduate type"[6].

The goal of establishing university of Master-Postgraduate type should be particularly noted. In the TPU rector's report of 2015 and plans for 2016 several goals directly related to the given task for 2016 were stated, namely: "to provide master-students and post-graduates with practical research (by research supervisors as well) so that they could perform their dissertation works on-time and at high standard; to develop and implement a new concept of post-graduate programme, to start-up at least one new unique educational programme in every educational-research institute of TPU; to set the groups for Master "double degree" programme training, network Master programmes; Master programmes implemented for industrial partners; English-language Master programmes"[7]. Up to 2020 the goal is to increase the share of post-graduates, master-and doctoral students to 55%.

Establishment of university of Master-Postgraduate type prescribes significant transformations in all university management systems. It is necessary to provide the conditions under which the critical amount of researchers would consist of "post-graduates, master-students as well as foreign scientists with modern research competences", that will be enhanced, among other factors, by network cooperation[8]. In other words, two mechanisms will be used simultaneously – education of TPU own researchers and involvement of leading world specialists who will share their unique knowledge and educate the young generation of TPU. The second mechanism may be implemented most efficiently under the condition of international network cooperation since such a form of scientific cooperation is one of the most popular and efficient at the moment to respond the scientific challenges [3]. The university will be attractive for the talented youth and highly-qualified specialists in the world

[6] Programma povysheniya konkurentosposobnosti NI TPU [Programme of increasing TPU competitiveness], available at: http://xn--80abucjiibhv9a.xn--p1ai/%D0%BD%D0%BE%D0%B2%D0%BE%D1%81%D1%82%D0%B8/3503/%D1%84%D0%B0%D0%B9%D0%BB/2383/13.07.07-%D0%9F%D1%80%D0%B5%D0%B7%D0%B5%D0%BD%D1%82%D0%B0%D1%86%D0%B8%D1%8F-%D0%A2%D0%9F%D0%A3.pdf

[7] "Ob itogakh raboty Natsional'nogo issledovatel'skogo Tomskogo politekhnicheskogo universiteta v 2015 godu i zadachakh na 2016 god" [About results of National research Tomsk Polytechnic University in 2015 and tasks for 2016], available at: http://tpu.ru/today/facts-numbers/reports/

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education-research market when TPU performs unique international research or implement unique Master and Post-graduate programmes. Besides, taking into account the fact that contemporary investigations are mostly cross-disciplinary, the interdisciplinary projects have become a constitutive element of the environment where young specialists are to be trained.

The concept "environment" was coined in pedagogical philosophy and sociology by I. Ten in the 20th century. In the 70 – 90's of the 20th century the given concept was of particular interest due to development of the theories dealing with essence, content, and structure of the environment in educational institutions [4]. Considering the concept of "educational-research environment" in the context of foreign pedagogy, it is necessary to underline inseparability of the given phenomenon with the conditions of high quality of educational and research activity in universities.

In the literature the term "research environment" is treated in the context of "educational-research environment" that implies a complex of internal and external resources, conditions, and organizational structures, which influence scientific and educational processes in higher professional education. According to Newman's definition [5], educational-research environment of a university is characterized by a set of architectural medium, management, research and academic, both formal and informal experience. Merriam [6] defines educational-research environment as a multi-component polymodal phenomenon including physical environment, emotional and psychological climate, a set of social and cultural factors that influence the level of education. Convey determines educational-research environment [7] as a set of objects, subjects, means, and technologies of collection, accumulation, transfer, and processing of academic and professional information as well as its distribution promoting the development of informative interaction among all participators of the complex system of higher education. J. Raven considers educational-research environment as a pedagogic system of staff training [8].

As the article considers the environment of research international projects, the following definition of research environment was developed: it is a complex system including a set of all social, physical, organizational, and psychological conditions and constantly improving interactions of all participants in research process focused on effective development of research creativity, research culture personal professional qualities, competencies, and self-actualization of teachers and students in the research sphere.

While considering research environment, an important condition is to reveal the mechanisms that would provide internal dynamic development of the elements of educational and research process as well as effective development of different cooperation and integration forms with different participated parts.

The RASA Center in Tomsk may be taken as an example of such environment development[9] on the basis of Tomsk Polytechnic University. The Center was established in 2015 after signing the Agreement about cooperation of Tomsk Polytechnic University and Russian-Speaking Academic Science Association (RASA). The Center was established, first of all, to develop active community of scientists from all over the world implementing unique interdisciplinary projects. The laboratories of the Center are headed by the world scientists, acknowledged experts achieved great success in the leading world universities and research centers. Using the example of the Center let us consider the way Tomsk Polytechnic University holds the events to develop research environment contributing to solution of the university problems in attracting talented people from the international educational-research market.

[9] RASA – Russian-speaking Academic Science Association, , Available at: http://rasa.tpu.ru/

It should be started with the fact that the strategic goal of the Center is to attract and implement complex projects of scientists from Asia-Pacific region, Europe, USA on the basis of Tomsk consortium of universities and scientific organizations[10]. Hence, the Center was initially organized according to the principle of network cooperation at the regional and international levels and is to provide a place for investigations which would be attractive at the international level. To achieve this goal, the following problems are to be solved in the RASA Center:

- development of research breakthroughs including additional one to those existing in TPU;
- intensive interaction with TPU departments and laboratories;
- joint projects with the universities of Russia and the world;
- TPU collaboration with the members of RASA association;
- university staff's active participation in international research;
- high publication activity of TPU researchers.
- participation in development and implementation of educational programmes in cooperation with leading world universities.

The Center established six interdisciplinary laboratories, four of which deal with translational medicine, unique for Tomsk Polytechnic University. At the moment, in the Center there are 30 workers; laboratory staff and supervisors are recruited from recognized at the international level research-educational institutions. Masters post-graduates, and young researchers are employed in the laboratories from three TPU research-educational centers, there is network cooperation with the researchers of all institutes. The biomedical laboratories of the Center are staffed with the workers of Siberian State Medical University, Tomsk Cancer Research Institute, Cardiology Research Institute; three postdoctoral fellows are employed from the universities of Russia and Europe. All employees have experience in training or working at leading Russian and international research centers and projects.

Apart from organizations, where scientists of RASA work, the partners of the Center are: CERN – Council of Europe for Nuclear Research (Switzerland), KEK – Organization for study of high-energy accelerators (Japan), National Institute of Health (USA), as well as leading Russian research institutions: National Research Center "Kurchatov Institute", Ye.D. Goldberg National Research Institute of Pharmacology and Regenerative Medicine, Institute of Cytology and Genetics of Siberian Branch of RAS, I.M. Sechenov First Moscow State Medical University etc.

Let us consider the mechanisms of organization and management in the Center contributing to development of attractive scientific environment to train staff for research interdisciplinary projects.

First of all, it is research internship for teachers and students of TPU (after competitive selection) in the leading international educational-research centers under RASA researchers' supervision in the Center spheres of activity. Based on the research internship results, the scientists are employed in the Center laboratories and continue their research using crucially new knowledge and skills acquired in the internships. For example, in 2015 14 students and young researchers of TPU interned in the leading universities and research centers: the trainees having long-term courses (more than 5 months) of internship are employed in the laboratories.

Apart from internships RASA researchers supervise participation of Center staff and TPU talented youth in international conferences, write co-articles in high-ranking journals (IF[11] not lower than 3). After internship under RASA researchers' supervision the master-students work at master thesis on the themes of the Center laboratories contributing to their Candidate thesis. These events develop students' and young researchers' skills in performing research at the high international level, particularly, in the course of internship and work in cross-cultural teams.

From the point of view of managerial and physiological conditions of the Center research environment, the interdisciplinary team work should be underlined, which is conditioned by staff composition, as in the interdisciplinary projects the research themes are at the interface of the sciences. It is also not of less importance that the Center staff and students collaborate with numerous partners from Russia and abroad, which contributes to the development of their personal-professional, communicative, managerial, and leadership skills, steady increase in their English language proficiency.

Finally, the work in strong research teams gives great experience for the staff in applying for Russian and international grants to perform research and be a part of grant team improving personal well-being and financial sustainability of research projects.

The short-term plan of the Center includes relocation to new TPU Research Park, a building covering the area of 360 m^2, applications for grants, students' and staff's new internships, as well as development of unique international education programmes in English.

It can be concluded that RASA center with its intensive international collaboration is an example of development of attractive research environment promoting the university of Master-Post-graduate type and contributing to TPU prestige and competitiveness in the world market.

[10] Association of nonprofit organizations "Tomsk consortium of universities and scientific organizations", Available at: http://unitomsk.ru/

[11] IF – Impact-factor – numerical indicator of scientific journal significance.

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UDC 378

V.V. Kondrat'ev

Training Engineering Students for Interdisciplinary Teamwork

Kazan National Research Technological University
V.V. Kondrat'ev

The paper proves the necessity to provide engineering students with methodological training based on new engineering and technological approaches to contemporary production. The emphasis is made on interdisciplinary programmes of engineering education and trends in their development. It also provides the example of interdisciplinary modules developing students' creativity competence.

Key words: engineering activity, interdisciplinary programmes of engineering education, interdisciplinary approach, interdisciplinary modules.

Methodological training of engineering students is becoming more and more important due to the shift from labour-intensive production to sciencedriven industries. However, there is no consistent development of students' methodological competencies in modern engineering universities. It results in the fact that engineers, technologists, and economic operators lack methodological skills with sufficient amount of special knowledge. A lot of modern productions require radically new technical and technological approaches that can be developed by professionals capable of integrating ideas from different scientific areas, using interdisciplinary categories and comprehending innovation.

Thus, one of the challenges that the higher technical school is facing with is to change mass education to training highly qualified professionals who are not only specialized in particular areas but also have a fundamental theoretical base [1, p. 7].

The existing system of mass education does not take into account new social requirements from the higher school, which has led to some contradictions. There is a great demand for new technical and technological approaches to the contemporary sciencedriven production, which requires interdisciplinary specialists. However, the current engineering system is focused on particular specialties. There is a necessity to teach engineering students new methodological activity, but the teaching staff lack methodological knowledge [1, p. 11].

The basic methodological approaches to the problem solving are as follows:

- Functional systems approach allows identifying a structure, content and functions of a sub-system, defining its concept and interdisciplinary relations with the content of engineering training.
- Integrative approach allows balancing objectives of mathematical and professional training via integration of content of general, professional, special, and scientific disciplines.

In an era of limited natural resources, environmental threats, hazardous technological processes, an engineer is a key person in the current society. It is an engineer who creates wealth, advances the progress of human civilization by developing new generations of communication facilities, transport, energy sources, constructions, consumer goods, production facilities, environmental protection and natural resource processing [2, pp. 13-14].

Contemporary stage of engineering activity is characterized by new technical and technological approaches to production, and shift from labourintensive production to science-driven processes. It can be a stage of the scientific technological revolution. The scientific world landscape and techno sphere image are changed by a new image that synthesizes them as a condition for new integrating kinds of activity. Currently, there are a lot of areas of professional activity that are still weakly impacted by the integrating processes. The synthesis process is the most intensively taking place in such areas as axiomatic that is closely connected with the advanced scientific and technological trends [3, p. 131].

Technical, scientific and social knowledge have the same stages of development. The last stage involves synthesis of science, technical knowledge and social and humanitarian knowledge. It is time to stop constantly enlarging the list of courses and subjects to be studied in higher technical schools, but to synthesize new subjects and disciplines based on new understanding of a knowledge unit. Now we still use the units of experience description developed in the XX century, while our own experience is of other nature.

Currently, an engineer is a mediator between science and production, the latter is being more and more dependent on efficient engineering and technical solutions at the stages of research and development. Approximate estimations reveal that a one-ruble error at the research stage leads to 10-ruble loss at the design stage, 100-ruble loss at the stage of test model construction, and 1000-ruble loss during the production stage [1, pp. 21-22].

International engineering education programmes are divided into three types:

- «traditional» programmes are focused on a particular engineering job (profession, specialty) of different levels of training;
- «integrated» («united» or «inclusive») programmes offer mutual activity of a higher technical school and an enterprise, or a research center involved in scientific and research activities of students;
- «interdisciplinary» programmes include more subjects related to other scientific fields, since the trained engineering specialty is of "double nature" [1, p. 72-73].

According to Mr. Stir, the vice-president of the Boeing company, it should be underlined that no matter how long a university programme might be, it cannot ensure training of engineering graduates who are completely ready for real engineering activity. Thus, the attempts to teach them everything are useless. A graduate should be ready for continuous professional development and constant changes in professional partnership during his/her career [4, p. 159].

In this regard, special attention should be paid to development of engineering education integrated with science and production. Thus, there are attempts to develop engineering education programmes in a new way. For example, there is a new education programme [5, p. 29], to train "Integrative engineers".

General trends in developing typical engineering programmes are as follows [6, p. 16-17]:

- There is growing similarity in structures and content between national engineering education programmes of different levels.
- A lot of national engineering education programmes meet Russian standards and contain subjects relating to different scientific areas.
- Standard engineering education programmes are becoming more and more interdisciplinary, and more often imply close university-science-production interaction.
- Higher technical school is developing a methodology that combines teaching particular disciplines with interdisciplinary integrative modules.
- There is a transition from information-based to problem-based learning,

conceptual approach and systemic engineering training.

- Continuous professional development and self-development of an engineer.

These trends comply well with the domestic projects of education standards implying flexible approach to professional training, as well as with the project of a new list of education programmes [7, p. 47] with greater share of interdisciplinary and integrated education programs.

The interdisciplinary approach [8, pp. 83-85] implies that subjects and even some particular themes and modules are viewed as parts of particular stages of professional training. Each of these parts can contain a number of interdisciplinary modules with individual character in terms of scientific knowledge and united by uniform requirements to learning outcomes. The modules of general training are united on the basis of their focus on developing analysis and synthesis skills that constitute the first level of intellectual engineering activity. The modules of general engineering training make a group responsible for algorithmic and intellectual motorial level, while the modules of special training are supposed to develop creative intellectual level (Fig.1).

To develop this or that psychological and professional level of engineering activity is an essential task of faculty staff. A module can involve the topics and parts of both prerequisites and post requisites. The sub-module that includes prerequisites should be finished with typical tasks and equations developed by the staff training the post-requisites.

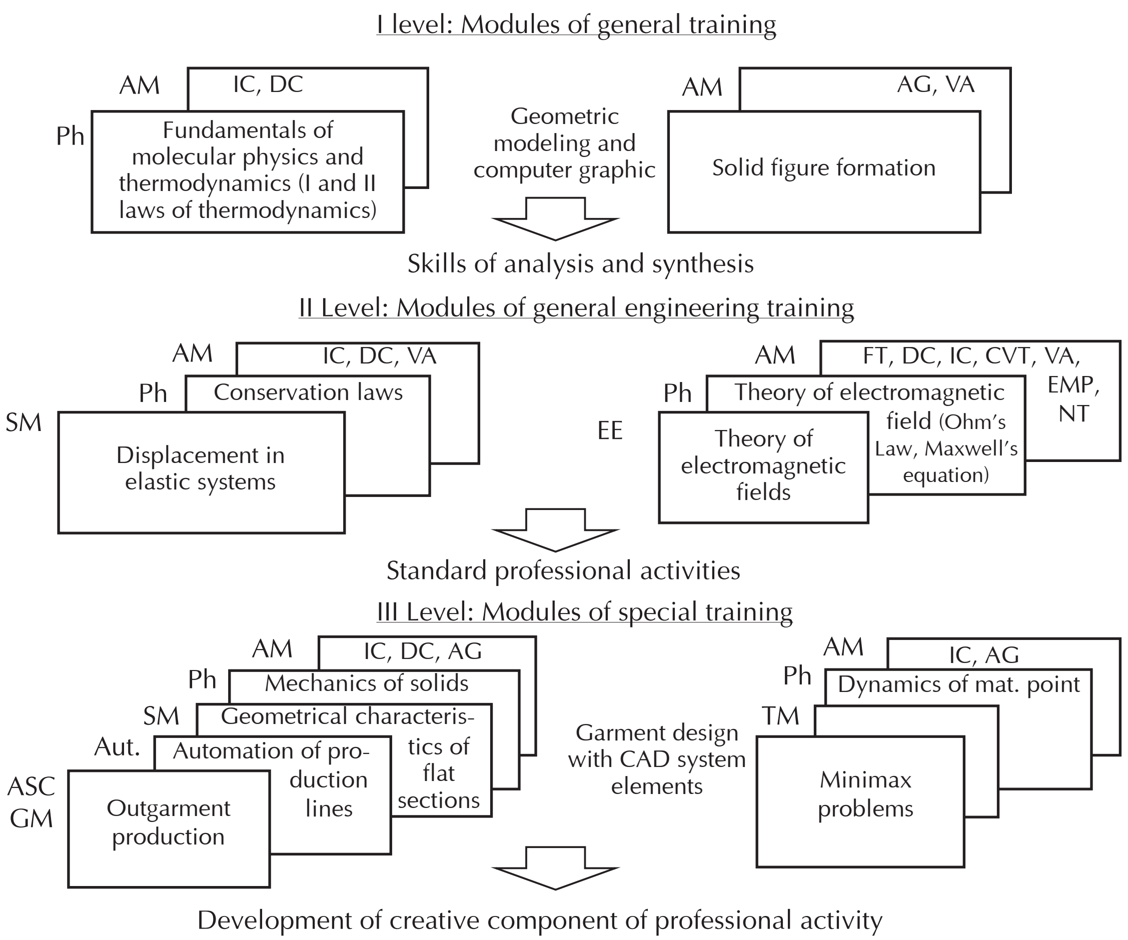
Modular training implies teamwork of different departments following development of training programmes in each discipline. The example of a modular content in specialty "Electric Motor Drive and Automation of Production Units and Technological Complexes" is an interdisciplinary module "Electromagnetic Field Theory". It is based on "Field Theory" from Advanced Mathematics, and accompanied with "Differential and Integral Calculus", "Complex Variable Theory", "Vector Analysis", "Partial Differential Equations", "Numerical Techniques". The basic theme of Physics in the module is "Electromagnetic Field Theory" accompanied with the "Om's Law" and "Maxwell's Equation". The module is finished with studying "Electromagnetic Field Theory" from the Electrical Engineering course (Fig.1) [1, pp. 225-227].

The scientific progress destroys the barriers between different scientific branches and areas. The opposition between "Exact science" and "Other science" is being vanished. The gap between science and humanities proves to be false, since the difference between social and natural phenomena has been exaggerated. The idea of the science unity is becoming more obvious. According to Max Planck, "all sciences form an internal unified whole. The distinction of disciplines is mostly caused by limitation of human mind rather than inner nature of phenomena and objects. Actually, there is a continuous link from physics to chemistry, through biology and anthropology to social science. This chain cannot be broken unless in an arbitrary way". However, the unity of science and natural interaction of its disciplines are not something inherent and ultimate. This is a result of historical development, the outcome of a long, controversial and never ending way of the universe's theoretical exploration. The Unity of science is implemented as the process of its integration [1, p. 275].

To acknowledge the unity of science [9, p. 29] does not mean to interpret subjectively specific features of its disciplines and to deny the objective qualitative (though not absolute) borders between them. The integration of scientific disciplines is implemented through their further differentiation, and the advanced study and analysis facilitate theoretical synthesis.

There has been hardly any leading scholar in pedagogy and education who

Fig. 1. Interdisciplinary modules



Legend:
Ph – Physics, SM – Strength of Materials, TM – Theoretical Mechanics, EE – Electrical Engineering, Aut. – Automatics, ACS GM – Automated Control System of Garment Manufacture, AM – Advanced Mathematics, VA – Vector Analysis, AG – Analytical Geometry, DC – Differential Calculus, IC – Integral Calculus, CVT – Complex Variable Theory, FT – Field theory, EMP – Equations of Mathematical Physics, NT – Numerical Techniques.

would have supported the idea of learning separate disciplines. As Jean-Jacques Rousseau noted, "…when you have a bent for sciences, the first thing you feel is the connection between them that ensures their mutual support and interrelation. The human mind is incapable of perceiving all the sciences, which makes it necessary to choose one as a basic science. However, without being aware of other disciplines, you are often benighted in your basic science as well…" [10].

As science advanced, the integration trends and interrelation of different disciplines became more and more distinct.

Vladimir I. Vernadsky, a founder of such integrated scientific disciplines as geochemistry, biogeochemistry, and radiogeology, noted: "The logical laws in natural sciences vary in different Earth's geological layers. We cannot clearly imagine the phenomena and processes that really occur there. We can only treat them mathematically, in the symbolic form, reflecting the reality logically without empirical confirmation. This is a significant contribution of mathematics in natural science" [11, p. 69].

While observing the trends and development of the modern-day science [12, p. 8-12], it can be concluded that differentiation and integration are two opposite but closely interrelated processes focused on the world study and exploration.

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Education Standards as a Basis for Interdisciplinary Integrative Module

Orel State University n.a. I.S. Turgenev
G.V. Bukalova

G.V. Bukalova

The author proves axiological function of the integrative approach, which is applied in engineering education to meet the new education standards. The conditions to enhance discipline integration process are determined in terms of systemology fundamentals. The author describes the stages of the integrative module design. The experience in the design of interdisciplinary integrative educational module (automotive transport) is shared and discussed.

Key words: integrative approach, interdisciplinary integrative module, education standards (competences), methodological perspective, professional training.

Introduction

Today, the main objective of engineering training is graduate's professional competence, which fails to be reached through summing all pieces of information obtained from different disciplines [1]. It is noteworthy that traditional engineering education is characterized by "disciplinarity", i.e. educational process comprises a range of particular disciplines, each implying certain logics of study. In this situation, it is for the student to integrate all the information, which is in contradiction with competency-based education widely implemented at higher education institutions today. Moreover, traditional "disciplinary" engineering training does not develop the ability for integrative engineering activity as well [2].

Therefore, competency-based education necessitates changes in the model of traditional engineering education. One of the pedagogical challenges is integration of studied disciplines, which implies identifying the criteria to select and structure the educational information [3].

However, traditional discrete disciplinary approach to educational process design is still important for modern engineering education, since the disciplines taught are the methodological basis for interdisciplinary integrative modules. The integrative approach to educational process design is used as a supplementary one, and the co-existence of integrative and discrete disciplinary approaches is secured by education standards, a set of education objectives, i.e. competencies [4]. These competencies are the expected learning outcomes and should be developed regardless of the approach.

Methodological basis for interdisciplinary integrative module design

The main document to regulate university educational process is basic professional education programme (BPEP) designed for a particular specialty [5]. These documents prescribes the learning outcomes of university education, which are referred to as a set of competencies. As a result, each competency is obligatory to obtain, and together they are referred to as education standards. In case of discrete disciplinary training, the distribution of competencies over the disciplines is quite challengeable. This necessitates the design of interdisciplinary integrative modules, which will ensure the development of relevant competencies. The structure of such educational process is unique since it allows combining the elements which used to be isolated within the discrete disciplinary educational pattern.

The interdisciplinary integrative module includes:

- a list of integrated disciplines selected in accordance with the relevant criteria;
- a list of overlapping issues (topics and blocks) considered by the integrated disciplines;
- a list of laboratory and practical tasks developed in accordance with the relevant criteria.

The interdisciplinary integrative module is a product of pedagogical integration, and the performance of pedagogical product is measured in terms of its didactic consistency [3]. Integrative pedagogical products can be characterized by different types of didactic consistency:

- "updating the education elements of other disciplines while studying a particular discipline;
- combining diverse education elements of two and more disciplines (conglomerate of education elements);
- logical, associative and heuristic correlation, …combination of con-natural education elements of disciplines, with keeping the elements relatively independent (didactic synthesis of new education elements);
- developing synthetic education elements from education elements of integrated disciplines, with the elements becoming strongly connected and interdependent (didactic synthesis of new education elements)" [3, p.117].

This classification can be used to define the structure of integrative pedagogical product, with due regard to the adopted level of didactic consistency.

The interdisciplinary integrative model may be considered as a system since the elements, each being easily identified, are obviously connected. Therefore, we can refer to systemology to identify the conditions for the module efficient implementation in the educational process.

In terms of systemology, the system is consistent if the bounds between the system elements are more stable than those with the environment [6]. Thus, it can be concluded that the educational objective, which induced interdisciplinary integrative module design, should only be reached by means of newly developed discipline (without involving educational tools of other disciplines, i.e. without additional bounds with the environment). This condition fulfilled, the integrative module is efficiently implemented and ensures obtaining the expected outcomes. Based on the above-mentioned systemology thesis, the bounds between the elements within the integrative module should be stable. This can be ensured through cooperation between partner educators who teach the integrated disciplines (meetings and consultations held on a regular basis).

However, the stability of bounds between the elements of the interdisciplinary integrative module should be optimal since, in compliance with another systemology thesis, the level of the element relative independence can be reduced if their interconnection is being strengthened. It is a well-known fact that engineering education fundamentals are strongly connected with autonomous scientific disciplines, which the foundation of the relevant academic disciplines rests on [7], [8]. Therefore, it is important for the integrated disciplines to remain fundamental even if the elements of the integrative model are inseparably connected.

Systemology indicates that a system acquires a new quality if it extends [6], therefore, it is possible to improve the efficiency of the integrative module implementation if to introduce additional elements of the integrated disciplines (with due regard to the element number) into the module structure. It is expected that the effect of educational activities will be more significant than that from studying the same disciplines without integrating.

Based on the systemic approach and using the integration process structure suggested by A.D. Ursul [9], the stages of interdisciplinary integrative module design can be presented as follows.

The first stage is to identify a mutual characteristic, which will become a basis for integration. In case of interdisciplinary integrative module design, this can be a prescribed competency (a set of competencies) or a particular requirement of the professional education standard [10], [11]. The basis for integration is a core factor of the integration process development and the choice of the basis is crucial for pedagogical integration efficiency.

The next stage is to identify the systems to be integrated. In our case, it is necessary to identify the academic disciplines, which serves as the basis for integration.

After that, one should determine the area of integration. Based on logical, associative and heuristic assumptions, a set of education elements to be integrated is determined. The integrated elements, which together make the area of integration, are certain blocks within academic disciplines, laboratory works, project work tasks, and self-study resources.

Then the education elements within the area of integration should be ordered in terms of their significance. The criterion for ordering is the element's role in the development of a particular competency or contribution it makes to meet a particular requirement of the professional education standard (taken as a basis for integration) – the element impact can be objective, methodological, or categorical.

The product of pedagogical integration is officially implemented as an interdisciplinary integrative module (study pack developed from the materials of integrated disciplines).

Integrative approach implementation

The workgroup of Orel State University n.a. I.S. Turgenev conducted a survey among the employers who run the most successful vehicle service stations in Orel. The respondents were the heads of the following companies: OOO "Vozrozhdenie" (authorized dealer of Ford, Renault, Volkswagen, Nissan, Hyundai, Mitsubishi), OOO "Forpost – Orel" (authorized dealer of KIA), ZAO "Orelavtotekhobsluzhivanie"; automotive holding company "Atlant M – Auto" (authorized dealer of Chevrolet, Opel, GM-AvtoVAZ). The staff policy at the enterprises is conducted in cooperation with the Department of Machine Service and Maintenance, Orel State University. The questionnaire for the survey was developed to find out whether the professional education standards (relevant competencies) of "Operation of Cars and Transport Systems" programme meet the requirements of the employers. The survey results indicated that the employers are rather interested in student training for innovative activities in automotive service sector. The competencies mentioned in the questionnaire and reflecting graduate's ability to perform innovative activities were estimated by the employers as "very important" and "the most important".

To train students for performing innovative activities in automotive service sector, the methodology for interdisciplinary integrative module design has been developed. According to the classification describing different types of didactic consistency of an integrated pedagogical product, the developed interdisciplinary integrative module is based on logical, associative and heuristic combination of connatural education elements of disciplines, with keeping the elements relatively independent.

The basis for integration, a core factor of the integration process development, is graduate's competency, namely, the ability to perform innovative professional activities.

The criterion to identify the systems (i.e. academic disciplines) to be integrated is the general stages of innovation implementation: need for innovations, fundamental research, applied research, use of innovation, positioning on the market [12].

The area of integration was determined through selecting the education elements of the integrated disciplines: lectures, laboratory works, project work tasks, and elements of graduate qualification work.

The area of integration includes not only the education elements which improve student's ability for performing innovative activities in automotive service sector, but also the elements which encourage innovative thinking.

Based on the expert analysis, the education elements were ranged as "significant", "very important, "the most important".

Conclusion

Interdisciplinary integrative module implementation stipulates integrative training sessions: polydisciplinary lectures, interdisciplinary engineering project activities, integrative self-study tasks.

Compared to traditional educational process, the integrative one is characterized by detailed structure and allows developing an integrative way of thinking, which can be considered a supplementary target. In fact, it is the integrative way of thinking that lays the foundation for successful engineering activities in any manufacturing profile.

SPECIALISTS' TRAINING FOR INTERDISCIPLINARY TEAMWORK AND PROJECTS
ENGINEERING EDUCATION 20'2016

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O.N. Timofeev

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Team Work for Comprehensive Engineering

Kazan National Research Technological University
O.N. Timofeev

The paper considers the ways to ensure education quality. The principles of creative self-development are described to demonstrate that the psychological function of education, i.e. goal-oriented activity and intentionality, plays an important role in transition from development to self-development. The personality self-development is controlled by the mechanism of emotion regulation and determined by the level of emotional intelligence. The author analyses the assessment criteria for the quality of engineering education provided in higher education institutions in the signatory countries of Washington Accord. The major requirement for engineering student training, which ensures the high quality of education, is to develop the abilities and skills of comprehensive engineering. The authors suggest that leadership skills are the key engineer's competencies to be developed in Russia. The interconnection between comprehensive engineering and leadership skills has been revealed. Also, it has been established that the four abilities and relevant skills included in emotional intelligence (EQ) are essential professional qualities of the leader. The levels of PDLS development have been identified.

Key words: self-development, self-actualization, intelligence, quality of education, psychological function of education.

The main trend in higher technical education improvement is the focus on development of student's individual psychological resources. While developing cognitive function, i.e. transferring scientific knowledge and providing the individual with scientific methods and tools, higher education also fulfils the psychological function – forming the inner world with regard to uniqueness and value of the student's psychological opportunities. It is necessary to develop the competitive specialist training concept on the basis of psychology and pedagogics regularities of formation and development of the personality intellectual qualities. In terms of intellectual development, it means that the training purpose of higher education is not mere learning of academic disciplines, but, first of all, development of students' reflection, ability for self-knowledge, self-management and self-development, broadening and improvement of individual intellectual resources by pedagogical means. The intrinsic line of this process is to include the students' activities in their self-development processes [1]. V.I. Andreev formulated the basic pedagogical principles of the personality creative self-development [2] and identified a stage of self-development within the framework of personality development called the law of ensured education quality. Now good education is an essential condition of professional and career development which a modern personality is focused on. According to V.I. Andreev, creative self-development is a complex type of creative activities focused on subject–subject relation aimed to intensify and enhance "self-qualities", with self-updating, self-knowledge, and self-government being key ones.

Post-industrial countries, co-signatories of the Washington Accord (WA), including Association of Engineering Education of Russia (AEER) that entered WA in 2012, implemented the system of education quality assessment based on the approved international criteria. Thus, high quality of engineering degree programmes is ensured, which promotes graduate's certification, professional mobility, and successful employment in the countries of WA. According to the WA standards, one of the programme quality criteria requires training to perform complex engineering activities [3].

Work [4] shows that professional competence of engineering graduates involves 12 professional competencies. The experts of AEER stated that leadership skills are the key criterion to assess the quality of engineering training in the Russian Federation.

The structure of leadership skills can be described in terms of psychology [5] and are defined as the individual ability for self-control and interpersonal relationship management. Leadership skills are conditioned by the level of understanding and management of personal and others' emotions, i.e. development of emotional intelligence – EQ.

The styles of leadership and the predominant characteristics of emotional intelligence are presented in tab. 1.

The leadership competency comprises four main components, each representing a set of skills and relevant professional qualities attributed to the leader in comprehensive engineering activity. They are consciousness, self-regulation, social empathy, and social skills. At Kazan National Research Technological University (KNRTU), engineering students were tested for leadership competency development via the technique elaborated at the Institute of Psychology of the Russian Academy of Sciences [6]. The results of research are provided in fig. 1. LL – low level; AL – average level; MHL – moderately high level; HL – high level [7].

According to the data obtained, more than 60% of engineering students have low and average levels of leadership competency development, which fails to conform to WA requirements. The contradiction between the level of leadership competency development, professional requirements and suggested EQ structure indicates that there is cause-and-effect relationship between the improved leadership competency and the pedagogical system designed and implemented in professional education.

EQ is an effective management of individual behavior and relationships (social sensitivity and emotion control); it is a professional competency relating to comprehensive engineering activities [3]. As for development of individual intellectual resources, it is based on psychological model of intelligence developed by M.A. Kholodnaya and introduced as the individual mental experience (IME). Mentality is a way of the worldview in which conscious and unconscious, individual thoughts and emotions are inseparable. Personal development is the record of individual experience, which is the main cell in consciousness structure (L.S. Vygodsky). The conflict between conscious and unconscious emotions is the cornerstone of many psychosomatic diseases [8]. In terms of ontogenesis, emotional development is expressed through differentiation of qualities and degree of emotion awareness, as well as the ability to control and express emotions. Therefore, an increase in the degree of emotion awareness in the structure of IME leads to intellectual development of students and is reflected in higher rates of EQ. EQ = PEQ + IPEQ (personal EQ + interpersonal EQ), where PEQ = SA + SM (SA – self-awareness, SM – self-management), and IPEQ = IU + IM (IU – interpersonal understanding, IM – interpersonal management). PEQ and IPEQ contributions to EQ development via technique [6] are provided in fig. 2.

Experimental data show that the engineering students have an average starting level of EQ development. It indicates the medium-developed ability to differentiate emotions and insufficient degree of emotion awareness in IME.

Table 1. Characteristics of leadership styles EQ

Characteristics/ situational management styles	Authoritarian	Authoritative	Companionate	Democratic	Model	Training
Leadership style	Demands immediate obedience	Mobilizes people to embody the plans in life	Forms emotional relations and creates harmony	Tries to obtain unanimity by means of active involvement of employees in management process	Establishes high standards of productivity	Helps employees to develop perspective abilities
Motto of style	"Do what I ordered you!"	"Follow me, everyone!"	"People first of all!"	"What do you think?"	"And now do as I do!"	"Try this option"
Predominant characteristics of emotional intelligence EQ	Determination, initiative, self-control (Self-regulation)	Self-confidence, ability to empathize, ability to implement innovations (Reflection + Empathy + Social skills)	Capability to empathize, ability to strengthen social relationships and to communicate effectively with people (Empathy + Social skills)	Ability to competently deal with other employees, to manage teamwork (Social skills)	Determination, initiative (Self-regulation)	Ability to encourage development of employee's skills, capability to empathize, consciousness (Reflection + Empathy + Social skills)
Optimal conditions for implementation	Crisis situations, need for reorganization, difficulty of interaction with confrontational employees	Implementation of new ideas or pathway	Improvement of relationships between the employee or need for their hard work under complicated circumstances	Dissemination of corporate policy, consensus achievement, and search for highly-qualified personnel's ideas	Effective performance of highly-qualified team	Assistance to employee in enhancing their productivity or developing professional skills
Impact on work climate	Destructive	Extremely favorable	Favorable	Favorable	Destructive	Favorable

The contradiction between the level of leadership competency development, professional requirements and suggested EQ structure indicates that there is cause-and-effect relationship between the increased IME level, education quality, and the pedagogical system designed and implemented in professional.

The analysis of works on pedagogy in the field of intelligence development shows that the authors develop IME only in terms of cognitive mental experience [1]. Development of IME and especially intentional and metacognitive mental

Fig. 1. Engineering student's leadership competency: levels of development

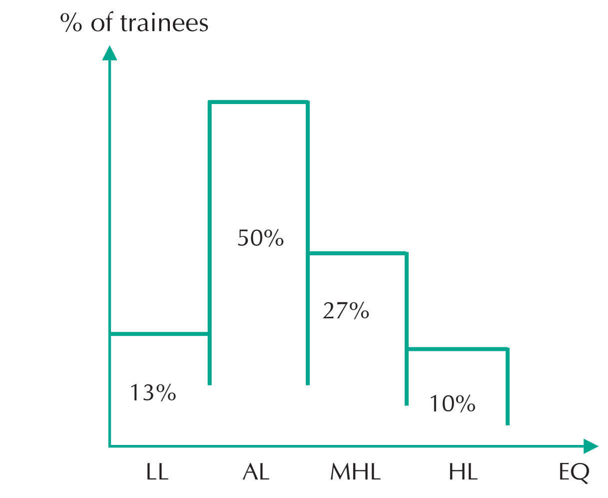
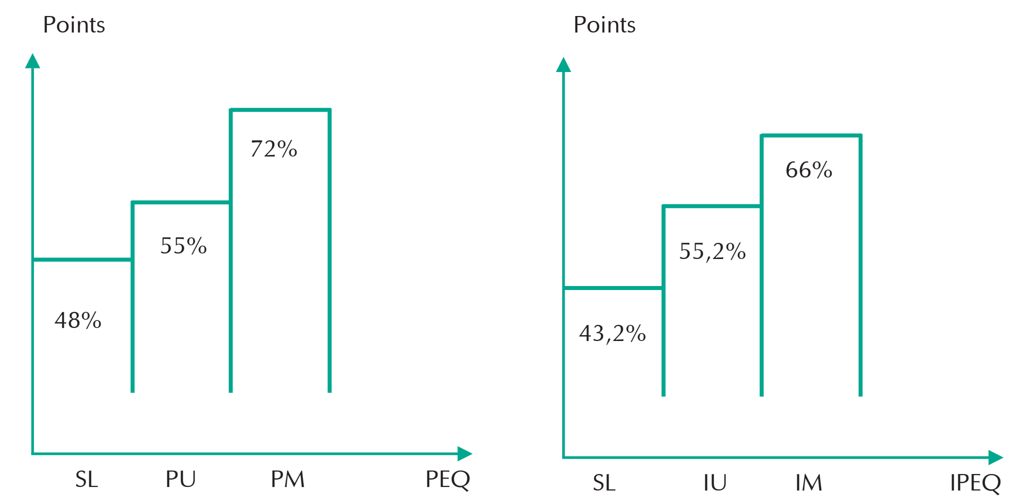


Fig. 2. The calculated levels of leadership competency development with regard to EQ structural element's contribution, where SEL – starting experimental level [6].



experience are possible on the basis of EQ structures. Intention is determined as a consciousness focus on any subject. Therefore, intentional mental experience is the focus of consciousness on effective self-management and management of relations with other people. Thus, IME with the emphasis on metacognitive and intentional mental experience is developed to increase the degree of emotions awareness, their differentiation and control over destructive emotions and impulses.

The hypothesis that individual intellectual skills can be improved via comprehensive engineering activity may be implemented through developing a pedagogical system on the basis of structural elements of emotional intelligence and adequate educational and methodical support. This support can be based on the theory of differential emotions (TDE) by K.E. Izard [8]. The results of TDE fundamental research allow classifying basic emotions according to the criteria as follows: emotional expression, physical manifestations, reasons and functions, interaction with other emotions, emotional control and manifestations of psychosomatic frustration arising from of low capability to effectively manage destructive emotions. The structure of IME, which includes three types of mental experience (cognitive, metacognitive, and intentional), stipulates development of individual intellectual resources of a leader via comprehensive engineering activities.

The pedagogical model and educational and methodical support based on TDE are presented in tab. 2.

The rate of PEQ development of students doing engineering education programmes at Kazan National Research Technological University was assessed via the technique developed by the Institute of Psychology of the Russian Academy of Sciences and with the educational and methodical support designed on the basis of TDE [5]. The results of research are provided in fig. 3.

Conclusion:

Development of students' individual intellectual skills within implementation of psychological function ensures high quality of engineering education and is connected with the focus on self-management and effective communication (intentionality). More than 50% of students have moderate individual mental experience, which prevents them from reaching self-development level. The bases of pedagogical IME development model with the emphasis on development of intentional and metacognitive mental experience have been developed. The level of an increase in PEQ to moderately high level, 48.9 points, is experimentally determined; it corresponds to the calculated values provided in fig. 1. Development of PU emotions improves three first points listed in PDLS column on the basis of TDE pedagogical model (see the tab.). In the table, there are twenty PDLSs involved in comprehensive engineering activities, as well as further ways to develop educational and methodical support for the pedagogical in terms of metacognitive mental experience (PM) to improve PEQ and develop IPEQ (IU + IM) up to the leader's rate.

Fig. 3. PEQ leadership skills development of engineering students at Kazan National Research Technological University: experimental levels (SL – starting experimental PEQ level of Kazan National Research Technological University) [6].

Table 2. Pedagogical model of IME development

Professional competence		
Intellectual competence		
Individual mental experience		
Cognitive mental experience	Metacognitive mental experience	Intentional mental experience (professionally demanded leadership skills, PDLS)
1. Ten differential emotions and awareness of their impact on individuals and their relationships: Interest-excitement; Pleasure-joy; Surprise-amazement; Anger-rage; Fear-alarm; Trouble-grief; Disgust-contempt; Confusion; Shame; Guilt. Awareness of disease symptoms: Schizophrenia; Depression when losing emotions; Maniacal aspiration to novelty; Sadism; Masochism; Bradycardia; Tachycardia; Gambling; Sleeplessness; Nonsense; Anorexia; Bulimia; Distress; Cancer; Rheumatoid arthritis; Psoriasis; Stomach ulcer; Epilepsy; Raynaud disease; Depression; Racism; Xenophobia; Alcoholism; Drug addiction; Suicide; Paranoia; etc. 2. Empathy.	1. Cognitive regulation; Emotional regulation; Motor regulation; Relaxation; Meditation; Formation of positive emotionality as a feature of the personality; Switching of attention; Disaccustoming from emotion; Sympathy awakening; Deprivation; Denial; Desenzitivization; Implosive therapy; Modeling; etc. 2. Situational leadership (management) styles [5]: Authoritarian Authoritative Companionate Democratic Model Training	1. Ability to analyze emotions and being aware of their impact on individuals and their relationships, etc. 2. Adequate self-assessment – understanding of strengths and weaknesses. 3. Self-confidence: self-esteem and adequate assessment of individual abilities. 4. Emotional control: ability to control destructive emotions and impulses. 5. Reliability: manifestation of honesty and frankness. 6. Work ethics: self-management and high level of responsibility. 7. Adaptability: adaptability to the changing situation and ability to overcome obstacles. 8. Achievement drive: persistent desire to conform to the inner quality standards. 9. Self-starter: readiness for active actions and ability not to miss an opportunity. 10. Ability to be sensitive, to understand alternative viewpoints and be helpful. 11. Business awareness: being aware of current events, organization hierarchy and policy conducted. 12. Courtesy: capability to identify and satisfy the needs of clients. 13. Strategic leadership: ability to lead and inspire people. 14. Power of persuasion: the ability to convince. 15. Encouragement of self-improvement: ability to encourage people to develop their abilities. 16. Communication: ability to listen and transmit clear, convincing and adapted information. 17. Promotion of changes: ability to initiate transformations, improve management methods and set new targets for employees. 18. Conflict management: ability to eliminate disagreements. 19. Strengthening of personal relationships: cultivation and support for social communications. 20. Team work and cooperation: interaction with other workers and teambuilding.

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Particularities of Self-Study within "Electronics and Nano-Electronics" Education Programmes

National Research University of Electronic Technology MIET
M.V. Akulyenok, A.V. Zheleznyakova

M.V. Akulyenok

A.V. Zheleznyakova

The paper considers the ways to organize student self-study within Electronics and Nano-Electronics education programs. The case-study is analyzed in terms of process approach to education and programme interdisciplinarity.

Key words: student self-study, Master degree training, nano-electronics.

The successful progress of Russian enterprises in developing competitive products and solving import-substitution tasks is impossible without highly-qualified personnel and skilled workers who are adaptable, well-targeted, ready to self-improvement, self-training, and nonstandard solutions.

Today the most urgent problem is the lack of target-focused specialist training resulting in the necessity of "re-adjusting graduate training" for overheating of high-tech enterprises [1]. This primarily concerns the enterprises within the special technology development economic area (STDEA) "Zelenograd". The task focused on training nanotechnology specialists is complicated by such facts as the interdisciplinary principles of problem-solving, relatively fast changes and ultra-fast emerging information from different sources, which, in its turn, stipulates the development of advanced personnel training programmes oriented on the specific targets of this or that enterprise.

The characteristic feature of the Master degree programme "Electronics and Solid-state Electronics" within the framework of education programme 11.04.04 "Electronics and Nano-electronics" [2] is oriented on solving technological problems in the domain of both microelectronics and nano-electronics. In this case, the important factors involve technological equipment proficiency, participation in R&D (micro- and nano-electronic device project development). The location of the University of Electronic Technology MIET in the special economic area and possible university profile development according with the Federal law 217, dated 02.09.09 set specific goals in training specialists, i.e. establishing new requirements for Master degree programs. The complex of education programmes "Electronics and Solid-state Electronics" includes in-depth study of not only sophisticated technology for materials and electronic devices production, but also the development and establishment of the technology infrastructure, production metrology support and investigation of micro- nano-electronic units, as well as quality assurance. Practice-oriented programs, implementation of updated learning technology, development of "mobile" disciplines, being sensitive to the current research results, offer highly-qualified training for the graduates who will be involved either in leading positions or within the education and science domain and/or innovation activities. This could be promoted by well-developed infrastructure designing innovation SEA products, including business-incubator "Zelenograd Nano-technology Center", which supports those entrepreneurs who strive to commercialize their project results within the domain of nanotechnology and other fields by organizing an in-house company.

Developing and shaping graduate competencies, achieving learning outcomes and, as a result, improving education quality are impossible without the active participation of a student. This determines the significance of Student Individual Work (SIW) in generating quality of education.

The effective management tool for any activity is the process approach. According to Standard ISO 9000 requirements [3-4], any activity applying resources and transforming "input" into "output" could be considered a process. Implementing the process approach into the quality management system (QMS) for both activity management and resource management, **"makes it possible to achieve effectively desired results."** Implementation of the process approach implies the definition of such concepts as input and output, resources and specifying the roles of those who are involved in this process.

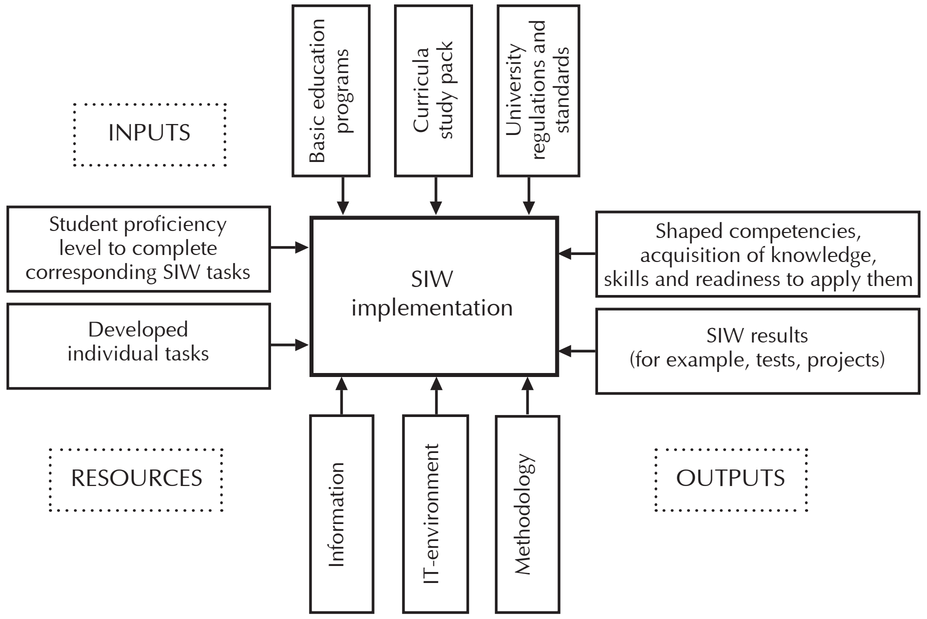
IDEF0-model process of Student Individual Work (SIW) is illustrated in fig. 1. This model shows that the main inputs are student competencies providing his/her readiness for corresponding SIW tasks, for example, acquisition of prior information; designed teaching techniques, multiple-task questions, etc. The basic outputs are knowledge acquisition, skills and/or their self-realization.

To effectively apply the process approach, it is important to determine not only the process inputs and outputs of corresponding resources but also those who are involved in this process, in particular, the role of students in this process and in the learning process as a whole. Implementing the competency-based approach enhances the possible changing of the passive student attitude in the learning process, which, in its turn, determines the product quality (result) of the education activity as graduate competencies shaped throughout the education programme implementation.

Comparable to the typical **"external customer"** the typical **"student":**

- is hardly free in selecting the attained "product and/or service"- universities organize a strict incoming test,

Fig. 1. Model process of Student Individual Work



enrolment competition, individual student records, etc.;
- rarely pays for rendered services as it is more often government funding, parents fee and/or enterprise contributions;
- is unable to put forward demands to the learning results; however, in many cases he/she has the possibilities of some supporting facilities, accommodation, extra-curricular activities, etc;
- should constantly certify his/her rights on obtaining education services;
- will be pleased if classes are canceled and, visa versa, a customer could be unsatisfied if he/she received a service denial (or even in some cases, deny in delivery);
- is unable to evaluate the quality of rendered services;
- to achieve qualitative results the student should not be passive comparable to a customer.

However, the student is interested in the acquisition of knowledge, skills and competencies, resulting in learning outcomes which define a student's competitiveness in the labor market.

Principle characteristic difference between a student and external customer is the fact that a student can be positioned as an internal customer of some processes. The student is also an important performer in the key learning process, especially SIW process.

Within the framework of the discipline "Technology fundamentals in developing integrated electronic instruments on flexible substrates" SIW involves project execution, while this approach enables solving several strategic problems in specialist training, i.e. quickly and with minimal loss adapt oneself within an enterprise. The project reveals not only generated creative thinking, but also having good grounding experience in innovative business-models.

The project targets are:

- shaping innovative activity skills;
- developing creative innovative thinking;
- shaping communicative skills with interested partners.

First project phase: designing an innovation project via advanced technology. For example, it can be projects based on breakthrough technology in developing innovative products, integrating sophisticated technology, developing updated materials in one specific domain of electronics. This teamwork includes such methods as brainstorming and case studies which are focused on not only the development of strategic and efficient teamwork, but also generating critical thinking.

Second project phase: representation of intellectual activity results at Research and Practice Seminar. It is well-known that any project requires investments, i.e. investors. At the same time, the development of such technology is closely connected with effective information background. At this phase the students executing the project present all required documentation for potential investors (for example, participating in Youth Scientific Innovative Competition Program) by themselves and, at the same time, could be experts. Youth Scientific Innovative Competition Programme includes 3 assessment-variants for each project, the first two involve student-experts who evaluate this or that project in view of its prospects comparing with other presented projects. The participation in such a seminar-competition shapes the student's presentation skills, as well as abilities to evaluate objectively external projects, reveal weaknesses and suggest solving methods which furthers communication skills within the professional domain.

To implement technological process into this or that enterprise, practical inherent capabilities are applied through statistical process control methods. This SIW type involves end-to-end solution throughout the semester with one set of statistic data of different methods, plotting a pilot process management map, identification of variation sources, proposal development of cause-effect variants, estimation of process indicator indexes, etc. This also embraces interdisciplinary interaction, including the staff of different departments.

The above-described examples could be of practical application, and obtained theoretical skills and abilities could be used in R&D. At the same time, these practical results could also be applied in theory acquisition.

Resources used in SIW process including information, methodological and technological resources should change the student's role in this process. Human resources in this process -highly-qualified teachers- should respond to the set targets, develop absolutely new innovative solutions and generate student autonomy and self-dependence.

Thus, apart from the integrated innovative SIW content, development of technology and methods enhancing the student activities, the following factors are necessary:

- improve interdisciplinary components not only within the discipline itself but also within profile modules of the education programs, eliminate the fragmentation between science, mathematical and professional disciplines and core disciplines;
- provide individual training and learning track diversification.

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Modern Approaches to the Assessment of Soft Skills and Professional Competences: Interdisciplinary Aspect

Kazan National Research Technological University
G.I. Ibragimov
Kazan Federal University
E.M. Ibragimova

G.I. Ibragimov

E.M. Ibragimova

This article discloses three approaches to understanding the structure of competences as an object of assessment. The key problems faced by teaching staff, when assessing competences, are underlined. The role and place of various means for diagnostics and assessment of competences are presented. The key development trends of different form, methods and means for competences assessment are determined in line with the interdisciplinary approach.

Key words: structure of competences, competences assessment, methods and means for competences assessment, aspects of competences assessment.

The execution of the competence-based approach faces a number of objective and subjective problems in spite of a vast expertise on the matter. One of the main problems is the problem of monitoring and assessment of soft skills' and professional competences' level of formation. It is this stage of the educational process, where teaching staff faces significant difficulties that, in our opinion, occur due to the contradiction between the interdisciplinary nature of competence, on the one side, and the on-going focus of the study process on formation, monitoring and assessment of disciplinary knowledge, skills and attitudes, on the other side. There is a certain level of vagueness in understanding the essence and structure of competences, and, therefore, the means and methods of their monitoring and assessment among the HEI faculty. Sociological studies indicate that 65.1% of faculty underline as a problem the lack of durable and convenient methodologies for competences assessment [1, c.25-26].

Whenever competences are deemed as the subject of an assessment, the issue of unveiling such elements of competences' structure that could be diagnosed and assessed impartially, become of the most importance. The conducted analysis allowed singling out three approaches for determining the structure of competences.

The adherents of the **first approach** (Kon E.L., Freyman V.I., Yuzhakov A.A., Kon E.M.) regard to competences as an integrative whole of knowledge, skills and attitudes. In order to formalize the understanding of each component of the monitoring, the following forms as determined: for **knowledge** – principles, models, processes, methods, algorithms, terms, definitions, etc.; for **skills** – application of methods, approaches; modeling, etc.; for **attitudes** – modeling and choosing research methods for models, processes, phenomena, etc., preparation of a set of documents (project's passport, technical and economic feasibility study, etc.) and other [2, c.37-41].

In the context of this approach another option is to put basis on the modified Bloom's Taxonomy of Objectives (developed by L.W. Anderson and D.R. Krathwohl in 2001), in which every educational objective can be described by means of knowledge evaluation (factual, conceptual, procedural, metacognitive) and evaluation of cognitive processes (to remember, to understand, to apply, to analyze, to evaluate, to create) [3, c. 214]. Each type of knowledge has a corresponding level (or several levels) of its acquisition. Taking this into consideration, it is possible to analyze educational objectives' state in the Federal State Education Standards (FSES) by using classification tables, where the columns indicate cognitive processes and the rows indicate knowledge categories.

The developers of the **second approach** (V.I. Blinov, O.F. Batrova, E.Yu. Esenina, A.A. Faktorovich et al.) believe that besides the knowledge, skills, and attitudes competences include the motivational (axiological) component that outlines individual's attitude towards actions. Therefore, the assessment criteria include new parameters for motivational component assessment [4].

The representatives of the **third approach** (A.I. Chuchalin, A.V. Epikhin, E.A. Muratova and others) suppose that besides the components identified above the structure of competences includes one more component – the conditions, in which the competence is exercised [5].

The third approach seems to be the most correct, in authors' opinion, regarding the level of its tenability, integrality and applicability to practice. According to this approach the competence is perceived as "the readiness of a graduate (his/her motivation and personal attitudes) to perform abilities (knowledge, skills and expertise) for successful conduction of professional and other activities under certain conditions (problem, task, resources for their solution)" [5, p. 15]. It is evident from this definition that the structure of a competence includes three interconnected components: readiness, abilities and conditions, which all together serve as corresponding criteria. Each of these components, in its turn, has a number of attributes. It is the motivation for **"readiness"** component; the knowledge, skills and expertise – for **"abilities"**; and the novelty, independence and resources – for **"conditions"**. In order to conduct the quantitative evaluation of indicators the ratings of competences components' attributes, criteria and the indicators themselves are determined [5, p.16].

The authors' opinion on the **subject of competences assessment** is presented further. According to the statutory requirements the expected learning outcomes consist of two groups:

1) the results of **study program's acquisition** (i.e. students' competences both general ones required by the FSES and complimentary ones set up by an HEI);

2) the results of **learning of each course (module) and internships** (i.e. knowledge, skills, attitudes and (or) practical experience) that characterize **stages of competence formation** and **assure** the achievement of expected learning outcomes of a study programme [6].

This allows for a distinct separation between the knowledge, skills and attitudes, on the one side, and the competences on the other. Competences (as results of study program's acquisition) are formed within learning of a whole study programme (or a total of its structural elements). Learning outcomes of each course represent the expected and the measurable components of competences: knowledge, skills, attitudes, practical experience, that students have to have fostered and are able to present after undergoing a certain element (a certain course, module or internship) of a study program. This implies that educational diagnostics and assessment are performed over both groups of learning outcomes:

1) the results of studying a course (module) or going through an internship; these results come down to corresponding knowledge, skills, attitudes and experience;

2) the results of a study programme that are represented by a total of general and professional competences determined by FSES on each major and each educational cycle.

It seems to be quite simple. And it is so, but only when it comes to the assessment of learning outcomes of a course (module) or an internship. Complications appear when solving the problem of competences' assessment. One of them relates to the fact that fostering a specific competence requires an interdisciplinary approach and, therefore, this process involves several courses and other elements of a curriculum (internships, Final State Attestation). For instance, according to the exemplary study programme on training future Master graduates within the major 44.04.01 "Pedagogy" (Pedagogy of Higher Education) the formation of one competence involves from 2 (General Professional Competence No. 3) to 20 (General Competence No. 5) elements.

In this case, each professor faces a number of tasks.

First task is to determine the way to form competences set by a study programme while learning a course, i.e. to find proper didactic means – contents, methods, forms, and teaching and learning methods. It is worth noting that for this reason there is a matrix connecting topics of study and competences formed within these topics developed for each course's work program. It all seems to be in the right place. However it is not, since it is not clear how a professor is supposed to correlate a certain topic with a certain competence. In order to solve this issue reasonably a professor has to have a clear understanding of the structure and contents of a certain competence – this would allow him/her to know what knowledge, skills, attitudes and personal features are needed for fostering this competence as a whole. On the other side, this would let him/her identify the opportunities given by a course and a specific topic for the formation of this competence.

The **second task** is to find mechanisms for complying activities teachers from different disciplines in order to: a) manage an equal understanding of a structure and contents of those specific competences that are formed within the study process of their course; b) have a possibility for interconnected and correspondent activity on competences formation. Otherwise, it seems that each teacher forms a system of knowledge, skills, and attitudes on a certain course, and a corresponding student's competence would be formed somehow automatically, since a student studies corresponding courses. But is a student ready for a complex interdisciplinary work on integrating subject knowledge, skills and attitudes him/herself? Does he/she know how to do it? These questions still do not have a conclusive solution and are awaiting for their researchers.

The **third and the most important task**, in authors' opinion, is to identify who and when should conduct the diagnostics of the level of formation of one or another competence in line with the FSES requirements, since not all the competences are assessed within the Final State Attestation. It seems that in order to solve this task it is needed to allocate all the competences (imposed by the FSES and study programmes of each major) between the forms of intermediate and final attestation among the study years. This allows receiving a clear understanding on which stage of training it is necessary to control the level of competences formation.

The following algorithm can be proposed: 1) analysis of a curriculum and development of a compliance matrix for fostered competences and study years; 2) determination of a total number and contents of courses involved in the formation of one or another competence; 3) determination of a certain course (module) or internship that is studied last for each competence. The last course is the final point, where the formation of a correspondent competence has to be controlled.

In this context, it should be mentioned that a number of researchers purposefully

ENGINEERING EDUCATION 20'2016
SPECIALISTS' TRAINING FOR INTERDISCIPLINARY TEAMWORK AND PROJECTS

emphasize the factors responsible for the quality of competences assessment: tenability, accessibility, credibility, applicability, and flexibility [7, pp. 102-103].

Further the focus is put on the **means for competences assessment.** Researchers propose various means for diagnostics and assessment of competences. In the framework of the first approach they come down to a complex of means specific for the assessment of each component: knowledge, skills, attitudes [2, p. 40]. Adherents of the second approach determine groups of competences and propose to assess them through corresponding integrated tasks. Thus, for instance, Sholokhov Moscow State University for Humanities has proposed a cluster classification of competences (mindset, statutory, instrumental). According to this classification a system of measuring instruments has been developed and includes the following: various forms of tests, simulation tasks, course projects, essays, projects (for the assessment of mindset competences); debates, discussion, roundtable discussions, expert assessments, case studies, role games (for the assessment of statutory competences); drawing up recommendations, research reports, situational analysis, brainstorming, internship reports, role games, quasiprofessional creative tasks, psychological tests (for the assessment of instrumental competences) [8, pp. 40-41; 9].

Taking into account the specifics of competences assessment process (its prolonging character), based on own experience, authors apply such diagnostic means, as **individual diagnostic maps.** These maps reflect all of stages of competence's components formation from year to year, from course to course, which allows receiving a dynamic competence model [10, pp.98-99].

It is worth noting that this research method can be efficient specifically for the purpose of assessing non-cognitive competence's components (motivational, axiological, active ones). The main difficulty in realization of such diagnostic map within the system of higher education is in the fact that the process of specialists' training is spread among several departments depending on the year of study. Therefore, the objective is to identify certain departments on each study year, which are involved in future specialists' training, and determine mechanisms for their interconnection. Based on the results of a long-standing applied and experimental research, the authors believe that one of the ways to solve this problem is to implement condensed education that implies a decrease in number of parallel courses to 3-4 courses in line with the principle of succession and interdisciplinary connections. As the experimental research has shown, the most seamless model for the implementation is the third model of condensed education that stipulates the development of 3 to 4 organization modules within a semester. Such organization of educational process decreases the number of courses and, therefore, the number of staff involved, which creates a more pleasant environment for coordinated actions, for orchestrating faculty efforts, etc. [11, 12].

Competences assessment has a number of peculiarities. The first specific feature concerns the development process for assessment means, which, in its essence, is an **iteration process** and intends work performance in parallel with a constant analysis of the results obtained and the correction of the previous work stages. The second peculiarity refers to the qualification **assessment procedure**, which, due to its professional activity, cannot be narrowed to a one-time inspection in a form of a test, a questionnaire, and other; but has to be prolonged and has to include the observation of an examinee under various profession-like conditions. Due to all these, the assessment procedure has a **stage-by-stage** nature: on the first stage an **interview** (a test or other) is run with an aim to determine the level of formation of professionally important knowledge and skills; in case of a successful passing of that stage the examinee is permitted to take up to the next stage – **qualification exam** [4, p.104].

To **conclude** it should be underlined that the competence paradigm brings to the attention the issue of unbiased assessment. It is not only about the attraction of external partners of a higher education institution to the process of graduates' competences assessment that is conducted at the final stage of educational process (as usual, it is the participation of employers in the State Attestation Board). The assessment has to be independent and continue during the whole educational process. In order to achieve this, it is worth separating educational function and function of assessing its learning outcomes both on the level of one professor and on the level of a whole study programme [13].

One of the mechanisms for solving this issue could be the transfer of the control function and the competences formation assessment function to the Educational Quality Unit, which exists in most universities. It is not the evaluation of current academic performance that is meant here, but specific assessment procedures for competences of students from all study years that are run regularly by an HEI quality control unit (preferably – at the end of each study year). This would require the development of a system of competence-oriented interdisciplinary knowledge for each major and for each year of study. Such an approach would solve at least two issues:

1) provide a competence-oriented nature to the real educational process of each course;

2) assure a valid unbiased and independent assessment of competences formation.

This approach is already being implemented in a number of countries. For instance, in the Netherlands educational organizations create cognitive laboratories that are considered indispensable when transmitting to the competence-based educational model. It is recommended to invite specialists from different fields of knowledge to these labs – educationalists, psychologists, methodologists, etc. These professionals are supposed to conduct audio recording and analysis of students' real-time execution of competence-based tasks, develop optimum evaluation scales for particular tasks, interpret results of undertaken tests, conduct monitoring of individual's progress growth on particular competences during the whole study process of each student [14].

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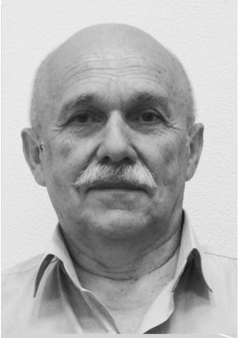
UDC 378

Adaptation of Bachelor and Master Degree Programmes to Meet Modern Standards (Information Systems and Technologies)

Saint Petersburg Electrotechnical University "LETI"
V.A. Dubenetsky, A.G. Kuznetsov, V.V. Tsekhanovsky

V.A. Dubenetsky

A.G. Kuznetsov



V.V. Tsekhanovsky

The paper considers different approaches to the use of models, which are applied in the sphere of information technologies and specified in modern standards and guidelines, for the development of Bachelor and Master degree programs, the specialty of Information Systems and Technologies. The authors give examples of educational process management based on Unified Modeling Language (UML).

Key words: education program, object-oriented approach, product life cycle, business model, the object of professional activity, information resource.

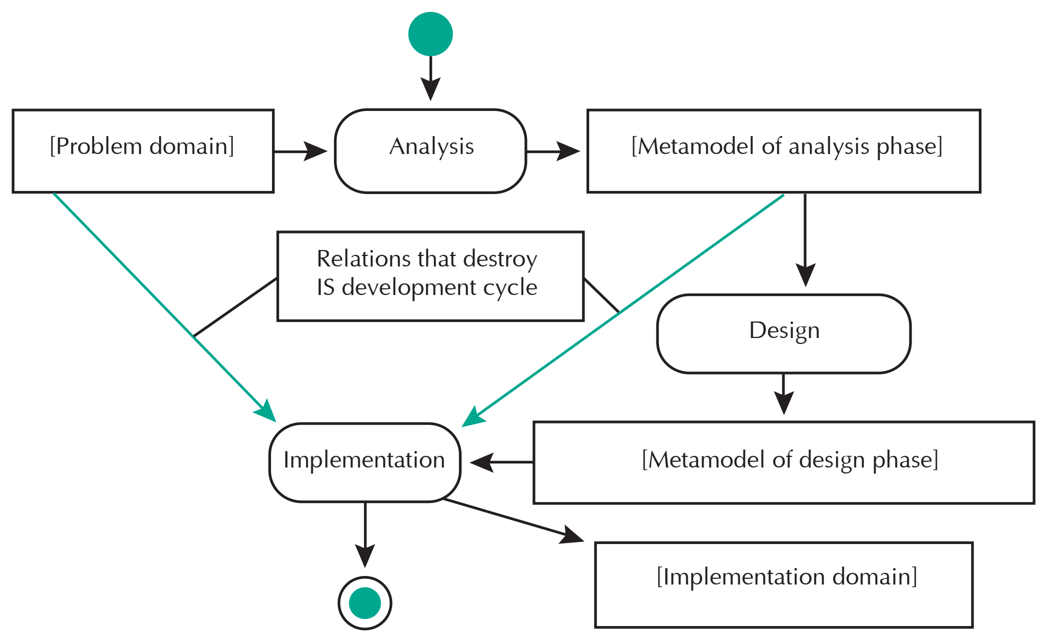
Providing Bachelor's and Master's degree courses in Information systems and technologies, one faces the following specific challenges:

1. Constant extension of IT application scope. Instead of studying different spheres of IT application, it is necessary to master IT analysis applicable in any sphere of activities.
2. Steady and intensive development and improvement of IT. Growing variety of IT models, methods and tools to design information systems (IS). It is necessary to use higher level of abstraction while describing both existing and newly designed methods of IS design in a uniform way.
3. Considerable diversity of classes of information resources. It is necessary to determine an appropriate level of abstraction while studying classes of information resources, which would prevent duplication and simplify study via inheritance mechanism.
4. Considerable gap between a problem domain and solution domain. It is necessary to use technologies of IS design focused on high-level domain-specific languages that allow reducing the gap between problem and solution domain.

All these challenges are quite well formalized by means of unified modeling language (UML), and CASE tools allow using modern informational technology to full extent.

The specific feature of the professional activity trained in the course is that the main part of information processed at the stages of analysis and design is presented as metadata, where classes of objects, processes, events, as well as various associations, relations and limits between them are formally described [1, pp.10-20]. Fig. 1 shows a diagram describing a gap between the income data for information system development and implementation. This gap can be overcome by obtaining intermediate data called a metamodel for problem frames and metamodel design patterns. One of the main aims of the course is to provide students with skills and knowledge that would allow them to identify and decompose a problem to obtain a metamodel of the analysis followed by a metamodel of a design solution and then system implementation. A variety of methods and tools can be applied at each stage of the system development and implementation [1, pp. 88-98].

Fig. 1. Gap between the problem domain and implementation domain



There are goals of adaptation as follows:

1. To adjust the content of the education programmes and student learning outcomes to the modern level of IT development and employers' requirements.
2. To comply the content of the education programmes with IT models required by modern standards and recommendations.
3. To enlarge the spectrum of used models, methods, and tools of IT design.

To achieve the goals, the following tasks should be performed:

1. To analyze the existing standards and recommendations to identify the elements that should be introduced into the curriculum and programmes of the subjects.
2. To enlarge the range of the studied models and methods for management problem-solving, to develop a unified approach to their description and study.
3. To enlarge the spectrum of the design and implementation tools to be studied.
4. To ensure a detail study of the basic classes of informational resources.
5. To develop laboratory classes, practical tasks, and course projects basing on project approach.

While adapting the education programmes of the courses, the following concepts, recommendations and standards should be taken into consideration:

1. The Federal State Education Standard (FSES) provides a framework and extension points to develop concrete education programs.
2. Conceive Design Implement Operate (CDIO) concept. The aim of the initiative is to bring the content of engineering education programme and students' learning outcomes to the level of modern technological development and employers' expectations [2].
3. Product Lifecycle Management (PLM) concept offers a standard structure of product lifecycle, recommendations on composition and structure of information about the product for all the stages of the lifecycle [1, pp. 33-45].
4. Document IEEE 1471 «Recommended Practice for Architectural Descriptions» contains a guideline to describe the architectures of information and programme systems. It offers a template to describe architectures as object models [3].
5. The ITIL recommendations (Infrastructure Library) are a catalogue of best practices for the IT organizations [4].

Let us study particular features of some recommendations. Fig. 2 shows a class diagram that depicts the structure of IS architecture recommended by IEEE 1471. There are such notions as Stakeholder, Viewpoint, and View. They allow developing complex requirements to a designed IS. Besides, it is recommended to use a spectrum of model to present architecture solutions from different viewpoints. To master technologies of IS design according to the recommendations makes it necessary to use interdisciplinary relations.

Fig. 3 shows a class diagram with fragment of information recourse classification. The classification complies with ITIL recom-mendations. The use of ITIL practices in the education programmes development allows structuring the study of different information resources, preventing duplication, and identifying views and used models.

The aspects of the education programmes to be adapted are as follows:

1. To make closer connections between theory and practice. CDIO recommendations are to be applied.
2. To agree on the content, views, and models of the studied information resource classes. ITIL, IEEE 1471 information resource management models are to be used.
3. To agree on the content, views, and models of the studied product classes. PLM models are to be used.
4. To agree on the studied models and methods of IS and IT analysis. IEEE 1471 models are to be used.
5. To organize and structure the education programmes according to FSES and basic IT standards.
6. To develop complex tasks that would simulate a real IT engineering activity.

Fig. 2. Class diagram presenting a structure of IS architecture

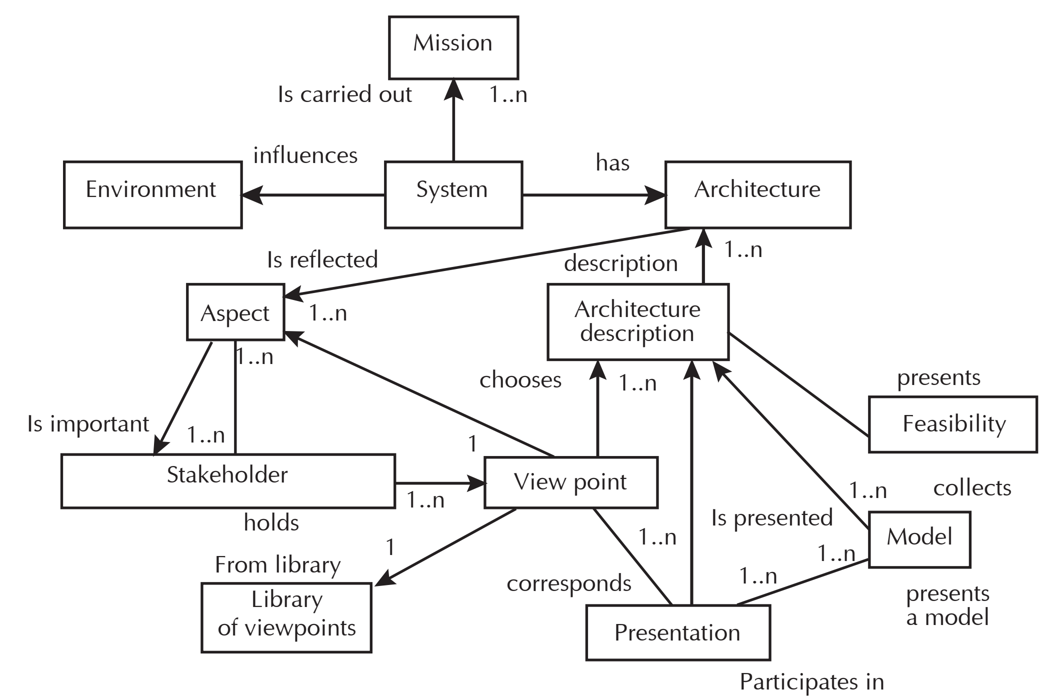
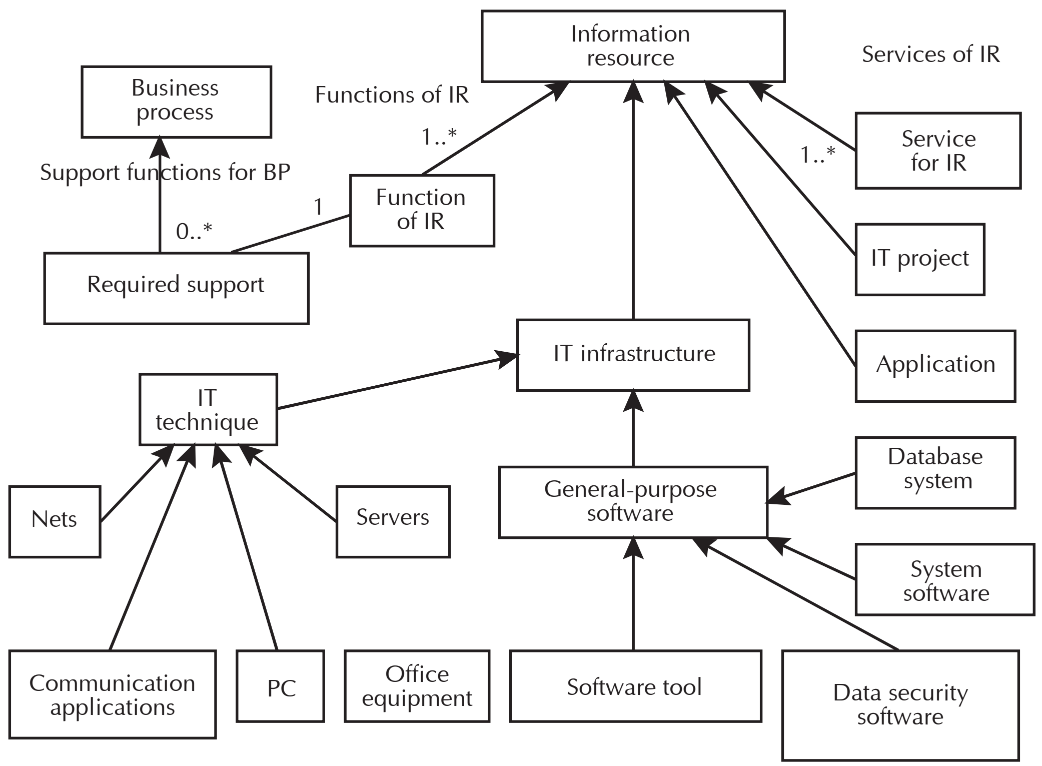


Fig. 3. The fragment of information resource classification



Object modeling with UML is used to perform complicated professional tasks. It is proved in [5, pp. 89] that most of known methods of IS design can be successfully modeled in UML. UML with some extensions allows providing formal representation of results of all design stages. These features of UML make it an ultimate tool to train theoretical and practical analysis, design, implementation, and maintenance of IS.

To control changes in the education programmes it is suggested developing a specialized IS that would allow performing a complete set of tasks related to education programme data management by analogy with PDM systems. The example of such system is shown in [5, pp. 110-141]. Fig. 4 demonstrates a fragment of metamodel for an education program.

Let us consider some results of education programme adaptation according to the requirements mentioned above. To manage laboratory works (LW) and practical classes (PC), the following approaches are offered:

1. Each LW is aimed at training a fragment of real professional task and includes the analysis of a domain fragment, development of design solutions, their implementation and test execution. All the stages are registered by corresponding CASE-tools.

2. A set of tasks is focused on the repeated use of the fragments developed beforehand. Each successive LW implies using the fragments developed beforehand.

3. Practical classes (PC) are focused on developing skills related to analysis, design and implementation of the IS fragments to be implemented in LWs.

4. The amount of LW is quite big (at least 12 academic hours). Some subjects have a united cycle of LWs. Each subject

Fig. 4. Fragment of an object model for an education program

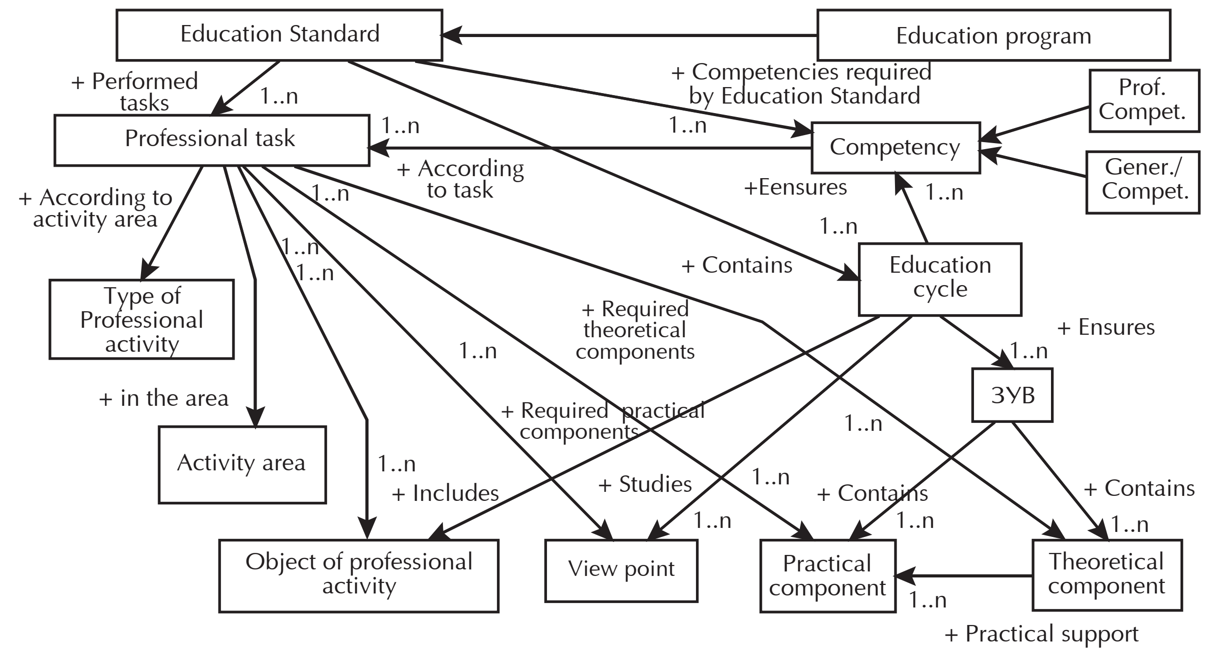


Table 1. Academic hour (credits) distribution to fulfill a set of tasks on design technology

Subject	Corporate IMS	Methods and tools for IS design	IS object and process models	Modern methods of IS design
Year	4	4	1	2
Term	8	8	1	3
Credits	2	3	5	5
Lectures	22	22	18	36
Practical Cl.	11	11	–	36
Lab. work	22	22	54	36
Class form. training	55	55	72	108
Independent work	13	47	108	72
Total	**68**	**102**	**180**	**180**

studies different aspects of the project solutions.

5. Internet sources are used to obtain income data. A basic set of tools is available for each student. It is allowed using other tools at student's discretion.

Tab. 1 presents an example of academic hours (credits) distribution with the emphasis of practical experience. Tab. 2 contains an example of report on task performance.

Thus, it can be concluded that:

- Introduction of fragments of real engineering activity in educational process is a challenging task.
- The education programmes should be adapted to this practical approach by incorporating the requirements and standards applied in engineering and science of a particular area.
- The use of object technology allows increasing significantly the level of abstraction in project solutions.
- There is a need in diversity of successive tasks for students.

Table 2. Model report on task performance

№	Stage	Result
1.	Input data analysis	Informal description of income data. Domain class model.
2.	Development of functional requirements to the designed sub-system	Use-case diagrams. Description of the diagram components.
3.	Development of a class model for dedicated processes	Class diagrams with attributes and operations.
4.	Development of a storage model to keep product data in database	ER diagrams. Metadata scripts with comments.
5.	Development of basic SQL procedures to work with the reference	SQL procedure scripts with comments.
6.	Procedure testing	Test description. Scripts of income data to be tested. Screenshots of test results.

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T.A. Starshinova

V.G. Ivanov

O.A. Larionova

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Development of Global Profession-Related Foreign Language Competency on the Basis of Integrative Approach as an Important Aspect in Interdisciplinary Team Work Training for Petroleum Workers

Kazan National Research Technological University
T.A. Starshinova, V.G. Ivanov, O.A. Larionova

Interdisciplinary tasks of petroleum industry boost intensive international collaboration and intercultural cooperation. This necessitates development of global profession-related foreign language competency required for both engineers and middle-ranking staff since it is a crucial factor in interdisciplinary and international team work training for the next generation of petroleum workers. The authors of the present paper suggest educational process design based on integrative approach and relevant principles.

Key words: interdisciplinary teams, foreign-language preparation, integrative approach, global professional foreign-language communicative competency.

Contemporary technologies in oil and gas industry are based on interdisciplinary approach, i.e. their development and implementation involve knowledge from different spheres – chemistry, physics, geology, biology, ecology, economics, information, etc. Such developments related, for instance, to tight oil recovery, environmental safety of offshore fields or associated gas utilization require knowledge and breakthrough technologies from different spheres which are, as a rule, developed unevenly in different countries. It is more effective to organize interdisciplinary cooperation at the international level using advantages of various national engineering and research schools, as well as practical experience of manufacturers – technologists and engineers – from different countries. One of the consequences of the globalization in petroleum industry is fractional production – when its components are produced in different countries, which increases significantly the number of international contacts and their significance. More and more joint upstream oil and gas projects are implemented on the basis of international and interdisciplinary developments, exchange of practical experience, and international cooperation with different share of domestic and foreign capital both in Russia and abroad. The effective interaction within teams becomes more important, the teams being not only interdisciplinary but also international. Now petroleum engineers' proficiency in English is one of the principle skills allowing companies to be integrated in the international professional community. The skill in professional foreign communication becomes of great importance for Russian engineering education, as students are to gain effective language training based on professional communicative competence [1, p. 33]. However, contemporary language training is to be performed in such a way that petroleum engineer could exercise professional activity in an international interdisciplinary team. It is of no doubt that there is a demand for a shift in the language training system

towards qualitatively new level of cross-cultural interaction competency, global professional language competency of both students and working specialists based on professional communicative competency.

The efforts to address the problem mentioned above have led to introduction of (ESP – English for Specific Purposes) into the system of professional training. It is considered to be a priority in the sphere of education innovation. ESP training allows using foreign language as a tool to develop global professional language competency (GPLC).

The essential features of the given competency derive from the requirements for education programmes specified by accreditation agencies, as well as from professional functions of a globally competent engineer.

As early as in 2007 the main criterion of all agencies was the demand for global model of engineering accreditation that can be used to assess engineers' global professional skills [2, p. 642]. As a result, in 2008 A. Patil, C.S. Nair and G. Codner distinguished six basic qualities of a globally competent engineer [3], in 2009 A.D. Chan, J. Fishbein and L.G. Brown expanded the list by adding ten qualities [4, p. 4-9]. Having analysed those qualities and requirements of leading international accreditation agencies for a globally competent engineer [5, p. 3-9; 6, p. 17-19; 7; 8, p. 6; 9], we identified five basic blocks of GPLC intended to master language skills of a globally competent engineer.

1. Communicative skills: ability to work and communicate in the national and international environment with representatives of any nations and cultures; transform information; ability to conduct discussions and arguments, brain storming, professional oral and written communication in native and foreign languages; make reports, present projects, ability to argue, and persuade.

2. Independence: ability to study and implement innovations independently in a single-discipline sphere, ability to use up-to-date information technologies; knowledge and skill of searching for and collecting professional information in different databases (library and electron ones); ability to perform self-study, self-development, self-education for the life-long personal professional development.

3. Developed critical thinking: ability to cope quickly with a problem of any complexity, respond adequately; ability to analyze, generalize, observe, interpret, criticize, reason, and act creatively; mastery of critical thinking techniques; ability to select evaluation criteria reasonably, knowledge of value system; ability to analyze, process, and present information in the form of review, report.

4. Skills of professional communication: ability to be a member/leader of multidisciplinary and cross-cultural team; ability to negotiate with employees of other organizations; ability to manage and report to; knowledge of labour market and economics; ability to effectively interact; ability to work in the innovative environment.

5. Global (ethical) communication: ability to understand the influence of his/her profession on society, industry, nature, and economy at the global scale; knowledge and ability to effectively apply professional ethics; understanding of responsibility in making professional decisions; skill of running international business, solving problems related to national differences; ability to understand diversities and differences between native and other cultures; knowledge of ethical aspects of cultures; knowledge of diverse disciplines and skill of their synthesizing to apply for non-diversified environment; ability to compete and cooperate in international context.

Based on the enumerated qualities required from a global engineer, we regard GPLC as future/working specialist's ability to effectively use language knowledge and skills in the secondary language environment to solve basic communicative, presentation, and technical professional problems, communicate successfully and ethically in the condition of professional international cooperation, to be a member or leader of interdisciplinary international teams, to think critically and respond flexibly in any conditions of professional cross-cultural cooperation, as well as readiness for life-long professional self-development in the sphere of international communication.

Analyzing GPLC components, it should be noted that communicative skills are not just in a row with other components, but they are basic, central skills, as mastering all other components is performed via, first of all, communication.

When comparing GPLC components, FSES and FSES 3 + requirements for the training petroleum workers of middle and top ranking, it is evident that education standards do not fully meet the requirements of global labour market. At most, one can say that GPLC components are presented separately, as constituents of different FSES competencies.

It is suggested that GPLC of petroleum engineers and students should be efficiently developed by introducing an "Intensive integrative foreign language course" based on integrative approach and interdisciplinarity. The course could be a part of both basic university and further professional development training.

The integrative approach is conditioned by the interdisciplinary character of petroleum engineer's professional activity, as well as more general trends – integration of science, education, and industry resulting in uniting the content of different disciplines [10, p. 222]. The integrative approach makes possible to link the profile disciplines with foreign language that generates sustained interest in language learning and increases motivation. The regular interdisciplinary integration focused on professional sphere at the foreign language classes has a positive effect on development of professional qualities. Interdisciplinary integration allows students to build an integrative professional worldview, develop critical thinking and imagination, increase cognitive activity, develop creative skills, as well as perform intensive cognitive and research activity [11, p. 43]. Such an approach strengthens the preparation for work in interdisciplinary international teams and projects, and can be adopted for both basic and additional education.

The following basic principles of "Intensive integrative course of foreign language" aimed at GPLC development were distinguished: the principle of professional relevance (the content of the course was designed in view of professional functionality), the principle of language authenticity (the course should not only facilitate communicative skills development, but also the skills of correct usage of speech patterns), the principle of time and load management (the course is designed in such a way that student's active and passive vocabulary increases 4 times as compared to that in the traditional training method), context-based principle (the content is selected in such a way that new words are learnt in the process of contextual guess and in the subsequent learning process they become a stimulus for student's reaction), the principle of motivating content (learning content creates professional environment producing situations/problems to encourage students to speak), the principle of integration of all learning activities (communicative skills cannot be separated from other types of language activity, hence, there should be integration of speaking with other language skills and competencies), the principle of teaching to learn (learning content is to teach students to use foreign language as a tool for information search and self-development), the principle of speaking and culture integration (the course content is to be focused on development of speaking interculture), the principle of critical thinking development (tasks are to be focused on development of student's critical thinking, which gives a future specialist flexibility to analyze professional conditions).

The "Intensive integrative course of foreign language" suggests a combination of learning methods forming the conditions of GPLC development, such as: role playing, debates, brain storming, Case-study, problem tasks, jigsaw technique, project method.

One of the ESP goals is to develop foreign language communicative competency related to a set of general culture competences (GC) (for instance, GC 1 – GC 12 of FSES SVE for future petroleum workers) that imply students' proficiency in General English. In the course of our experiment, language communicative competency was a starting point for GPLC development. Therefore, we assume that comparison of language communicative competency levels made before the experiment has confirmed their homogeneity. The test results showed that all groups had approximately the same low level of language communicative competency, since 50-53% of students made less than 50% of the test.

To evaluate the effectiveness of the suggested principles and the approach to GPLC development, we carried out an experiment involving prospective oil field equipment technicians trained at Almetiev Polytechnic College, as well as a group of working oil field equipment technicians from the departments of Tatneft "Yamashneft" (graduated no later than 6 years ago) in the framework of additional education. In total, 70 students and workers were involved in the experiment.

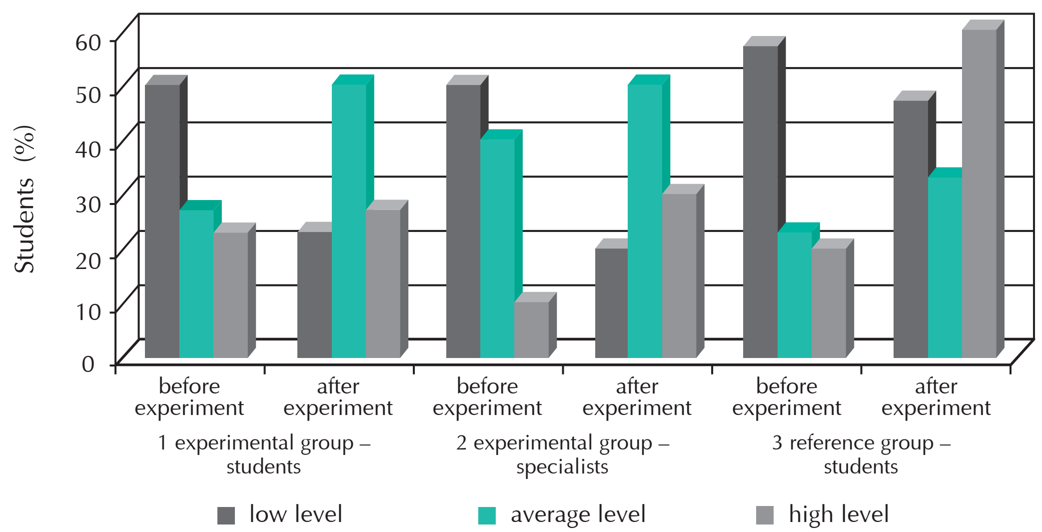
In the course of the experiment the English language was taught on the basis of selected material integrated with the major disciplines of professional profile. To implement the integrative approach a variable set of practical tasks was used with the problems close to those faced in the professional condition and global interdisciplinary environment. For example, during communicative games students were divided into teams, each with its own role of future profession, for example, geologist, geotechnician, technician etc. Competitive base and high level of independency in the problem solving intensified motivation to learn professional English. The students solved relevant professional problems of cross-cultural and interdisciplinary character. For example, during business role playing, projects, and problem tasks the students could address the issues of presenting new petroleum field equipment, studying methods of oil and gas production used abroad. While performing the task, it was necessary to follow rules of decorum, cross-cultural conventions, take into account national and cultural features of foreign colleagues.

Test was chosen as a form of placement and final assessment of GPLC development. It consisted of blocks corresponding to designated earlier GPLC components. Tests consisted of 5 parts, each containing: foreign language context: tasks aimed at checking the level of communicative skill development – 10 points; tasks on revealing the ability to self-study and self-develop in the sphere of professional communication – 10 points; tasks on the ability to think critically in the professional environment – 10 points; tasks revealing the level of professional interdisciplinary communication skills – 10 points; tasks stating the ability to communicate ethically in cross-cultural environment – 10 points. The criterion of assessment was percent of tasks performed correctly. Therefore, 3 levels of GPLC development were defined, where, in its turn, 3 levels were specified: low level (0-50% of correctly performed tasks); average level (51-75% of correctly performed tasks); high level (76-100 % of correctly performed tasks).

The results of the experiment have shown that the number of students with low and average level of GPLC is significantly lower in the experimental groups in comparison with the reference group. The diagram (Fig. 1) shows the average dynamics of changes in all components of GPLC.

If we take the levels (low, average, high) of GPLC development as grades (3, 4, 5), correspondingly, then qualitative

Fig. 1. Dynamics of students' GPLC development

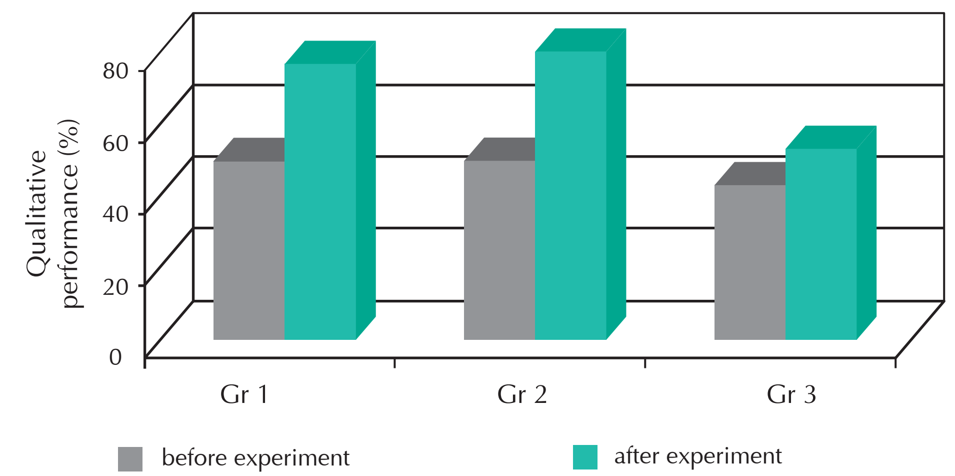


Dynamics of students' GPLC development levels before and after experiment (%)

performance in groups before and after experiment can be presented in the graph (Fig. 2) that shows positive dynamics. The quality level in the experimental groups grew by 27-30%, whereas in the reference group the results increased by 10%. The experimental results confirm that GPLC is effectively developed within "Intensive integrative course of foreign language", content and structure of which are based on integrative approach and a set of suggested organizational principles.

Competitiveness of contemporary production is provided by a specialist of new type capable of working at global international scale, performing effective professional activity in international interdisciplinary teams. We strongly believe that the shift of foreign language training towards development of global professional language competency is a turning point in change of focus on foreign language training of national engineering community and medium level specialists of not only petroleum engineering, but also other industries with high potential of international cooperation and interdisciplinary developments.

Fig. 2. Dynamics of qualitative performance in the experimental and reference groups



Dynamics of qualitative performance in groups before and after experiment (%)

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Economic, Scientific and Technical Factors in Quality Management

Saint Petersburg Electrotechnical University "LETI"
V.P. Semenov

V.P. Semenov

The article examines interaction of economic, scientific and technical factors in quality management training including not only development of new approaches, but also design of integrated systems based on the principles of total quality management. In order to estimate efficiency of interdisciplinary projects, multi-criteria and multi-model approaches are considered essential.

Key words: quality management, integrated systems, total quality management, scientific and technical factors, economic factors, estimation of project efficiency, multi-criteria approach, multi-model approach.

By the end of the 20th century, people have come to understand that quality management rests on the strategies and tactics to achieve economic well-being of a certain employee and society in general.

The 21st century was rightly called a Century of Quality by UNESCO. The current approaches to quality management do not only concern engineering process, but also direct and control an organization and society as a whole. In fact, quality is an integral notion that involves engineering, technical, economic, social, philosophical and other aspects, as well as their interaction. Today, quality management is of great importance as it is regarded as a strategy to improve economic efficiency within the international integration frame.

Different market processes stipulated the origin of various quality management systems based on the principles of Total quality management (TQM). The modern toolbox to enhance quality and productivity in business has been recently enriched by such approaches as Project Management, benchmarking (a method to compare key metrics), teaching organization theory, Balanced Scorecard, the concept of "6 sigma", Business Excellence, Total Productive Maintenance (TPM) [1, p. 82].

Managers of the companies have started to use more often various methods of analysis and problem solving which encourage and develop creativity. Benchmarking continues to grow in popularity and is used to enhance economic efficiency of organizations. Project management that allows creating flexible project-based and horizontal organizations also develops, though, not as rapidly as desired. Among the approaches that are likely to grow in popularity, Balanced Scorecard and Knowledge Management are worth mentioning. The requirement for a life-long learning has become an inevitable reality.

It is obvious that the basic concept of Scientific Management is directly dependent on the quality policy, which, in its turn, is the basis for effective implementation of other strategies of a company. Today, quality management is gradually becoming the key method to control and direct business, i.e. management of the fourth generation [2, p. 25].

The end of the 20th century witnessed a transition from "Mass production" to "Lean production". The beginning of the 21st century is viewed as a period of a new type manufacturing, called by a number of authors "Agile Manufacturing". Lean production, agile manufacturing, and simple use of process approach in line with the standards ISO 9000 can eliminate the borders, first of all, between organizations, then, between countries [3, p. 16].

The competitiveness of an enterprise or company directly depends on the quality of management. International standardization of management systems and their integration are one of the methods to ensure sustainable development of an organization.

Therefore, design of the integrated management systems (IMSs) has become rather popular. IMSs create the conditions for further improvement of the management system. However, IMSs should not be identified with the system of general management which unites all activities of an organization. Even in the case of implementing all existing universal and industry-specific standards, IMSs are not the same as general management of an organization as IMSs do not include financial management, staff management, innovation management, risk management, management of value documents, and etc.

When designing IMS, principles of sustainable development and continuous business processes with regard to the risk assessment are basically used. These principles are specified in ISO 9004:2009 "Managing for the sustained success of an organization – A quality management approach", ISO 31000:2009 "Risk management. Principles and guidance", ISO 31010:2009 "Risk management. Risk assessment techniques", BS 25999-1:2006 "Business continuity management. Code of practice", BS 25999-2:2007 "Business continuity management. Specification".

Modern marketing has created a new type of competitiveness – intellectual capital competitiveness within the international frame. In the developed countries, the maximum growth of the national income is secured due to the forward-looking development of science, i.e. knowledge growth. The import of technologies is significantly more effective than the import of products, while the import of intellectual capital is several times more efficient than import of technologies. Therefore, a number of developed countries focus on import of intellectual capital and professionalism making it a part of the state policy.

Modern quality management can be definitely referred to relevant activity. It is proved by the fact that it covers various processes of product lifecycle and includes numerous methods, technologies, and approaches which are based on different design, analysis, and forecast techniques [4, p. 162-163].

Throughout the history of management theory and practice development, there is still debate on the importance of technical and humanitarian issues in management. The current conditions resulted from the need to facilitate the transfer to knowledge-innovation economy urge to solve the problems related to the effective interaction of scientific, technical, and economic factors. Thus, search for the rational combination of technological and economic potential is a key task of quality management [5, p. 284].

Technological potential is secured by objective physical, biological, chemical and other terminal parameters. At any given time, the terminal parameter is defined by the gap between the achieved level of technical efficiency and the theoretical limit to the efficiency of the given technology. In addition, technical efficiency or technical level is defined on the basis of the parameters which have high customer value and do not directly associated with the technical advancements.

Technological efficiency is necessary but not sufficient condition for commercial success. The efficiency of a new product is comprised of two components: technological and cost efficiencies. Therefore, a new product will be effective if two types of efficiency are rather high. When a new product is technologically effective, but meets no demand, the total efficiency is negative.

Implementation of the interdisciplinary project should provide a given level of profitability, planned outputs, acceptable risk level and financial stability of an organization. Methodologically, it necessitates the use of multi-criteria approach for assessing interdisciplinary projects.

In order to assess the projects via multi-criteria approach, it is necessary to use a set of partial models followed by multi-criteria optimization of decision-making process. Methodologically, this indicates the shift to polymodel principle of comparative analysis of variance for interdisciplinary projects.

Logically, the essence of the polymodel assessment and construction of the corresponding complex model for certain alternatives of interdisciplinary projects is reduced to an adaptive design and conceptual substantiation of the methodological provisions of a multivariable assessment. In addition, specific properties and corresponding conditions of the assessment should be also considered.

In our opinion, mechanism to evaluate and select the most effective projects should consist of the following units: evaluation of project technology, evaluation and taking investment decisions, evaluation of network (corporate) interaction, comprehensive evaluation and selection of projects.

Polymodel assessment of investment decisions rests on the complex structure of the general model of evaluation and decision-making. It consists of a number of partial models to perform multidimensional analysis of the options and make the decision on the basis of the criterion of preference in the process of multi-criteria optimization. Thus, the unit of evaluation and taking investment decision involves the following models: model of economic evaluation of projects, corporate evaluation of projects, risk assessment model, model of multi-criteria decision analysis based on the designed criterion of preference.

The first three models can be regarded as partial models, while the model of multi-criteria analysis and decision taking – as a general model for decision optimization.

The algorithm of finding the desired solution consists of a number of stages. Firstly, polymodel assessment of projects is performed in order to redefine the problem of optimizing the choice of the preferred project version in accordance with the relevant criteria and scientific, technical, and economic factors. The next stage is a multicriteria optimization of decision-making process. The stage involves the aggregation of criteria for project assessment and expert multi-criteria evaluation of alternative projects. A final decision on the choice of the preferred project is taken at the final stage of the algorithm.

Thus, the objectives of process management necessitate the use of multi-criteria decision-making methods. To a certain extent, they are often generalization of one-criterion methods. However, most of the management decisions are aimed at achieving a number of, often conflicting, goals. Hence, it is almost always difficult to reduce the problem of finding optimal solution to the traditional one-criterion methods. Therefore, enormous attention, both in theoretical and practical sense, has been recently paid to the development of new methods to evaluate and optimize management solutions. In this respect, the theory of fuzzy set should be mentioned first. Along with the calculus of variations, solution of differential equations, linear programming, Pareto optimization techniques and finding of the planes of indifference are frequently used.

It has been proved that the required complex approach to quality management is secured in the case when systems, statistical and engineering methods are in line with the appropriate production relations. However, the proposed set of methods has not been applied in quality management yet [1, p. 82].

In present conditions of business and enterprise management, knowledge, both in modern production technologies, i.e. production management, and quality management, i.e. quality management efficiency, is becoming more and more essential. This constitutes a key parameter in developing competitive advantages of enterprises and organizations. In this respect, students should possess knowledge in quality efficiency in order to make rational management decisions in the research area.

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UDC 378.14+681.2

Interdisciplinarity in Practice-Oriented Training of Bachelors in Line with the CDIO Initiative

Saint Petersburg Electrotechnical University "LETI"
A.M. Boronakhin, A.A. Minina, R.V. Shalymov

A.M. Boronakhin

A.A. Minina

R.V. Shalymov

In the context of modern constantly changing realm the successfulness of technical HEIs' graduates is determined not only by their current knowledge, but also by their ability to adapt to these changes. This article is devoted to the efforts of the Saint Petersburg Electrotechnical University "LETI" and namely the Faculty of Information Measurement and Biotechnical Systems (FIMBS) on implementing the CDIO Initiative approaches for development of the required students' competences.

Key words: CDIO, engineering education, quality of education, interdisciplinarity, instrumentation technology.

One of the key factors influencing formation of specialists on any stage of educational process is the motivation of a student. Therefore, HEIs that want to increase the demand for their graduates have to pay significant attention to enrolling motivated school graduates, bachelors, master students, and PhDs. Throughout the study process all of these types of students have to have certain understanding of the connection between each step they make and the final result they can achieve; in this case, it is the successful employment [1, p. 166].

Working with school students

The introduction of a new enrollment procedure in Russian HEIs, which is based on the results of the Unified State Exam, has significantly changed the approach towards enrollees. Previously, in order to apply for admission to university prospective students had to come to an HEI, meet the Admission Board and exam administrators, which gave both enrollees and HEI an opportunity to get to know each other to some extent. The current situation is conceptually different, since the admission becomes accessible even by sending the documents via mail. In this case, the understanding of prospective students' motivation to receive the education in a certain HEI on a certain major becomes perceptible only during the educational process itself. The solution to this problem is active interaction between an HEI and its prospective enrollees both in the city and in other regions or countries.

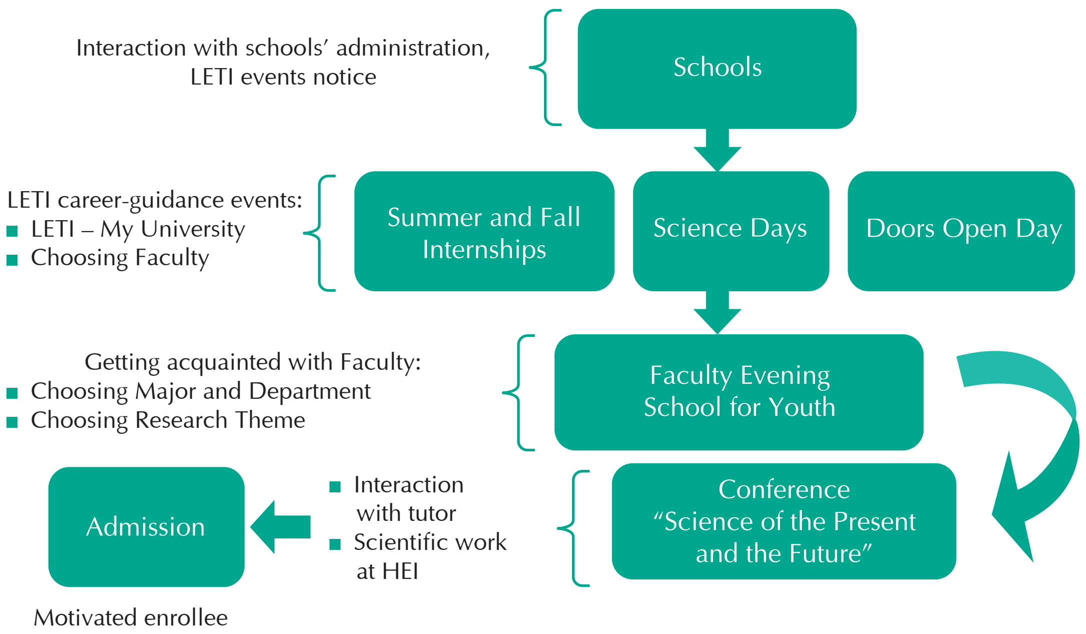
LETI, and the Faculty of Information Measurement and Biotechnical Systems in particular, spend significant financial and labor resources on career-guidance activities for enrollees (Fig. 1).

The aim of this process is to get enrollees acquainted with peculiarities of studying at this university and faculty, and to attract to enroll at LETI those prospective students, who are interested in receiving engineering education in this field. By going through a consecutive set of events each prospective student will be able to choose his/her future educational path deliberately and, moreover, foster extra skills of communication, team work, as well we adapt to the upcoming learning process at an HEI [1, p. 167].

Features of educational process

The optimization of educational process that aims to increase the demand for graduates within the real sector of economy is a complex multifactor problem. The LETI Faculty of Information Measurement and Biotechnical Systems, when solving this problem, focused on the requirements

Fig. 1. Pattern of LETI interaction with school students



towards employees at partner enterprises, such as JSC State Research Center of the Russian Federation Concern CSRI "Elektropribor", JSC "Okeanpribor" and others [2]. These enterprises are leading in the corresponding industrial fields and their requirements for employees serve as best practices for the whole industry.

The result of these actions is the design of curriculum in such a way that by graduating any of the educational stages a graduate is in demand by the labor market, i.e. the graduate possesses the required competences (Fig. 2).

Bachelor graduate, in such case, has a choice: either to continue education on a Master level, or, having received plentiful practical skills, to get employed on a position, adequately corresponding with his/her qualification. A Master programme graduate, having a higher level of qualification, can get employed to a conceptually different type of job positions or can continue his/her education as a PhD student. PhD school at LETI is the highest cycle of education that allows fostering competences required for scientific and research activities as well as pedagogy.

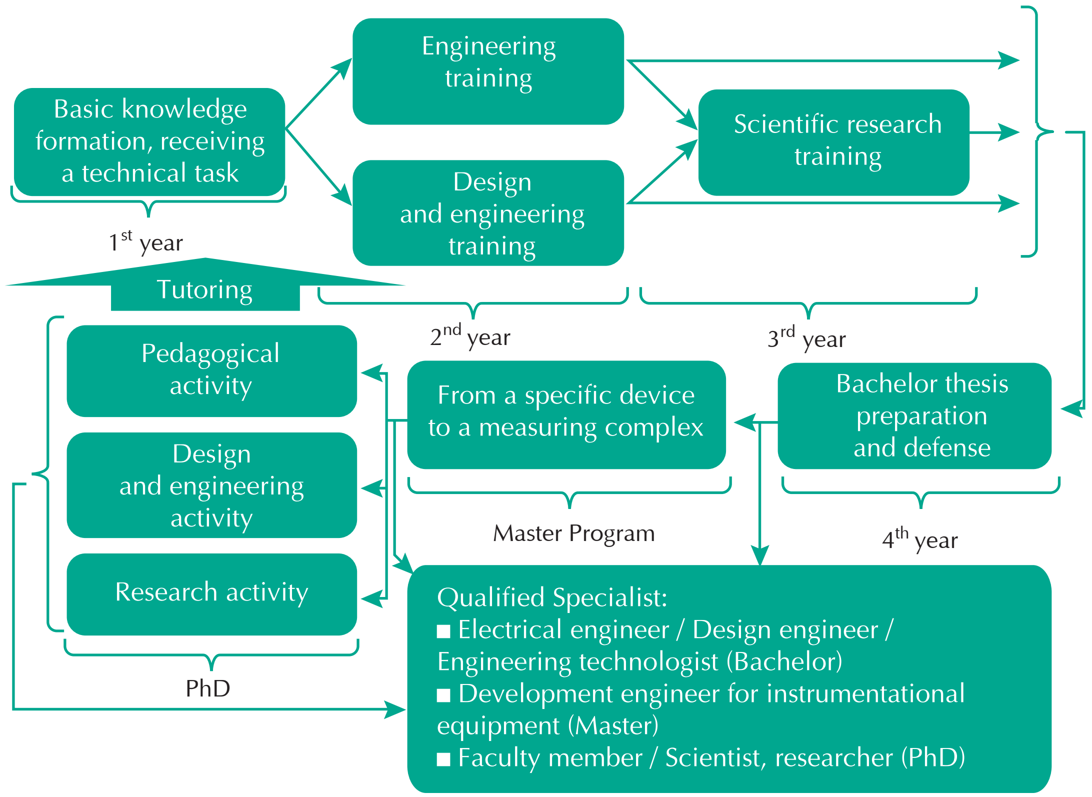
The Bachelor cycle of education is set in such a way that as a result there are three types of graduates with prevailing engineering, design engineering or research skills. Training of each type of Bachelor graduates differs significantly; that assures fostering proper competences. The common feature of Bachelor studies at FIMBS LETI is the suballocated approach to thesis preparation. First-year students get acquainted with departments and educational process (in the framework of an all-faculty course "Introduction to Specialty") and by the end of the first year students receive technical tasks for their theses on agreed themes.

From technical task to real market

Thesis commonly consists of a set of sections, among which are:

1. State-of-the-art analysis
1.1. Marketing research
2. Technical instrument description
2.1. Mathematical model
2.2. Electric circuit description

Fig. 2. Structure of educational process



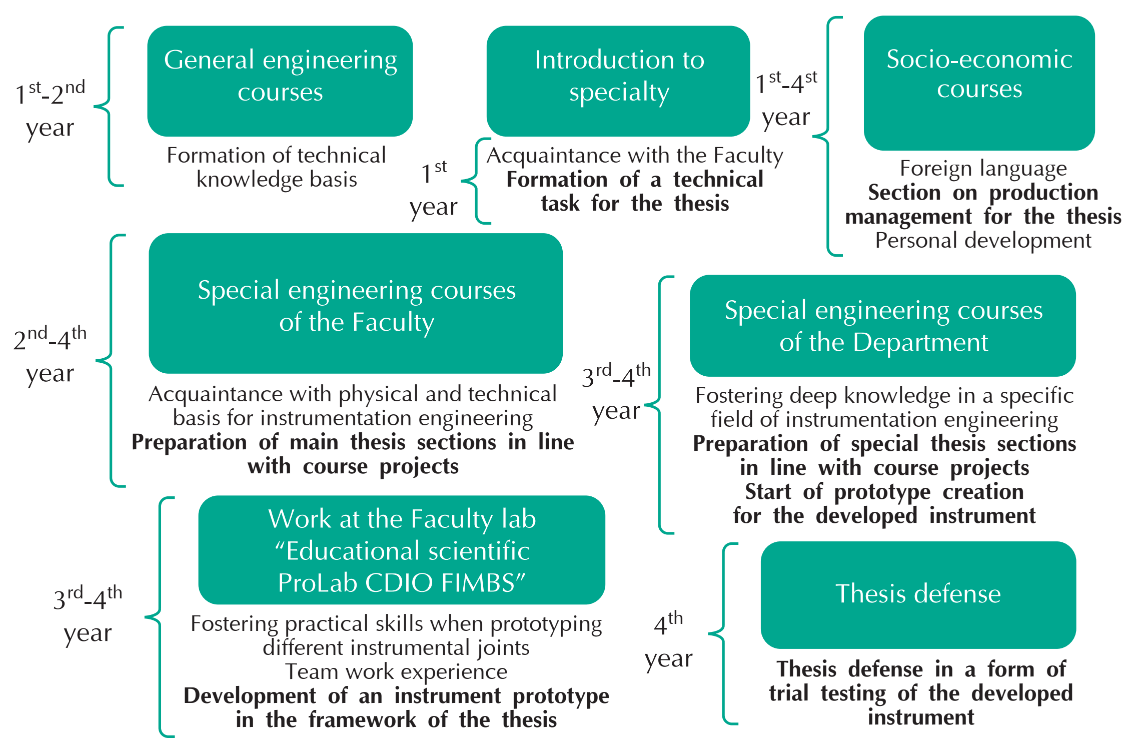
2.3. Design and engineering aspects
2.4. Test results
3. Work safety
3.1. Health and safety protection
3.2. Environmental protection
4. Economic aspects
4.1. Feasibility study
4.2. Business plan
Conclusion
References

Students are supposed to work consecutively on each of these sections in line with preset technical tasks for their theses (Fig. 3) [1, p. 169]. For instance, while learning the ecology course a student has to conduct a course work that will later become a 3.2. part of the thesis. Course works and individual home tasks, in this case, are not devoted to some abstract calculations, by serve as one or the other part of a thesis.

Thus, on each study year students attend various educational modules both technical and other courses that allow preparing thesis sections consecutively up to the final year of study. At the final year students create prototypes of the developed measuring instruments. Thesis defense in this case is held in a form of trial testing of the developed instrument.

The result is the formation of an integrated structure of knowledge and skills: within the process of measuring instruments' development students have to apply the knowledge from various courses (not only the technical ones). By these means the interdisciplinary approach according to the CDIO principles in practice-oriented learning of Bachelors is achieved. The same approach, in a slightly different form, is disseminated on Master and PhD students. For instance, the

Fig. 3. Connecting thesis sections with study courses



latter ones perform as tutors for Bachelor students working on projects; therefore, PhD students improve their pedagogical skills.

"Educational scientific ProLab CDIO FIMBS"

Project prototyping is conducted in the framework of the "Educational scientific ProLab CDIO FIMBS" project (Fig. 4) – a practice-oriented laboratory of the Faculty of Information Measurement and Biotechnical Systems. The lab's foundation has been actively supported by the previously mentioned partner enterprises of the Faculty [1, p. 170-171].

Laboratory aims at solving a number of issues relevant for FIMBS::

- Pre-commissioning procedures and prototyping of instruments developed within Bachelor theses.
- Scientific and research activities of Master students.
- Design and engineering centers for PhD students.
- Cooperation with industry.
- Enrollee involvement in projects in the framework of career-guidance events of the Saint Petersburg Electrotechnical University "LETI".

An important aspect of the FIMBS lab practice-oriented work is the interaction between different scientific fields and learning of some common aspects regarding instrumentation technology as a whole [1, p. 168]. This is especially important considering the fact that the Faculty works at the intersection of sciences: classical engineering, biology, chemistry, medicine, and, therefore, forms a new field of science and technology – "Biotectonics" [3].

In 2016 a pilot Project has been launched that confirmed the viability of the proposed approach. In the framework of the Project, 3rd-year students of Bachelor programmes conducted Project work on "Design and development of a prototype for registering human's physiological indicators " (Fig. 5).

Fig 4. Lab logo

У Н Л
ПРОЛАБ
C D I O
CONCEIVE DESIGN IMPLEMENT OPERATE
ФИБС

Fig. 5. Working on the Project prototype

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L. Musílek

UDC 378

Promotion of Cooperation in Research and Development Between Universities and Industry in the Czech Republic

Czech Technical University in Prague, Czech Republic
L. Musílek

Universities must react to the situation in industry, increasingly oriented towards sophisticated technologies. Grant applications submitted together with industrial companies, direct support of applied research by industry, integrating students into applied research, project-oriented education, all these ways help to bring universities closer to the needs of industry. Supporting collaboration between universities and industry in the Czech Republic is briefly reviewed in the paper.

Key words: applied research, technical universities, industrial companies, cooperation, support in the Czech Republic.

1. Introduction

The traditional model of an industrial company has changed considerably in the last decades. Heavy industry "dinosaurs" have lost their key importance, which has passed to firms producing more sophisticated technologies. Both engineering education and research at universities must react to these developments. If this does not happen, there is a real danger that technically-oriented universities will lose their position to other forms of education, carried out by industrial companies and various private schools and courses, which are fitted closely to the needs of specific branches of industry. Applied research and development should form one of the main activities of universities and their faculties oriented to engineering, and this should also be reflected in the educational activities. If it reflects the needs of industry, it can be an important contributor to limited budgets of universities, but, which is even more important, it can substantially contribute to spectra of themes of projects, in which advanced students can be involved. In this way, engineering education at universities can be closer to the real life, and prepare graduates for "swimming in the waters" of industrial practice.

2. Problem of mutual understanding between universities and companies

Expectations of companies and academic institutions concerning research and its results are often different. Universities usually prefer long term fundamental research guaranteed by stable financing. In many countries, the Czech Republic including, their research is evaluated according to the number of publications, impact factors of journals, in which their results are published, a number of citations and h-factors of their academic employees. The number of Nobel candidates among the staff or graduates might be an interesting contribution to the prestige of the university. However, no one of these criteria is interesting for industrial company.

Industrial companies in general are not interested in topic scientific results with the long way from investigations to practical applications. They live in the highly competitive environment and, therefore, they must innovate their products as quickly as possible, as they need to have applicable results earlier than their rivals. Economical aspects of the proposed innovative solutions play also a crucial role. The management needs to weigh carefully relations between costs and benefits, which determine the success of a particular product in the market.

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These often contradictory approaches result in the fact, that finding common language between an industrial company and an academic world is sometimes difficult. What to do with this discrepancy? The approach of technical universities to research is (slowly) changing. They understand that, though fundamental research is prestigious, interesting and important, they need to extend their research activities in the direction to applied research, development and innovations. The field for collaboration with industry is (also slowly) opening. The necessary step in this direction should also be extending criteria for evaluation of universities, and especially of engineering branches at universities. They should not be based nearly exclusively on the publication record. Agreements with industry, patents, prototypes and functional devices, original software written for needs of information and automation in industrial companies should be comparably prestigious outputs.

The usual evaluation of fresh graduates by their future employers is also related to the orientation of their university towards fundamental and applied research. Frequent complaints of industrial managers to their address are: they are very good in theory, mathematics, sometimes also in information sciences, but they are not prepared as well for practical life, they have deficiencies in communication and their practical experience, readiness to solve unexpected problems, is not as high as desirable.

3. Ways of collaboration

The ways of contacts between universities and industrial companies are multiple and range from the simple "head-hunting" and the offer of jobs for graduates to the deep research and educational collaboration. Let us summarize them briefly.

The head-hunting has two forms: The first one is advertising the job at the university, job fairs, etc. This is useful for students and graduates, however it brings nearly nothing to the university. The more sophisticated way of search for good graduates is participation of students in joint projects, and, at a higher level, in joint laboratories. Companies and other external institutions can assign the themes of student research works and theses at various levels of courses from the bachelor to the doctoral ones, which extend the offer of topics and are supervised jointly from the university and from the external institution. The research task linked this way to the practice helps to students in understanding real problems, and moreover, they often find a future job this way and are for it better prepared. A pre-condition for achieving this goal is to change the old fashioned mind sets of both some academics and some industrial managers.

The most direct form of research collaboration is commission of some research work by a company. Such research needs to be and usually is narrowly targeted to a particular problem, which cannot be solved by the own research capabilities of a company. If such order is a part of wider contact between both institutions, it enhances not only the budget of the university, but also its practical abilities. However, because of time limits for such work, it is often impossible to use it as a theme for students' theses. Moreover, the bad habit of some companies is that they want to avoid payment of overhead charges to the university and they contract directly with members of the university staff. On the other hand, the bad habit of some universities is that they ask for so high overhead that it makes them not competitive in the market.

Direct forms of collaboration can relate also to education. External lecturers from various institution including industrial companies are a welcomed enhancement of courses especially for advanced students. On the other hand, companies can ask for and realize life-long learning courses tailored according to their needs.

However, universities are usually more obliging in this way of collaboration than companies, as education is one of their primary missions. Releasing workers temporarily from their working tasks due to their engagement at the university as lecturers in regular courses or as students of life-long learning courses makes sometimes problems in those companies, in which the management is oriented more to the immediate profit than to the future.

Joint laboratories of universities and technologically advanced companies are probably the best way of collaboration, which is long lasting and profitable for both sides. They represent useful material basis for joint projects and stronger financial possibilities of a company give good possibilities to equip the laboratory by up-to-date instrumentation and devices. As a benefit for a company, students familiarise themselves with the company and its products, and therefore they tend to prefer these products in their future jobs.

Finally, the joint grant projects are the main tool for supporting collaborative research of universities and industrial companies by the state authorities and the state budget in many countries including the Czech Republic. Specialised grant agencies operate usually in this way, in some cases subordinated to various ministries, in some cases independent and subordinated directly to the government. The Czech Republic has two main grant agencies, the Grant Agency of the Czech Republic (GA CR), which supports fundamental research projects, and the Technology Agency of the Czech Republic (TA CR), supporting applied research and innovations. Let us deal by the Technology Agency of the Czech Republic as an example of good practice in this field.

4. The Technology Agency of the Czech Republic and university-industry collaboration

The mission of TA CR is expressed in its documents [1] as follows: "The Technology Agency of the Czech Republic (TA CR) is the main organisation which implements the state policy in the sphere of applied research, development and innovations. The mission of the TA CR is to create and implement effective and transparent system of applied research, development and innovations support to the whole extent thereof. The TA CR participates in the conceptual orientation and creating of research environment of the CR, in the preparation of National Policy of Research, Development and Innovations, produces strategic documents in the field of applied research, development and innovations and implements key programmes in this field, in particular based on national priorities of oriented research and development. The Agency performs analysis of results and data received from its activity and provides them for the needs of further course of applied research, development and innovations. It comes from and develops international cooperation with partner agencies of applied research. The TA CR cooperates upon the preparation of programmes with other sectors and providers of support in the field of applied research, development and innovations and promotes its activity by effective cooperation among research organisations and application sphere and contributes to the attainment of strategic economic and social goals of the Czech Republic while respecting the sustainable development principles."

When passing through the programmes of TA CR for supporting applied research, development and innovations, we can notice that they give wide possibilities for joint projects of industrial companies and research institutions (universities in the Czech Republic are from the point of view of legislation included among research institutions), and rules of some of them even ask for such collaboration as the compulsory condition.

The ALPHA programme has been very interesting for technical universities, as it has aimed to support applied research and experimental development especially in the field of advanced technologies, materials and systems, energy resources and the protection and creation of the environment and the sustainable development of transport. The relevant outputs of this programme are patents, pilot operation, proven technology, results with legal protection, i.e. utility models, industrial designs, technically realized results, i.e. prototypes, functional samples, certified methodologies and procedures, maps with expert content and software [2]. This means that the recognized outputs from the point of view of evaluation of the results reflect needs of collaboration of academic sphere with industry. They might be less accustomed for some research departments at universities, for which publications in scientific journals with high impact factor are the most frequent and most relevant outputs. The ALPHA programme ends in 2016, but it is replaced by the very similar EPSILON programme, which will extend for further 5 years. Expenses of research institutions, including universities, may be covered fully from the grant, whereas industrial companies must contribute 20 to 75% (depending on their size and the character of the project) from their own sources.

Similar conditions are also in the other programmes. The Competence Centres programme supports the establishment and operation of large (virtual) centres for research, development and innovation with many participating institutions. Compulsorily, at least one research organisation must be a member of a consortium, therefore the wide area for participation of universities opens here. Emphasis is placed on the innovative potential of the projects and the sustainability of the research agenda of the competence centres.

The programme GAMMA is one step closer to the immediate needs of industry, as it aims to support the verification of results of applied research and experimental development in terms of their practical application, and to prepare their subsequent commercial use. It has two sub-programmes: In the sub-programme 1, recipients can only be research organizations, industrial companies are collaborators. Sub-programme 2 is aimed at supporting projects leading to direct commercialization of the achieved results. Recipients can only enterprises, research organizations may participate as other project participants.

The other programmes are rather specific: The main objective of the programme OMEGA is to strengthen research activities in the area of applied social sciences. Therefore, the relevant outputs are adapted to this type of sciences. Universities can take part in this programme, however it is of minor importance for engineering. The programme BETA is oriented to the specific topics and issues that state authorities want to address in the area of research through public procurement. And finally, the programme DELTA supports mutual collaboration with foreign institutions and companies in the framework of agreements with similar agencies as TA CR abroad. As it is oriented only to a few selected countries, it is usable, but it is not a matter of preferred interest for universities.

The programmes of TA CR are useful tools for strengthening applied research, development and innovations in the Czech Republic and for promoting mutual collaboration of universities, and especially of technical universities and engineering faculties, with industrial companies. Nevertheless, it is possible to see three serious shadows in this system. First of all, the Czech science is sub-financed and the hunger for financing projects from the programmes of TA CR is enormous. The budget of TA CR is lower than desirable and does not allow the satisfactory success rate. The second problem is more or less general for most of grant competitions, especially for those, in which organisations with different legal statute take part. The rules must be in the necessary conformity with the legal system for all types of organisations, which are recipients of grants, and therefore, the administrative load in projects is enormous. And finally, as in many grant competitions, the problem of highly qualified reviewing is substantial. Reviewers are chosen by a lot from the database of specialists. The possibility that the particular reviewer is more demanding that the others, or even that he has some relation to the rivalrous company, and therefore he gives a bad rating to a project, is not negligible. And as the success rate is low, one "unfriendly" review means usually that the project has no chance to be accepted and financed.

In addition, some Czech ministries have their own programmes supporting applied research and development (e.g., the Ministry of Industry and Trade, the Ministry of Culture, the Ministry of Environment). Come collaboration can also be covered by programmes financed from European funds, but the majority of state support of applied research, development and innovation goes through the TA CR. For the better picture, the TA CR budget in 2015 was nearly 3 milliard CZK (about 110 million EUR), and 1 125 904 700 CZK, i.e., more than one third of this budget, was transferred in grants to universities.

5. Conclusion

In the modern world of sophisticated technologies, technical universities with ambitious engineering programmes should play an increasing role. However, the young generation is interested more in soft sciences. The extensive production of "managers for everything" has become a significant characteristic even at some faculties and universities specialising in economics and management, and the labour market sometimes has difficulties in absorbing them. Advanced engineering education needs to arouse more interest of graduates from high schools. Increased research collaboration with industry, leading also to creating more highly qualified and well paid jobs, can help the technical universities to convince potential customers, i.e., young graduates from high schools, about attractiveness and usefulness of engineering.

However, the key importance of academic world is that it is an important factor moving industrial technologies and quality of life forward. It is needless to say, that as the secondary effect it also helps to improve both practical competences of universities and their budget, and contributes to their equipment with modern instrumentation, software and methods.

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UDC 378

The Vital Collaboration of Industry and Academia for the Creation of Interdisciplinary Real World Student Projects

Purdue University, USA
Ph.A. Sanger

Ph.A. Sanger

The global economy in which engineers live is in constant change and evolution. The requirements for engineers today includes not only solid technical knowledge but also require they know how to apply that knowledge to real world problems. For these reasons, engineering education must reach beyond the academic world and draw in industry. The real world experiences that engineering students must have to be effective come from industry and not the more research oriented university environment. This paper reviews what avenues are available to enrich and grow the university/industry relationship and in particular, this paper describes an approach successfully implemented in the U.S. of industry sponsored and driven, final year, interdisciplinary, year long, capstone projects.

Key words: interdisciplinary approach, engineering education, university/industry relationship.

Industry Involvement in Education: There are several avenues for industry and universities to build strong relationships with each other:

1. Industry commercialization of university created technology and intellectual property.
2. Joint research either sponsored by industry or by external organizations such governmental agencies.
3. Participation of industry experts in university curricula as instructors and guest lecturers.
4. Support for updating of laboratories and university resources.
5. Challenging internships for students within the entreprise.
6. Creating projects for students through the curriculum that support the learning process.

In these last two categories, the incorporation of real world projects and experience coming from industry into technical engineering curricula provides a unique and invaluable enhancement to the educational experience. Specifically the inclusion of projects into the curricula supports the pedagogical philosophy of Project Based Learning (PBL). PBL is one of the modern technologies that universities in many parts of the world are adopting to develop engineering graduates capable of being the practical, application oriented, problem solving engineers needed in industry. This pedagogical approach is well established and has been reviewed extensively [1, 2, 3].

PBL is being implemented in a variety of different ways depending on the curriculum and the surrounding economic climate. Essential characteristic of projects within PBL are that the projects are central, not peripheral to the course, they are focused on a driving question, they require transforming acquired knowledge, they are largely student controlled, and finally are real world problems [1]. One of the very successful approaches has been the tackling of projects that have a value to local industry. Industry sponsorship brings industry into the educational process in a vital and important participative way: the projects are real world problems, the mentors from industry are experienced practitioners of engineering and the funding from these projects supports the infrastructure at the university essential for successful projects.

Projects within a PBL programme may enter the curriculum at many points but the following three approaches are common: 1) demonstration type competitive projects usually not industry based but created for pedagogical goals to teach and exercise project skills, 2) focused single discipline projects within a specific course and 3) interdisciplinary final year or senior year capstone projects on complex open-ended problems for industry.

The third type of project is discussed in the following sections and demonstrate the vital role that industry should play with their academic colleagues in preparing engineers for the complexity of the real global world.

Industry Driven Inter-disciplinary Final Year Projects: One of the strongest examples of industry projects being both economic engines for regional growth and stimulating experiences for students is the interdisciplinary senior (or final year) capstone project. In many institutions this project brings together and synthesizes the engineering student's entire education by applying it to a complex real world problem. The capstone project, which occurs in the Purdue School of Engineering Technology (SoET) programme in the senior and typical fourth year, combines project management, new product development, and interdisciplinary student teams. The project's purpose is to produce engineering graduates who are open to new ideas, comfortable in an environment with diverse disciplines and can mature promising ideas into actual business propositions. Interaction with local industry creates a renewing flow of real projects sponsored by regional industry to create interdisciplinary project for the teams to select and engage with the region.

Common characteristics of a senior capstone project are:

- **Open ended** meaning that the sponsor must not have established an approach and simply needs students to implement it. One of the goals of the project is have the students define the requirements and scope and then deal with ambiguity and the uncertainty coming from having to explore options, select an option based on the best knowledge available at the time and execute the project. This is first course in which no one knows what the correct answer is--- not the professor, not the mentors and themselves. It is up to them to sort these issues out.
- **Complex and Multidisciplinary** requiring team execution and effect interaction across disciplines. In the past the final year projects were individual thesis/projects. However the global world rarely results in an engineer working in isolation and thus an interdisciplinary team experience is an essential part of the project.
- Unfamiliar element requiring the student to act as **self-directed learner.** Just because a particular type of software or technology or sensor was not covered in one of their classes doesn't mean that the student should be able to research the subject, call and talk to experts in the subject including the vendor and use the new element competently.

Capstone projects should allow the students to integrate and synthesize as much of their education as possible. Student teams should tackle real problems in a realistic setting. Commonly accepted project management tools are taught and expected to be applied in the execution of the project. These tools include scope of work, requirement matrices, quantitative down-selection procedures, brainstorming and triage, failure modes and effects analysis, and test planning. The concept of a schedule evolving out of a work plan based on a work breakdown structure and the interdependence of task defined in a gantt chart is developed and applied to their projects. Standard project review processes are imposed moving the projects through six stages and gates: project proposal, conceptual design, preliminary design, critical design review, fabrication and test spanning a full academic year. At each of these gates, presentations are made, a report is written, and the contribution of each member of the team is assessed using a peer to peer evaluation tool. Each team is supported by the course instructor, a faculty mentor and an industry mentor as a minimum remembering that the project is owned, directed, organized and executed by the students. The mentors' role is to guide, not direct. Occasionally intervention by the mentor is needed to correct the trajectory of the project [5].

Pivotal Role of the Industry Sponsor: The first and most important responsibility of the sponsor is to provide project ideas that are valuable to the company while tolerating a certain degree of incompletion. At Purdue University the sponsors are asked to pay a fee for each project. While this fee plays an important role in paying for the infrastructure that allows projects to be successful, a secondary and just as important role that the fee plays is to ensure that the project submitted by the sponsor does indeed have value to them. From the author experience, simply asking for fee of any size drives the generation of projects that are valuable. Frankly speaking, the students and the mentors do not have time to waste on projects that the sponsor does not care about.

With the fee in mind, however, it is important to make clear to the sponsor that perfect results must not be expected. This is a learning exercise. The students are running the project. They must be allowed to make mistakes and recover from the mistakes. Thus the final result may vary and fall short of a finished product or process. These projects are, in fact, the students' projects and, in order to enhance the learning experience, errors are inevitable. Nevertheless the project has a fixed and unyielding termination date, that is, the student's graduation. Extensions are not possible no matter how poor the result. At the end of the semester the project is over and the results are what they are. The university must play the crucial role of managing sponsors expectations, for the students sake as well as for the sponsors sake. Some sponsors are unable to accept that situation and thus are not appropriate participants in this program. Having said all this, it should always be expected that competent technical progress and exploration of potential solutions are made and documented by the students.

Appropriate Project Identification: Given these constraints, what kinds of industry project make good projects? Most real companies have more problems on their development project list than they have resources, skills and talents to pursue. No progress is being made on these often decades old problems and some of the topics, with this lower priority are important and thus can make excellent and challenging senior projects. In order to avoid bureaucratic and something unresolvable issues, projects are deliberately chosen to avoid the need for divulging sensitive company information to the team as well as projects that are intentionally directed as creating new intellectual property and patents. For those projects, the company and the university can engage in contracts and joint research separate from this capstone programme as mentioned earlier in this paper.

Some companies have found it very useful to use senior capstone projects as a means of exploring high payoff approaches that would normally be deemed too risky to pursue in a normal company project. Since a senior capstone project is by design not on the company's critical path, these high risk approaches can be explored paving the way for later pursuit by the company if reasonable approaches are revealed during the project.

Several companies have also found a powerful role for senior capstone projects within their personnel development programs. Most industry professional development is focused on project direction and project management. Very little training effort is aimed at developing mentoring skills in the employee. Mentoring is distinctly different from directing. And yet one of the very important roles of a good manager is the mentoring of his subordinates and surrounding colleagues. Playing the role of mentor on a senior capstone project offers promising management candidates an opportunity to develop mentoring skills in a non-threatening activity.

Types of projects that have been undertaken are shown in tab. 1.

As can be seen, the topics range from novel inspection techniques, design and testing of alternative energy technologies, building of manufacturing automation equipment,

In summary, participation in the senior capstone projects offers the following:

- Students experience real world engineering conditions.
- Companies get progress on neglected but important projects.
- Companies and students have an opportunity to evaluate each other as potential new employees.
- Companies get an opportunity to create application, industry ready engineers that meet their needs.

International Cross Cultural Projects: Even though these projects are very challenging, these projects do not give the students the opportunity to understand the complexity of working with people from a different culture, i.e. performing in the global community.

To fill this additional need, the SoET programme created an international capstone experience [5]. For the international capstone project, the resources and course content is expanded to include history, languages, psychology and many of the social sciences that naturally fit in and are important for the success of the project.

This international capstone project builds on the existing, industry sponsored, inter-disciplinary capstone team project programme but differs in several ways. In the international project, half of the team members are students from a non-US university. The full team works on a project proposed by companies with a global footprint in both the U.S. and in proximity to the foreign institution. Most of the global project is carried out using the full range of electronic communication tools such as email, skype, and blogs. Communicating using these tools can be challenging when dealing with different cultures. The overall plan includes at least two trips in opposite direction by the teams accompanied by their mentors. These trips are approximately ten days long including both weekends. Most of the week involves intense project work. Ideally the first of these trips occurs early in the project and allows for solution conceptualization and for the forming of work assignment and responsibilities. The second trip is usually the integration phase of the final deliverables. Each of the trips has a cultural element – activities that are typical of the host culture. For instance, in the U.S. it has included a football game and visit to local tourist attractions or activities such as skiing, hiking, museums etc. depending on the location. To increase the development of solid relationships, the students of the host teams are responsible for the logistics and housing of the visiting team. Visiting team members live with the host students instead of hotels or with faculty. This latter feature does not work for all cultures. However, where this hosting feature has been used, the feature is highly popular with the students, reduces the cost to the sponsoring company but most importantly gives the visitors an authentic real cultural experience and improves the building of personal relationships across cultures. In fig. 1 and 2, two of the project completed in 2014-2015 are shown.

In fig. 3, the locations where international project have taken place are highlighted as well as locations presently under development in Australia, South America, and Europe.

Response from Students and Sponsors: The response from industry sponsors is highly positive with over 60% return rate. In some cases, problems that

Table 1. Final Year Capstone Project completed in 2015-2016 at the Purdue Polytechnic Institute

Sponsor	Topic
General Motors	High speed vision system for chain inspection
Subaru	Solution for Vehicle Transfer Errors
GE Aviation	Automated Poly-Film Remover
GE Aviation	High Accuracy CMC Nozzle Micro-Positioning Fixture
GE Aviation	Portable Wireless marking reader
GE Aviation	Automated EDM Electrode Loader for Turbine Blade Fabrication
GE Aviation	Inspecting Aircraft Engines for Hardware Placement Accuracy
First Build	Gesture control for Venthood with LED lighting
First Build	ADA Compliant Technology Ideas for Appliances
Power Sys	Demonstration of Off-Grid Power System for Parking Lot Lighting
Kimball International	Re-design Tablet table and charging system
Caterpillar	Leak Detection of Diesel Engines
Caterpillar	Assuring Proper Installation of Oil Cooler and Water Manifold
John Deere	Develop an Animated Power Outage Map
John Deere	Develop a camera system to support a kitting station using the Baxter robot
Internafl Idea	Water Flow Controller using the Perfect Gas Law to Control Heating System
Molex	Commercial IR Camera System to Monitor Crop Conditions
Biowall	Automated Plant Health/Water Assessment
Eaton (Forging)	Automated Chute for Hot Part Positioning and Measurement
Eaton (Clutch Assembly)	Line Set Improvement
Eaton (Clutch Assembly)	Large and Small Clutch Spin Box Controls, Data Acquisition and Reporting
Eaton (Hoses and Fittings)	Modification to a Skiving Machine
Eaton (Hoses and Fittings)	Tag Wrapping Machine
Fiat Chrysler Automobiles	Asset Control Utilizing Rfid Tracking Technology
International Projects	
UTEC	House Utilities-lighting and heat for Remote Andean Village
Northrop Grumman UTEC	Access to Internet for Remote Andean Village
GUT/Flextroncs	Automated Inspection of PCB and RF electronics assemblies
GUT	Solar Boat Competition in Amsterdam
Stryker / Netherlands	New Approach to Patient Handling
Lenze Corp	Thermal Management and Health Monitoring of Accuator Drives

Fig. 1. The goal of the Lenze project was to design, build and test a motor system that fit a cylindrical form factor: the original system on the left and the reconfigured system on the right

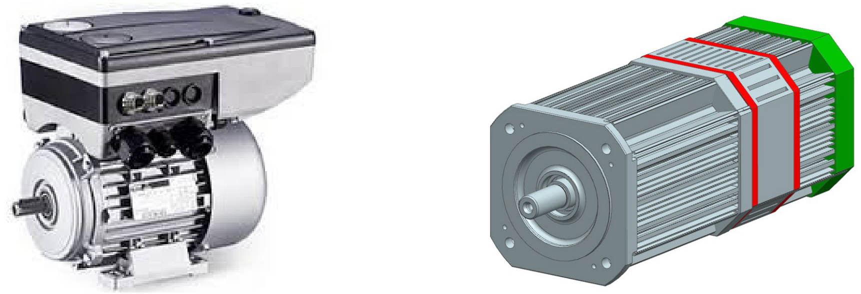


Fig. 2. Clutch Rivet inspection performed using Image Analysis for Eaton Corp

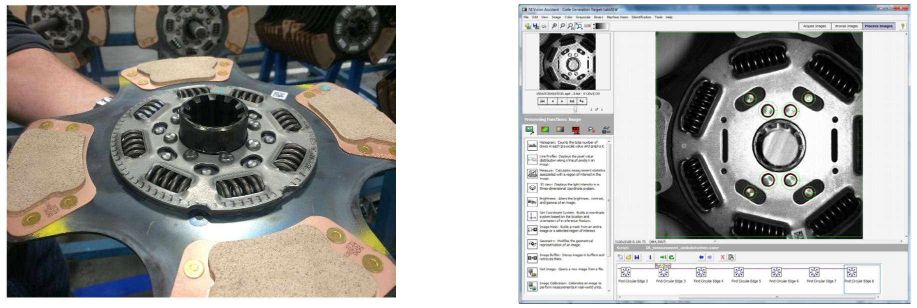
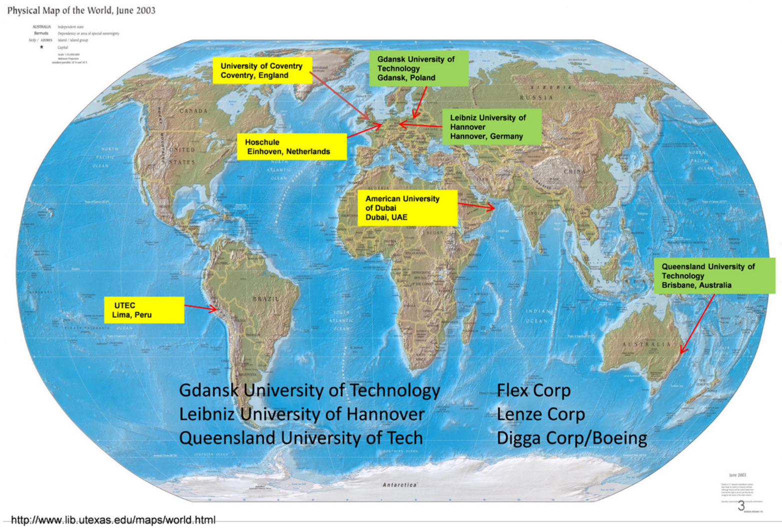


Fig. 3. Location around the world where final year international capstone project have or are taking place. (map taken from www.lib.utexas.edu/mnps/world.html)



have been in the plants for 30 years finally got solutions. The feedback from students is highly variable with excellent ratings to poor ratings. After further interviews, the poor ratings stem primarily from the fact that these projects demand a lot of work, more work than the typical course where homework and test results are the measure of success. Furthermore having to work with and depend on team members to perform is a frustration for some students particularly the students who have excelled in the normal course structure and could operate by themselves. The following occurrence is also observed. Students returning back to campus after a few years of experience on the job comment that they did not like the course at the time but, in retrospect, was the best course they had to prepare them for the reality of the workplace. "You were right" is often begrudgingly given.

Conclusion: Industry plays a vital role in producing the type of engineer who performs well in the real world, solving real problems. Projects and internships provided by industry form part of the complete picture needed for this training. International projects add the complexity of different cultures into the challenging dynamics of team projects.

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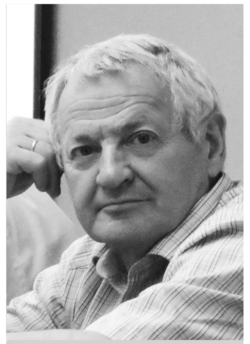
UDC 378


V.S. Sheinbaum


P.V. Pyatibratov


M.S. Khokhlova

Professional Activities in Virtual Learning Environment: Interdisciplinary Training Case Study

Gubkin Russian State University of Oil and Gas (National Research University)
V.S. Sheinbaum, P.V. Pyatibratov, M.S. Khokhlova, D.V. Grishin, A.A. Pel'menyeva

The technology of professional activities in virtual learning environment has been developed and is being successfully implemented at Gubkin Russian State University of Oil and Gas. The education is provided in the form of trainings for interdisciplinary groups of students, which simulate real world project and production activities. The paper describes one of the training case studies.

Key words: interdisciplinary learning, training, virtual environment for professional activities, professional standards.

In the industry of knowledge, the major sector in national economies. which are the leaders in scientific and technical progress, universities take the role of system-forming institutes. Silicon Valley and its alma mater Stanford University are an example which has already become classical.

A variety of trends in engineering education provided at national high schools are illustrated in the scheme given below (fig. 1).

One of the trends is creation of new training environment, i.e. the virtual environment for modern engineering activities and implementation of interdisciplinary educational technologies. The RF in general, and Gubkin Russian State University, in particular, are pioneers in this sphere.

The corresponding innovative project was launched at the university ten years ago with the support of the Ministry of Education and Science of the Russian Federation, the project team was awarded by the Government of the Russian Federation in the field of education last year for the results obtained.

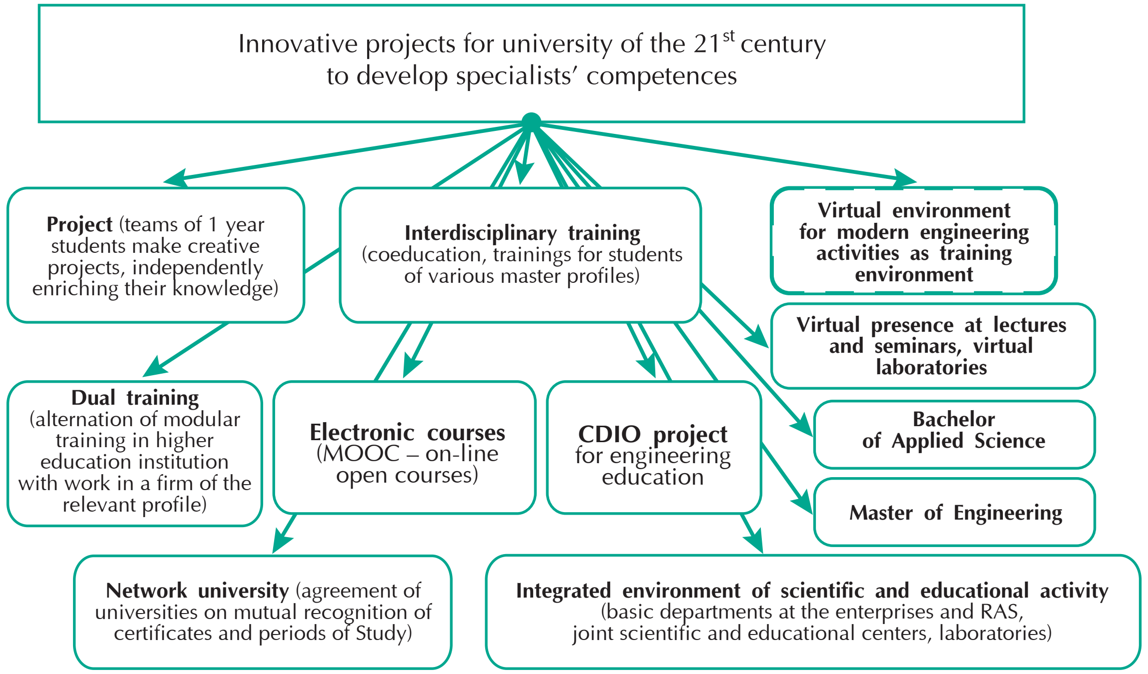
To better understand this project, it is worth beginning with the fact that ten years ago the Russian Union of Industrialists and Entrepreneurs (RUIE) and the Ministry of Education and Science of the Russian Federation began transition to the new regulatory base in the sphere of qualifications, in particular, professional standards (PS). Intensive implementation of RUIE resulted in the events as follows: in May, 2012 there was the Presidential decree that forced (within two years) development of eight hundred PSs; at the end of the same year, a new article was added to the Labor code of the Russian Federation (195-1), which defined the concept of qualification and status of PS as the main document on requirements to professional qualifications. The competency-based approach failed to be applied to PS requirements; however, necessary professional competencies (such as knowledge, skills) are still implicitly determined. It is essential that these competences are related to specific labor functions and actions. Being the basic document for the Federal State Educational Standards (FSES) and the main education programme (MEP) of the higher education, PSs accurately determine efficient professional activity model, which implies high quality of student training.

This activity model is also possible to be implemented in the training environment which was defined as a virtual environment of professional activity (VEPA) [1]. While developing VEPA within the above-mentioned innovative project, Gubkin


D.V. Grishin


A.A. Pel'menyeva

Fig. 1. A variety of innovative educational projects of the 21st century



Russian State University was intensively developing PSs for oil and gas complex (OGC). Within the programme of national research university development, the PS projects for all technological chains of oil and gas production were developed with participation of the leading OGC employers.

The Interdisciplinary Educational Technologies (IET) in VEPA are implemented in the form of trainings and case-study [2, 3].

A version of the developed IET is given below as an example of virtual oil field.

The basic elements of virtual field are:

- 3D geological and hydrodynamic models of the field;
- digital (computer) models of processes and facilities (well, borehole equipment, gathering equipment and well completion facilities);
- the computerized workstations (WKSs) for the specialists of various profile jointly working in the field, united in a local network system of high performance: geologist, developer, various technologists, driller, mechanic, chemist, ecologist, economist, specialist in industrial safety;
- the situation center of decision making – Control center of field development – CCFD.

Training method of students in the virtual environment of professional activity is simulation of real online productive activity of field specialists – geologists, geophysicists, developers, drillers, mechanics, power engineers, field chemists. Its content includes comprehensive analysis of real production situations (cases), search and decision-making, implementation of decisions, and subsequent monitoring of the situation.

We should emphasize once again: this educational technology is based on the following principles:

- training through activity;
- interdisciplinarity of activity;
- advanced training.

The IET is implemented within the discipline «Field operational management» included in MEP as a practical work of «Methods of engineering activity» for Master students in Petroleum Engineering, Technological Machines and Equipment, Chemical Engineering and Biotechnology, Economy and Management directions.

The method of Case-study involves continuous updating and replenishment of the cases used in training. Experience showed that it is the most complex and expensive work in all the project of the VEPA interdisciplinary training.

The example reviewed in the paper is given to illustrate this fact.

In this context, the case, in other words, information basis of the training scenario, is the production situation on a definite field in the North of Tyumen Oblast, consisting in sharp water production at one of more than 100 production wells. The training should simulate the working meeting for analysis and investigation of the causes for current situation, students of various master profiles play the roles of a field chief engineer, a head of field geological service, a head of the contracting organization, a chief field mechanical engineer.

To train students, they are, first of all, given full field data in advance according to the roles they play. It is the major and most crucial stage in IET implementation.

The paper format does not allow giving full the initial data, as it is mostly presented in the EXCEL tables and copies, etc., therefore, the reduced information is given below.

General data and geological-physical characteristic of the field

The training field is located in Nadym region of Yamalo-Nenets Autonomous Area of Tyumen Oblast. The area of the field is 322.6 sq.km. The territory of the field is located in the zone of northern taiga; it includes the isolated uplands and separated boggy depressions. The winter is long, frosty and snowy, the summer is short. Steady snow cover is formed approximately to the middle of October and melts to the middle of May. The average annual air temperature is -5.3 ^{0}C, the average air temperature of the winter period -29 ^{0}C, the average temperature of July +15.5 ^{0}C. The frost-free period is less than 90 days a year. The average annual amount of precipitation is 555 mm.

There are zones of deep permafrost occurrence in the site. The cryosolic relief is confined by frost mounds, conical depressions, and thawing fields. The lower frostline can reach 400 m. The hydrographic network of the study area is characterized by high density. There are a lot of lakes, rivers, rivulets and streams.

In the field the oil inflows are produced by reservoir sampling: Yu_5, Yu_4, $Yu_{2\text{-}3}$, Yu_0, Ach_1 and Ach_2 in the exploratory wells, but commercial content is found in the AC_{10} and $AC_9$3 formations of Cherkashinsky suite deposits of the Lower Cretaceous period.

In the study area there are numerous deposits with productive AC, $AC_9$3 and $AC_9$1 formations. General thickness of the complex from the suite section changes from 87 to 137 m, an increase in thickness is observed westward.

As a part of productive strata the most reliable local benchmark is the clay strata dividing $AC_9$3 and AC_{10} formations. Its thickness increases from 10 to 18 m westward.

AC10 formation lies in the range of 2727.2 – 2788.2 m and is confined by a thick stratum of alterating sand-stones, aleurolites, limestones and clays. The general well thickness changes from 29.8 m (well 357) to 52.8 m (well 712). The average net thickness of the formation is 10.5 m, the average oil-saturation is 7.1 m.

The permeable differences in the formation section are everywhere. The thickness of reservoir layer changes from 0.2 m to 6.4 m, the quantity is 2-26, and only in several wells the reservoir is confined by two interlayers.

According to the results of GIS data interpretation and well sampling, the water oil contact in the deposit is accepted at the

absolute mark-2651 m and confirmed by data of well operation.

Based on the developed geological model the area of oil zone is 24 % of all field area, water and oil zone is 76 %. The effective oil saturation of the wells in the oil zone changes from 2.2 m to 15.6 m, in water oil – from 2.6 m to 31.8 m.

The oil deposit of AC10 formation has the sizes of 23.9 x 2.3-7.0 km., the height of 15.1-33.2 m. The deposit type is bedded, arch-like.

According to the hydrodynamic researches of 27 AC_{10} formation wells the permeability changes from 0.9 to $180.0x10^{-3}$ mkm^2. The average value is $53.6x10^{-3}$ mkm^2.

According to 300 laboratory core saturation determination of connate water was 31.3 % in average with the change interval of separate samples from 2.1 to 81.5 %.

According to GIS, porosity was defined 580 times in the intervals of oil and water-saturated strata; the average value is 18 % with the change interval of separate interlayers – 15-21 %.

The average initial oil saturation of 99 wells was defined 580 times; it was 56 %, separate interlayers changed from 44 to 69 %. Distribution of oil saturation in three-dimensional geological model is shown in Fig. 2. The geological and physical parameters of the field are given in Tab. 1.

History and current development

B In December, 2007 the exploratory well No. 57 was put into operation. In 2008 the rotation and turbine drilling methods were used for field development.

The MS-GAU (MSGSh) and SVSh (SV) cone cutter bits were used as rock cutting tools. The clay drilling mud with a density of 1.16-1.18 g/cm3 was used for the well. The completion drilling was performed with the drilling fluid of the following parameters: relative weight – 1.06-1.17 g/cm^2, fluid loss – 5-6 cm^3/30 min. Such a fluid allows preventing well-drilling accidents, but leads to high reservoir productive zone contamination while drilling. The well mouth was equipped with the casing heads of OKK2-35 168x245x324 type and AFK-2-65x35 christmas tree. The geological section of AC_{10} consists of terrigenous rock inclined to caving formation.

Fig. 2. Oil Saturation Distribution of AC_{10} formation of the Training field

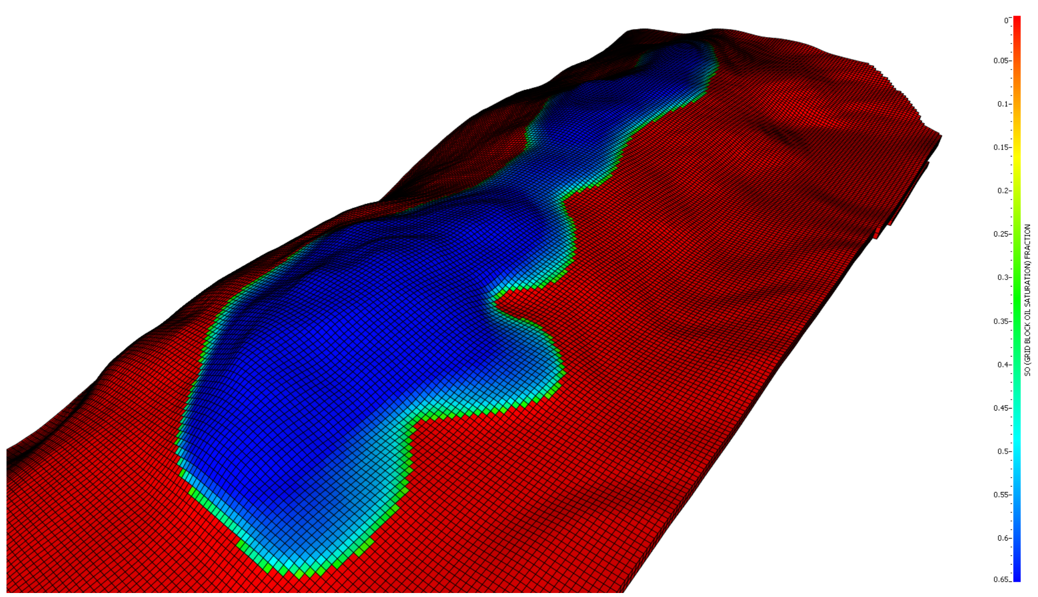


Table 1. Geological and physical characteristic of the field

Parameters	AC_{10}
Average stratum depth, m	2727-2788
Deposit type	bedded, arch-like
Reservoir type	porous
Average general thickness, m	40,9
Average oil saturation, m	7,1
Average oil saturation, fr.unit	0,56
Porosity, fr.unit	0,18
Permeability according to the core sampling, mkm^2*10^{-3}	89
Net/gross ratio, fr.unit	0,25
Number of permeable intervals	9
Initial formation temperature, ^0C	85,9
Oil viscosity in the formation, mPa*s	0,49
Oil density in the formation, t/m^3	0,729
Oil density on the surface, t/m^3	0,815
Absolute OWC mark, m	2651
Formation volume factor	1,218
Initial formation pressure, MPa	26,2
Bubble-point pressure, MPa	11,1
Gas-oil ratio, m^3/t	93,9
Water viscosity in the formation, mPa*s	0,42

There are no AHRP intervals in the section. The well equipment 57 of production string includes stage cementing collar. MSC is at the depth of 1540 m down (Fig. 3).

According to the existing project document AC_{10} formation is an independent unit to be developed. The project provided its development by watering, wells placement in terms of the nine-point scheme with a well grid density of 32 hectares/well. Selective watering is implemented in reality.

By the meeting day 114 wells including 100 production, 5 injection, 9 water-supply ones have been drilled up.

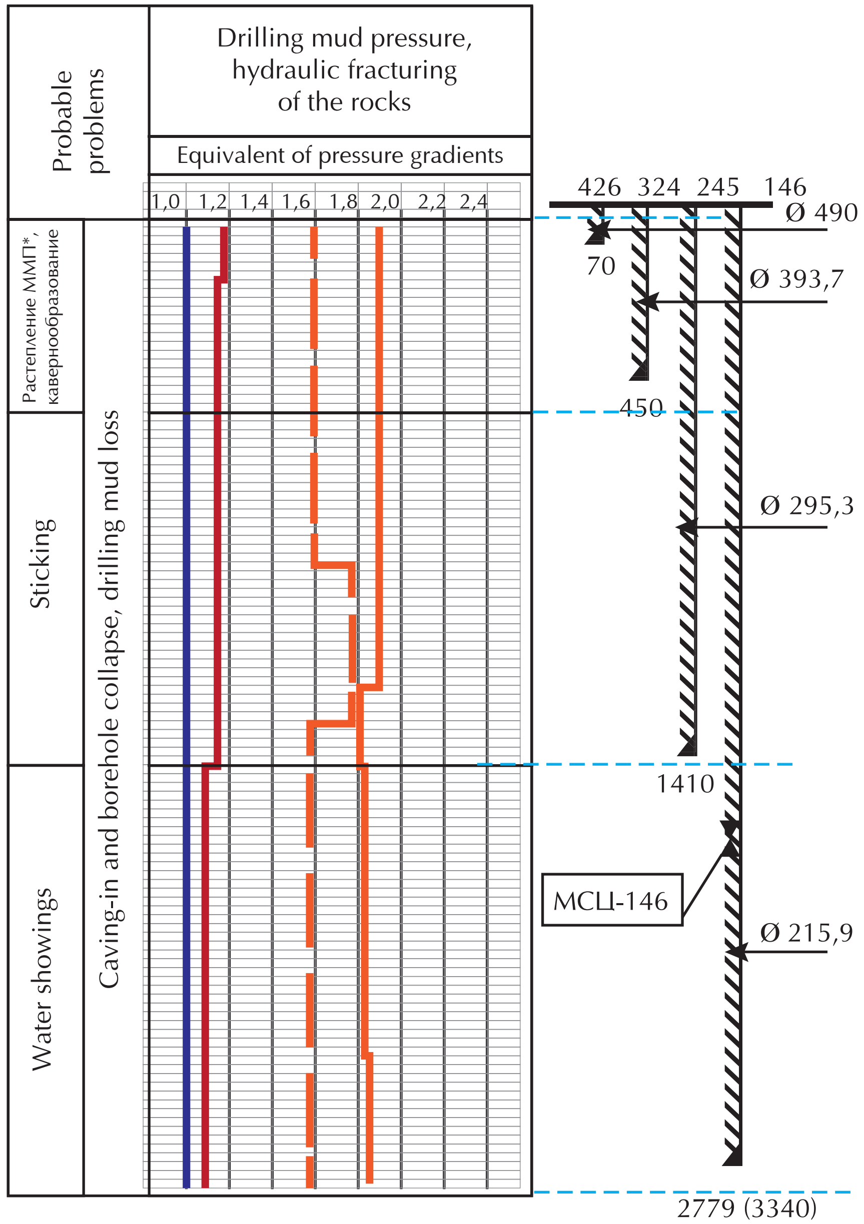
The most part of production wells was transferred to artificial lift (about 92 %). 6 wells of the field were developed by free-flow production method.

Wells placement on the net oil map and the target site near the well 57 are given in Fig. 4.

The average formation values of the well 57 and surrounding wells according to the results of well geophysical survey interpretation are given in Tab. 2.

The results of geophysical survey interpretation of all wells, laboratory core sampling, and data processing, for example, geological profiles (Fig. 5) are

Fig. 3. Well 57 scheme



* ММП – многолетнемерзлые породы

also presented as the initial data in electronic form.

An intensive water breakthrough occurred in well 57 in August, 2009. According to the monthly production reports (MPR), water production increased from 30 % up to 90 % (Fig. 6).

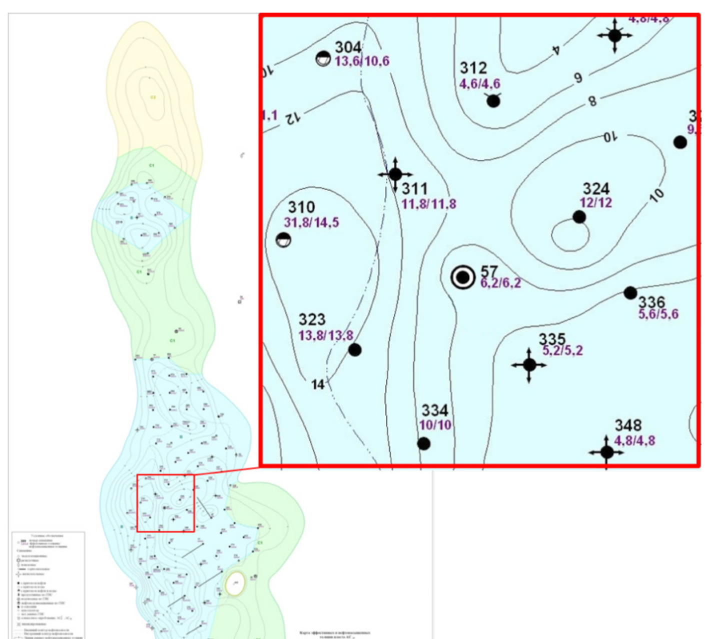
Besides, in accordance with the electronic MPR, artificial lift methods were introduced in August.

To determine filtration velocity and direction, as well as hydrodynamic pattern in injection and production zones, log-inject-log techniques were applied in the

Table 2. The average parameters of the well 57 and neighboring wells formation

Well №	Formation	Formation interval, m		H_{eff}, m	$H_{eff.i}$, m	Kp, fr.unit	Knp, 10^{-3} mkm²	Kн, fr.unit
		Top	Bottom					
57	AC_{10}	2727.2	2767.1	6.2	6.2	0.175	11.7	0.664
304	AC_{10}	2985.2	3027.3	13.6	10.6	0.197	54.30	0.597
311	AC_{10}	2809.6	2852.4	12.8	11.8	0.187	30.00	0.555
322	AC_{10}	3037.7	3080.5	15.0	7.6	0.194	55.78	0.530
323	AC_{10}	2787.5	2826.3	13.8	13.8	0.186	30.12	0.600
234	AC_{10}	2879.7	2928.6	18.4	12.0	0.177	20.10	0.566
325	AC_{10}	2884.6	2933.8	15.4	9.6	0.173	13.36	0.525
335	AC_{10}	2807.0	2843.8	5.2	5.2	0.170	12.25	0.585

Fig. 4. Wells placement on net oil map



study area within wells No. No. 311, 368, 381, 55R and 335 one year prior to the meeting. The obtained results revealed that the most intensive connectivity is between injection well No. 311 and production wells No. No. 57, 312, 303, 304, 310, 324.

Case study procedure

With the data given above, the participants should be ready to discuss and resolve the issues according to the following agenda:

Fig. 5. Geological cross-sections through wells 304-311-57-335-348

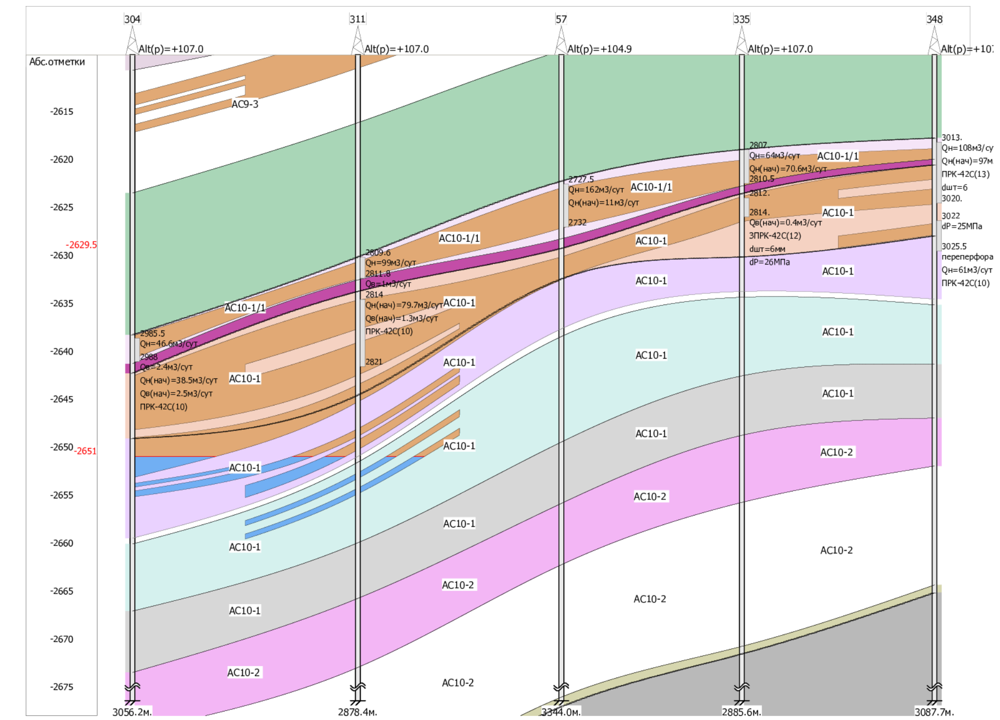


Fig. 6. Oil/water ratio and dynamics of coning in well № 57

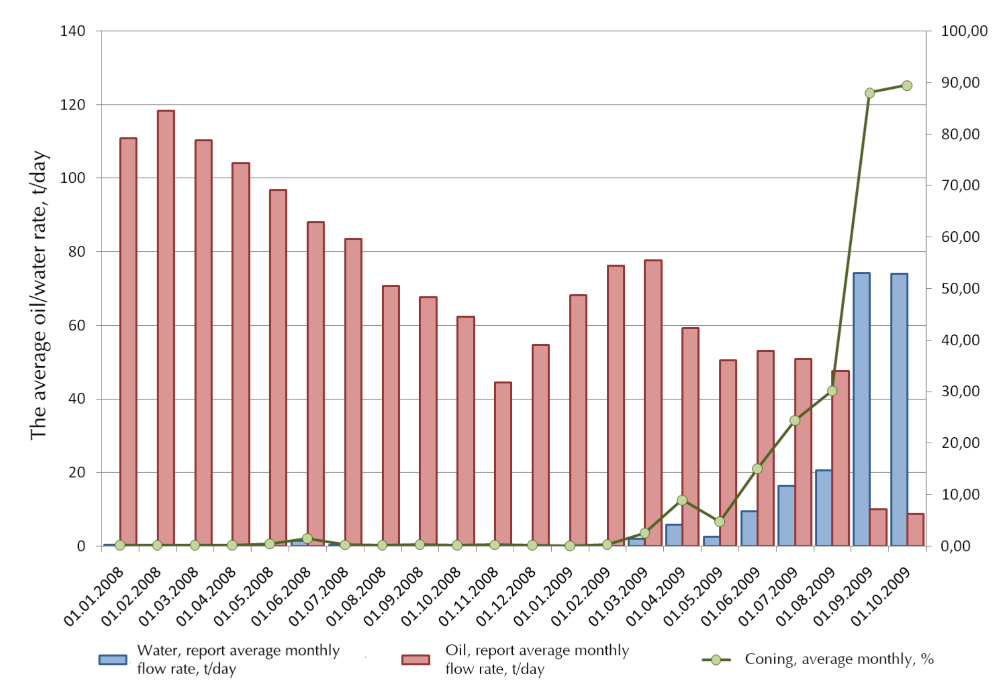


Table 3. Case study procedure

№	Tasks	Duration
1	Rationale for the possible causes for the well 57 watering	30 min.
2	Development of the reasonable research programme for the watering cause determination	30 min.
3	Search for possible methods to increase the efficiency of the well operation	20 min.
4	Preparation of the presentation	it is carried out simultaneously with the tasks 1-3
5	Presentation of the results to the chiefs of the departments	15 min. for each of five departments (teams)
6	Team discussion and making the final decision including the research programme and possible actions	25 min.

1. Reasons for intensive water breakthrough in well 57.

2. If required, additional investigation techniques to clarify the cause of water breakthrough

3. Methods to improve production efficiency.

In order to do a comprehensive analysis of the case, students are divided into five groups that correspond to five different departments of the enterprise. The work is carried out in CCFD where students can meet, discuss the progress of the project, make carefully weighed decisions in the time allotted (4 academic hours).

To resolve the tasks and be ready to participate in the meeting held to exchange views among the departments of "oil producing enterprise", the teams are made on the basis of the professional principle, i.e. each team is made up of students pursuing degree in one and the same field. For example, Field Development Department may consist of the undergraduates studying the programmes 131000.05 "Modeling of oil field development» and 131000.06 "Management of oil field development" within 131000 "Oil and Gas Engineering"; Drilling Department may consist of the undergraduates studying the programmes 131000.01 "Oil and gas well completion", 131000.02 "Construction of oil and gas wells in difficult mining and geological conditions" and 131000.03 "Off-shore drilling" within 131000 "Oil and Gas Engineering", etc.

A team leader, i.e. "head of the department" is selected by team members; one of his/her basic tasks is to allocate the roles to team members depending on the objective.

Case study procedure is given in tab. 3.

The training consists of a wide range of the issues related to geology and oil field development, drilling and operation of wells, water control technologies, etc. It leads to non-standard process of the training – the teachers of the departments of oil and gas well drilling, geographic information systems and development and operation of oil fields are simultaneously involved in the training. One of the teachers (the moderator) plays a role of chief geologist, the others answer the arising questions and actually supervise the work of the relevant departments.

The importance of the team discussion stage should also be noted. At this stage the «mistakes» are corrected with the assistance of all teachers; the decisions which cannot be realized for any reasons are rejected, and the final decision is accepted.

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UDC 378

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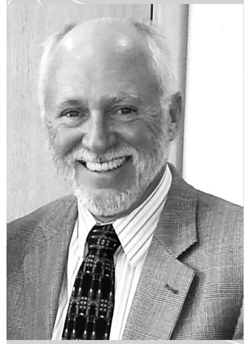
I.V. Pavlova


V.G. Ivanov


Ph.A. Sanger

Powerful Interdisciplinary Adult Education for Industry: "Combining Andragogy and Project Based Learning"

Kazan National Research Technological University
I.V. Pavlova, V.G. Ivanov
Purdue University, USA
Ph.A. Sanger

In this rapidly changing world of technology and economic conditions, it is essential that practicing professionals continue to grow in their skills and knowledge in order to stay competitive and relevant in the industrial workplace. This paper describes an approach to adult education that combines the best techniques of andragogy with project based learning taking advantage of the experience, maturity and wisdom of the adult learner. Well known project based learning (PBL) exercises such as the Skyscraper Project [1] and the "Deep Dive" video [2] have been adapted and expanded to include andragogic approaches and capitalize on the knowledge and depth of maturity in these mature learners.

Key words: inter-disciplinary, andragogy, project based learning, industry adult education, project management.

The Need for Adult Education.

A person's initial period of education takes 15-20 years of life and prepares them to enter the work force. The working life of most adults continues for 30-40 years or more particularly as longevity is continually increasing. Investment in adult education is not only beneficial to the individual but is beneficial to society as well. It is important to create an awareness during the initial education period that self-directed learning and continuous personal development is critical to success and depends largely on the ability to learn independently. In fact the UNESCO International Commission Report on Education for the XXI century [4] proclaims that teaching people how to independently acquire knowledge, skills and abilities should be the main objective of traditional education. Beside technical skills, improving interpersonal skills in an interdisciplinary environment is critical to professional growth in industry.

Today's engineering professional working in industry is challenged to grow and remain current in their areas of expertise. Besides the challenging requirements of rapidly changing technology particularly in the information technology, their career growth is often into human resource management involving inter-disciplinary teams and require a high degree of interpersonal skills to manage and direct such teams. In fact an engineer in most countries and specifically in Russia are required to seek and enroll in continuing education [8, 9]. Nevertheless, in their years of industry experience, these professional have acquired vast experience themselves and by observation of others in their environment. This experience gives the learner a context for applying new knowledge and new techniques.

Universities, on the other hand, are superbly positioned to and do provide such ongoing, continuing education to these learners. Universities play a major role in providing exciting learning opportunities for professionals and are a key component of the economic and social development of a region and country. An example of this role is the Institute of Additional Professional Education (IAPE) at Kazan National Research Technological University in Kazan, Tartarstan where thousands of hours of further classes and education are provided to industry participants in topics including technological processes of chemical and machine building complex, organizational psychology, management and entrepreneurship, economics of petrochemical industry, social communication and foreign languages in professional communication. While the technical knowledge unquestionably resides in the faculty and instructors of the Institute, the challenge is provide the content in a stimulating manner to engage the mature and experienced learner. To this end, IAPE has adopted many of the principles of andragogy in these courses. To further increase the effectiveness of these courses, the techniques of project based learning is being added to create exciting environments and learning opportunities to their students.

Andragogy – What is it?

Although the early concepts on adult education go back to the early 1800s, the concepts and name "andragogy" was popularized by Malcom Knowles in order to distinguish adult education from pedagogy or child education [3]. Since that time, andragogy has continued to grow particularly in Europe. Knowles theory and later embodiments in Europe are is based on several assumptions that differentiate the mature and experienced learners from student just entering their careers.

1. Mature learners must see the relevance of what their learning in their careers.

2. Mature learners have a solid basic in their experience to make the content relevant.

3. Mature learners must take responsibility for their education.

4. Mature learners are focused on the application of the content to problems, not on the content for the sake of the content.

5. Mature learners are internally motivated and driven to learn.

Based in these fundamental assumption, the principles of andragogy include

1) Active learning
2) Problem centric
3) Relevancy of Previous experience
4) Relevancy of the content to life
5) Emotional Connection
6) Self-Learning
7) Alignment
8) Fun

In adult learning situations, teaching should focus on training. Training activities should be less formal, and the role of the instructor shifts from a disseminator of information to a mentor and guide requiring a greater variety of methods. When traditional lectures and seminars are used, they must provide practical exercises, often experimental in nature, discussions, role plays, case studies, addressing specific industrial challenges. Effective use of group discussions and group work is common. The approach moves away from the theoretical knowledge and into practical application of the knowledge. In the tradition pedagogical paradigm widely used in Russia, the teacher acts as «the sage (the wise man) on the stage". Andragogic approach involves a subject-subject teaching. The teacher becomes instead a «mentor beside» and facilitator. Typical techniques used in the andragogic approach are: case studies, critical incidents, lecturettes (short concentrated lectures), peer to peer round table discussions.

Learning – what is it?

Project-based learning (PBL) is a pedagogical concept developed in the 1970s and initially applied to early childhood education. Lately project based learning has resurfaced and is being recognized as a path to relating engineering training to real world experience. The value of project-based learning is in training the individual to life experiences, and in the process of mastering new ways of solving problems and generating new knowledge. PBL is one of the modern technologies that universities in many parts of the world are adopting to develop engineering graduates capable of being the practical application oriented engineers needed in industry. This pedagogical approach is well established and has been reviewed extensively [5, 6, 7].

PBL is being implemented in a variety of different ways depending on the curriculum and the surrounding economic climate. Essential characteristic of projects within PBL are that the projects are central to the content being taught and not peripheral to the course, projects are focused on a driving question, the projects require transforming acquired knowledge, the projects are largely student controlled, and finally the projects are real world problems [5].

With the introduction of projects into the learning process, students investigate problems and propose solutions over an extended period of time to acquire a deeper understand of the techniques and approaches being taught. The learner is actively engaged in the project, feels responsibility for the results and recognizes the trust placed in him. The PBL approach is often described as "learning by doing". An additional benefit to PBL is that many of these projects are team based requiring the acquisition of and practice of interpersonal skills and increases an awareness of the complexity of interdisciplinary work.

There are many educational outcomes attributed to PBL and among them are the following:

1) An ability to navigate changing conditions and to adapt to the new conditions which is a common occurrence in production activities.

2) An ability to use modern computer technologies in the processing of the results.

3) A thorough understanding of the theory and possession of the practical skills in the technical area.

4) An ability to analyze literature in order to select the direction of the project.

5) An ability to analyze results, reaching the necessary conclusions and formulate proposals.

6) An ability to communicate conclusions and their basis in data and fact.

Integrating PBL with Andragogy. It is at once clear that the two approaches, andragogy and PBL, share many of the same principles and approaches. Projects provide a pathway to relevancy, projects are learner centric, properly designed projects require active participation, engage the learner emotionally and are usually fun (sometimes only in retrospect). The value of project based education is a preparation for reality and its development in the process of mastering new ways of solving problems and generating new knowledge [2]. At the same time, the combination can create supplemental benefits. When projects are used in adult education, particularly for participants from industry, the project provide an opportunity to create something of direct value to their company as a result of the educational experience. Moreover projects can be created that require interdisciplinary teams and the development of interpersonal skills alongside the exploration of technical knowledge. For all the reasons above, an initiative at KNRTU was created to integrate both approaches, andragogy and PBL, into adult engineering and professional education.

This approach represents a comprehensive system integrating andragogic and pedagogical techniques and methods of individual and team work (lectures, discussions, round tables, brainstorming, search methods, research methods, independent work and teamwork) that will allow students to actively participate in learning, analysis and finding solutions to problematic situations. This approach requires active engagement of each participant, which feels its responsibility, and trust. It ensures a high level of involvement of all participants in the educational process. This individual responsibility coupled with team based, project oriented responsibilities in a unique learning opportunity. This approach is even more challenging, as it is implemented in a very traditional Russian structure of education.

This work is the combination of andragogic learning methods with project based learning applied to the development, testing, implementation of a sustainable training programme of courses and seminars with capable coaching practices. The results will be more mature professionals using a set of organizational tools to improve productivity, innovation and organizational effectiveness. This toolkit includes the field of project management tools ranging from systems engineering, from lean philosophy with skills in the team based on human interaction techniques, personal conflict management skills and communication.

Initial Steps- A Progress Report. As mentioned above this initiative has started in the area of project management and systems engineering. The tools in these two disciplines include the development of a clearly defined scope of activities, the establishment of a matrix of requirements with measurable results, brainstorm and quantitative analysis of alternatives, as a result of a project approach based on consensus, development tasks structure using Gantt charts, in-depth analysis of the solution of the problem, develop a test plan for to ensure that the product or project meets the expectations and requirements. Two projects that have been highly successful in training both early career students and mature students in these areas are the Skyscraper Project [1] and the video "Deep Dive" [2].

The Skyscraper Exercise was created by engineering educators from Massachusetts Institute of Technology and United States Naval Academy and it contains all the major components of the conceive, design,

Fig. 1. Enthusiastic mature learners with the Skyscraper project from Russian faculty and industry (Arkhangelsk, Russia, 2015-2016)

implement and operate (CDIO) pedagogical approach in an exciting format. The three hour exercise is to design, build and test a model skyscraper based on an historical scenario using a variety of foam blocks and pencils as the fasteners. The structure is required to support a 0.5 liter bottle of water while being tilted on a 10 % slope to simulate earthquake durability. Overall height and aesthetics are the principal evaluation factors. The exercise is available at with both instructor guidance as well as the challenge elements for the students. www.cdio.org/files/document/file/Skyscraper_Template_Full.pdf

The PBL outcomes include exercising of basic disciplinary knowledge about structures, anticipating and mitigating risks through concurrent testing and research activities, maximizing team performance through organization and delegation of tasks, allocating time and managing to a schedule, trading off technical performance within a defined and fixed budget and executing the design strictly according to the design documentation. This project was used with a group of twenty two professor with a wide range of disciplines and a second group of professionals from a wide range of industry including the Russian Post office, Gazprom Bank and a large Pulp and Paper company. To enhance this project and capitalize on the experience of mature learners, this project was extended to include group discussion on the issues experience during the project. The groups were asked to reflect on the activity, give examples in their own jobs where research and advance planning had avoided problems, to consider the impact of budget constraints on the solutions developed. The groups then reported back to the whole group. From the reactions of the group and the engagement of the group in realizing common observations, this approach shall be expanded.

The video, "The Deep Dive" was first aired on ABC on July 13, 1999. In this video a process of development of new ideas is applied to the task of re-designed the shopping cart. The focus is on researching the problem, brainstorming solutions, generating prototypes of the solutions and testing it in the real world. For a classroom of young learners, it is common for the instructor to guide the students to conclusions based on his/her perceptions and experience. For mature learners, the situation is flipped. Once again in groups of five to six, the group is asked to give their observations asking questions such as: what would work in their plant? What would not work? What was their experience with innovation, brainstorming? What were the problems? What creates a culture that encourages innovation? What destroys innovation?

These are just two examples where established tools and exercises in project based learning has been applied to project management and extended with andragogy techniques to appeal to the mature learner with good success. During this initiative, this approach will be expanded into other areas of knowledge.

Conclusions. The introduction of integrated andragogic/PBL techniques applied to project management has added interactivity, effectiveness, independence and involvement of students in the learning process while promoting the formation of key competences of future specialists. As the initiative continues, expansion of these techniques will serve adult learners in more areas of content and knowledge.

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UDC 378

M.A. Loschilova

M.S. Vaichuk

Interdisciplinary Project Management in Networking Cooperation: Training Students of Bachelor's Degree Programme (Machinery Engineering)

Urga Technological Institute, National Research Tomsk Polytechnic University
M.A. Loschilova, M.S. Vaichuk

The paper reveals the necessity for new open system of professional education to eliminate the gap between labor market demand and education services. The authors suggest the ways for networking cooperation in training students of bachelor's degree in machinery engineering programme, which is based on the principles of openness and continuation.

Key words: training, network, networking, social partnership.

At present, contemporary state of engineering education is recognized as a crisis as it has a system gap between labour market demands for graduates and incompetence to these demands in the system of education.

Nowadays, the issue of transition to an open professional education, including not only educational institutions, but also other collective bodies interested in improvement of engineering education, is rather topical. Such an educational system implements the idea of social partnership as a special type of communication focused on increasing quality of education as a primary goal under the condition of mutual interest of all participants in this communication [2, p. 80].

It should be noted that bachelors' training in machinery engineering is influenced by a number of external factors: social-economic condition in the country, scientific and technical achievements, continuous professional training system, social partnership and internal ones – values and standards of machinery engineering bachelors' training, professional needs, personal qualities and status [4, p. 95].

Theoretical research of some scholars (S. Ya. Batyshev, A. N. Leibovich,

Ye.I. Ogarev, V.G. Onushkin) allows for conclusion on the fact that there is no single approach to definition of "machinery engineering bachelor's professional training" in pedagogy. This notion is considered as a stage of personal professional development including learning process in an educational institution; as a process of development of students' training for solving future problems; as a result of students' acquiring systematic scientific knowledge, skills, and competencies required for task performance.

Professional training of bachelors in machinery engineering means an integrated dynamic process of developing non-technical, professional, and supra-professional competencies ensuring machinery engineering bachelors' readiness for management, research, project activities under the condition of network cooperation between educational institutions and social partners [5, p. 49].

It should be pointed out that open system of professional education allows implementing dual education integrating theoretical classes and students' practical professional activity in working environment via "university – specialized enterprise" cooperation. The organizational structure of dual education includes a network. [7, p. 7].

According to Article 15 of the Federal Law of 29.12.2012 № 273-FZ "On Education in the Russian Federation" networking of learning process presents "an opportunity of students' completing educational programme using resources of several institutions".

The analysis of theoretical and practical investigations (A.I. Adamsky,

T.A. Zubareva, Ye.Ye. Sartakova, S.V. Tarasov, M.M. Chuchkevich, etc.) permits defining "network cooperation" as an arrangement of joint efforts of network participants to achieve common goals under the condition of collective activity including the relationship of social partners.

Networking defines a new organization form of open professional education and is characterized by flexible structure, functions within information-educational environment, in which different enterprises are incorporated.

The experience in "university – enterprise" network cooperation in Institute of Non-Ferrous Metals and Material Science (Siberian Federal University) and Urga Technological Institute (a branch of National Research Tomsk Polytechnic University) (hereafter UTI TPU) has allowed revealing the peculiarities of this activity [6, p. 544].

The key social partners of UTI TPU are groups of network cooperation participants: employers (industry); state administration bodies (employment service); educational institution including labour organizations, students' union at the co-management level.

Cooperation of UTI TPU with social partners and graduates' consumers requires the university to develop a new approach to request analysis of the region and industries in training machinery engineering bachelors to solve the priority problems of social-economic and engineering development, extension of basic trends in cooperation with strategic partners, implementation of which provides the synergy, replicable models, best practices for their expansion in the professional education system [6, p. 545].

Network cooperation of institutions and enterprises focused on improvement of quality of engineering education differs in the number of specialized enterprises integrated in the network of the universities mentioned above [6, p. 546].

The major strategic partner of UTI TPU is LLC "Urga Mashzavod" which consists of a number of full-cycle plants from open-hearth steelmaking to manufacture of machines.

The academic process in UTI TPU is characterized by a sequence of study and internship terms when the students study full-time and combine it with intra-extramural form at the specialized enterprise [1, p. 55].

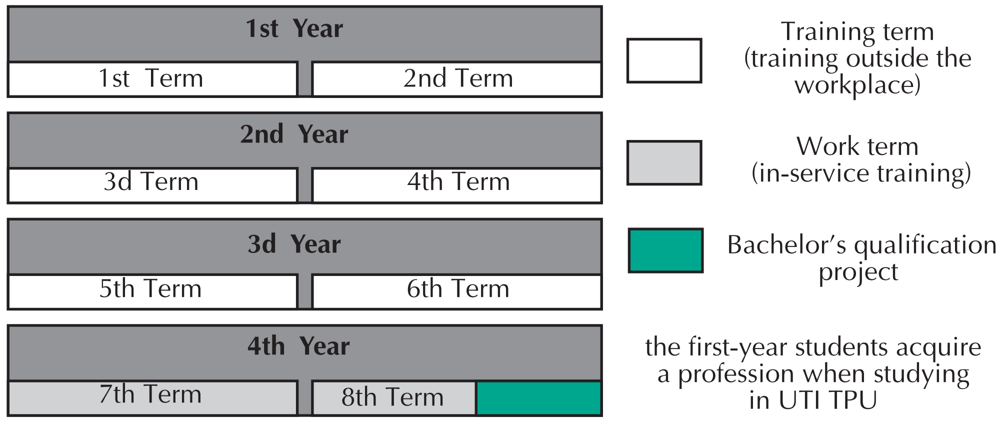
Production activity is performed at workplaces, in the departments of specialized enterprise, but the appointment for the workplace is made according to the programme included in "Student's production-training passport" and "Schedule of rotation of workplaces and engineering positions" (Fig. 1).

State administration bodies (employment service) participate in students' career guidance in educational institutions; hold practice-oriented courses; arrange special employment fairs of working and university places; contribute to academic process orientation towards graduates' professional career; participate in arrangement of students' short-term internship at regional small innovative companies, young specialists' employment, perform selection of appropriate work position from job vacancies database, assist in self-employment [3, p. 66].

In the course of our research the following *aspects of cooperation among the network participants* have been defined in bachelors' professional training in machinery engineering based on the principles of openness and continuation.

The first aspect – target training of bachelors in machinery engineering in terms of practical activity using integrated educational-industrial and educational-research programmes implemented by university together with leading enterprises-social partners, graduates' employment programmes, benefits for employers in young professionals' employment.

Fig. 1. Pre-service and in-service training of bachelors in mechanical engineering under the condition of networking



The second aspect of cooperation among the network participants is continuation of additional professional programmes for professional development to train teachers and masters of in-service training in the system of additional professional education [3, p. 67].

The aspects of cooperation mentioned above as well as implementation of complex interdisciplinary projects in development of high-tech production result in necessity of continuous professional engineering education including training courses, internships for students of professional educational institutions, participation in Open-Door Days, employment fairs, agreements in specialists' training, professional development [5, p.112].

An important aspect of network cooperation is mutual involvement of teaching staff and students in performing urgent for the industry research engineering and design developments that enhances the practice-orientedness of learning process.

One of the interdisciplinary projects implemented in engineering majors at UTI TPU is a term project in the discipline "Mechanical Engineering Technology" that is performed by the fourth-year students under the employers' supervision.

The main stages of the project are design of technological process of product machining "Corpus" with the serial number K 500.04.04.031 produced by LLC "Urga Mashzavod", development of technological process of product machining FURA.390089.001 for medium-scale production.

The course "Technologies of mechanical engineering" includes such disciplines as "Bases of mechanical engineering technology", "Machine parts and bases of design", "Construction materials engineering", "Cutting and production tools" etc.

The given project contains specific description of current production, product designation, annual calculation of product programme and specification of production type, analysis of product design. The technological part of the project implies selection of feedstock and method of its production, selection of base, development of process route, selection of equipment as well as jigs, fixtures and tools, calculation of machining allowance, calculation of cutting conditions, process rate making. The design section contains description of design, calculations of parts and tools.

As a result, bachelors in mechanical engineering solve the set problem independently or by joint efforts, apply the necessary knowledge from different fields, obtain an actual and measurable result.

Another interdisciplinary project is a term project in the discipline "Cutting tool" that has prerequisites of the following engineering disciplines: "Cutting machine tools", "Bases of mechanical engineering", "Material science". The term project on the given discipline is to contain the design of special cutting and technique tools.

It should be noted that in the course of fulfillment and implementation of different projects the students acquire professionally important qualities: communicative skills, teamwork skills, critical thinking, capacity for self-development and some other.

Thus, as a result of machinery engineering bachelors' training in interdisciplinary project management under the condition of network cooperation the efficient innovative mechanism of participants' integration in education sphere has been developed which allows them to develop dynamically, providing the consistency of students' competence development with the requirements of knowledge economy.

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V.V. Kondrat'ev

V.G. Ivanov

UDC 378

Engineering Teacher Training on the Basis of Interdisciplinary Approach

Kazan National Research Technological University
V.V. Kondrat'ev, V.G. Ivanov

The paper deals with one of the topical issues of today's engineering education, i.e. integrated interdisciplinary knowledge acquired by an engineer. Considering engineering teacher training based on interdisciplinary approach, the authors analyze such notions as "interdisciplinarity" and "interdisciplinary approach". These notions are connected with changes in the system of university teacher training and continuous professional development, which are specified in the paper. The most important methodological principle to ensure the efficiency of teacher training system has been identified – the education system should be sensitive to the changes in science, technics and technologies, which, in turn, results in changes in engineer's and teacher's professional activities.

Key words: engineering activity, engineering education, interdisciplinarity, interdisciplinary approach, professional training and continuing professional development for university teachers.

One of the most important issues of today's education system is to train a professional with integrated interdisciplinary knowledge.

However, this is the issue to speculate on in future. The question to be solved today is how to ensure effective communication between two professionals specializing in one field.

It is particularly important to educate students within interdisciplinary framework and to develop teamwork skills necessary to cooperate with experts specializing in different fields, which cannot be reached immediately.

Considering teacher training based on interdisciplinary approach, we need to introduce such terms as "interdisciplinarity" and "interdisciplinary approach". According to [1, p. 447-449], the term "interdisciplinarity" can be used to denote:

- concordance between the languages of two correlated disciplines and two thesauruses (for example, physics and chemistry, biology and chemistry, psychology and sociology, etc.);
- concordance between the languages of two different uncorrelated disciplines in terms of applied methods and scientific invariants including those of mathematics (the language of natural science), system analysis and synergetics (the last two are more applicable for humanities);
- heuristic hypothesis or analogy which allows transferring the structures of one discipline into the other without any profound basis;
- robust interdisciplinary project integrating different disciplines to conceive and operate supercomplex systems, such as environmental and globalization issues, anti-crisis management, social construction, artificial intelligence, integral psychology and medicine, outer space exploration, etc. It should be noted that interdisciplinary project implementation implies many hypotheses of analogy between different disciplines, and the cost of mistake (in the hypothesis or at the confluence of the disciplines) is quite significant;

- network or adaptive communication, which implies implementation of interdisciplinary methodology, transdisciplinary norms and values, invariants essential for scientific worldview. These are different scientific schools and associations which contribute to the development of synergetics and system analysis within the global scientific consortium.

How can interdisciplinarity be applied in pedagogic research? There are, at least, two points – research issue and methodology. The complexity of research objectives due to the current global challenges led to the situation when interdisciplinary synthesis is necessary to solve complex practical tasks. In term of methodology, interdisciplinarity is essential to select the adequate approaches and methods, as well as to develop interdisciplinary research [2, p. 147-148].

Interdisciplinaity is the issue connected with the education system. Both secondary school and professional (engineering) education systems should develop interdisciplinary way of thinking or "offset sight". It means that the disciplinary knowledge is still acquired to the full extent but the material is taught via interdisciplinary methods, which develop interdisciplinary way of thinking.

To reach this objective, different courses within the scope of the same intellectual field should be taught as a conceptual unity. For example, let us consider the course "Continuum Mechanics" by the academician N.N. Moiseev: the course included hydrodynamics, elasticity theory, and magnetohydrodynamics. As N.N. Moiseev wrote, "it is important for the course to be taught by the same professor – this is the only way to ensure consistency" [3, p. 62].

The particularity of interdisciplinary approach is in transferring research methods of one discipline into the other. The transfer is adequate due to the parallels in the disciplines, which creates an "interdisciplinary discipline" based on interdisciplinary approach. This is the principle to develop any binary interdisciplinary discipline. The application of "alien" methodology rarely leads to the changes in the disciplinary image of the research subject. To keep the boundaries between two disciplines in the course of interdisciplinary research, it is necessary to identify the major discipline and the supporting one. The research outcomes including those obtained via supporting discipline methodology are interpreted in terms of the major discipline. Therefore, interdisciplinary approach is to solve hand-on tasks where the application of concepts and methodology of the only discipline is inadequate. This approach allows overcoming a wide range of scientific challenges since it is based on the unity of two or more disciplines under the aegis of a new concept to obtain new research outcomes. As a rule, such consolidating concepts are those of synergetics, which deals with self-organization and breakdown of different structures within the systems far from equilibrium.

It is noteworthy that we are currently witnessing a process of science integration. This process is described by the following words by N.N. Moiseev: "the river of knowledge is separating into more and more spill streams and feeders, however, it does not lead to their drying out since they are supported by the main stream. Interdisciplinary approach is an instrument of integration which allows feeding the narrow fields of knowledge and science. Based on the particular criteria, these fields may be consolidated, which allows us to reach the major target of science, i.e. to make a consolidated description of the world" [4, p. 182].

Interdisciplinarity is in contradiction with the previous engineering education paradigm, which was focused on training engineers with a particular set of qualifications, had vertical structure, and was based on unconsolidated disciplinary activities.

Interdisciplinary education leads to the complete rethink of education content and pedagogical activities. Today, the teacher opens the door into the dynamic and ever-changing world; he or she is not an indisputable authority but a leader whose responsibilities are not to ensure comprehension and duly "packing" of knowledge, but to develop flexible thinking which allows feeling confident under the changing conditions.

The educator should familiarize students with communicative (interdisciplinary) areas of science, where dynamics is essential. The educator is a mediator between the student and science as a disciplinary unity. Within these interdisciplinary areas, the truth and knowledge can be estimated from different perspectives, therefore, the major educator's aim should be to develop adequate, i.e. communicative or interdisciplinary, vision. This ensures that the professional meets the requirement and is able to overcome challenges essential for today's science and professional world. In this case, the education being pragmatics-oriented is still fundamental. Interdisciplinary as a modern form of education fundamentality is a major trend in national education enhancement, which takes place at university, in particular [5, p.12-13].

The changes in content and structure of university teacher training and continuous professional development are attributed to new targets of engineering education, integration of science, education, and manufacturing, new standards of professional qualification.

Since educator's professional practice is multi-targeted and multi-functional, the objectives of teacher training and professional development programmes are multiple as well. These programmes are developed to satisfy today's and prospective demands of universities, science and manufacturing sectors, to nurture professional culture, which the foundation of the educator's professional activities rests on.

The education programmes of teacher training and professional development are based on integration of knowledge domains reflected in educator's professional activities. This secures acquisition of system knowledge and development of systems thinking via time-saving learning.

In terms of psychology and pedagogy, the key aspect of teacher training is consistency. This idea is implemented in the consistency in natural sciences, general engineering, particular professional disciplines, and humanities, which together form a complete cycle of theoretical and practice-oriented education at the technical higher education institution.

The knowledge obtained through studying fundamental disciplines creates a basis for profound knowledge of professional fundamentals (engineering mechanics, electromechanics, combustion engineering, etc.), which, in their turn, allow deep understanding of professional disciplines and becoming an expert.

Integration of psychological and pedagogical disciplines is the consistency of objectives, principles, contents, methods, educational forms and tools [6, p. 260-261].

Such an approach ensures profound comprehension of pedagogical activities, the content and structure of teacher training and continuous development systems, interconnected knowledge of psychology, pedagogy, natural sciences, engineering, etc.

It is a well-known fact that the teacher of engineering at higher education institution should possess two types of knowledge – technical and pedagogical. These two aspects are reflected in all pedagogic functions: knowledge domain of conceived, selected, and structured material is within the scope of engineering (or technical) knowledge. As for the principles, methods, and stages of conceiving, selecting, and structuring, they are within the framework of engineering pedagogy. This synthesis is characteristic for all educational methods, forms, and tools.

It is impossible to acquire profound knowledge of a discipline with no regard to its being overlapping with the other fields or disciplines. Engineering pedagogy integrates all elements of teacher training: technical, technological, pedagogical, psychological, sociological, cultural, biological, etc. Systematic approach to studying objects and systems ensures the synthesis of interdisciplinary and inter-cycle links.

Pedagogic knowledge is an open system which is connected with all human activities. It is a component of administrative, production, social and economic activities, therefore, all spheres of life are more or less connected with pedagogy.

Pedagogical and psychological sciences focus on studying natural laws of organic and inorganic worlds.

Engineering knowledge also possess integrating potential since the technology, which is the object of engineering science, is connected with the life of society and social pedagogy. Today, technology can be characterized as a dynamic system, which interferes into many aspects of human life. Development of technology and technology skills is a key factor to ensure intellectual wealth and aesthetic perception of the world. Therefore, it allows identifying the pedagogical component as a type of sociotechnical knowledge within the structure of engineering knowledge including natural-science, social, technical, and sociotechnical elements. This can be proved by the fact that pedagogical and engineering knowledge overlap within the disciplines boosting progress in science and technology – cybernetics, ergonomics, and engineering psychology. For instance, psychological and pedagogical notions of "teaching", "behavior", and "play" became key concepts of cybernetics.

Pedagogical and engineering background knowledge is deeply interconnected within the system of professional training, i.e. education objectives, principles, content, organization, methods, and tools. This is also true for the engineering pedagogy influenced by technical, technological, cybernetic ideas and approaches, as well as still developing subjects – pedagogical cybernetics, pedagogical design, pedagogical ergonomics, etc.

Being interconnected and integrated, the psychological and pedagogical disciplines still possess different subject domains and do not lose their principle concepts, categories, and particularities.

It is the objectives of education and professional development programmes that facilitate the integration of psychological and pedagogical disciplines Another integrating factor is learning outcome (feedback).

Based on the above-mentioned arguments, the main principle to create and implement the systems of teacher training and professional development is to make the topics responsive to changes taking place in science, technology, and professional activities of engineers and teachers [6, p. 262-264].

When designing teacher training programs, integrative approach is an important issue. Knowledge integration is attributed to the integrative changes in science, education, technology, economics, and manufacturing. These processes modify the content of university teacher training programs.

Engineering competency imperatives, which stipulate the level of graduate competitive capability, are overlapping and this is an integrative approach that should be used here. Therefore, the issues of competency, competitive capability, education quality and other relevant questions should be considered together.

An integrative structure of education developed via module system is a set of interdisciplinary modules taught over several semesters with mutual global and interim objectives, educational methods and tools, as well as monitoring and analysis of learning outcomes, taken together to train a competitive professional [6, p. 15].

New paradigm of education implies developing ability to independently obtain new knowledge instead of comprehending the knowledge provided. This principle is known as "lifelong learning". Within this education paradigm, fundamental and interdisciplinary knowledge plays a major part since it allows understanding allied sciences and developing skills of allied professional activities, which results in multiple career prospects.

The foundation of today's engineering education should rest on the principles of individualization, self-development, and self-organization, which are based on education fundamentality and interdisciplinarity [7, p. 13].

Interdisciplinarity allows implementation of integrative learning (acquisition of competencies) and secures competency synthesis. It is noteworthy that interdisciplinarity implies strengthening interdisciplinary connections with keeping integrity of particular disciplines and blocks within education programmes [8, p. 10-12]. The disciplinary knowledge should be taught in terms of their expediency, which is secured by the synthesis of abilities and skills developed through learning various disciplines.

Implementation of interdisciplinary principles into competency-based system of national higher education ensures training highly-qualified engineers in demand under the conditions of innovation economy [7, p. 19].

The pioneer of Kazan scientific school of engineering pedagogy is the academician of Russian Academy of Education A.A. Kirsanov (1923-2010), who played a key role in the establishment of Centre for University Teacher Training and Professional Development (Povolzhye and Ural) on the basis of KNRTU in 1994, the Centre for Engineering Pedagogy accredited by the International Society for Engineering Education IGIP in 1996. This centre became the second in Russia after the analogous centre at Bauman Moscow State Technical University.

Being the main local centre dealing with university teacher training and professional development, the Centre for Engineering Pedagogy:

- is the biggest national center for engineering pedagogy (there are two departments – Engineering Pedagogy and Psychology and Engineering Methodology);
- possesses the license granted by the International Society for Engineering Education IGIP to implement the programme "European (International) Educator for Technical University";
- is a co-organizer of three national conferences on continuous professional development (2004, 2006, 2008), international scientific schools "Higher Technical Education as a Booster of Innovation Development" (October 5–7, 2011), «Russia in WTO: New Objectives of Engineering Education in Oil and Gas Production and Petrochemistry" (November 26–30, 2012), "Engineering Education for New Industrialization" (September 23–28, 2013); 42nd IGIP International Symposium "Global Challenges for Engineering Education" (September 24–26, 2013). Within IGIP International Symposium, there were different panels, seminars, and round tables, with more than 500 participants, including 156 representatives of 46 countries;
- is the platform for postgraduate and postdoctoral programmes since 1996; there is also Thesis Board D212.080.04 for specialties 13.00.02 "Theory and Methodology of Chemistry Teaching" and 13.00.08 "Theory and Methodology of Professional Education" (there are only a few of such Boards in the technical universities of Russia);
- involves educators who are the head editors of journals ("Vysshee obrazovanie v Rossii [Higher Education in Russia]" (M.B. Sapunov), "Kul'tura. Obrazovanie. Vremya [Culture. Education. Time]" (R.Z. Bogoudinova) and members of editorial boards of journals listed by State Commission for Academic degrees and Titles ("Vysshee obrazovanie v Rossii [Higher Education in Russia]" (V.G. Ivanov), "Kazanskaya nauka [Kazan Science]" (V.V. Kondrat'ev, Yu.M. Kudryavtsev), "Kazanskii pedagogicheskii zhurnal [Kazan Pedagogical Journal]" (G.I. Ibragimov));
- conducts scientific research on theory and methodology of professional education (system design for prognostic models of professional and educator in 21st century; methodology and methods for designing educational process for professionals and educators; versatile education for today's professionals; fundamental professional education: approaches and methods; integrative basis for innovative educational process, etc.), included in coordination plans of Tatarstan Academy of Sciences and the Russian Academy of Sciences and funded by Analytical departmental target programme of the Ministry of Education and Science of the RF (about 40 million rubles, 2006–2013).

Within this research domain, there are about 30 doctoral and 190 candidate degree theses defended, including doctoral degree dissertations as follows: "Proektirovanie soderzhaniya professional'nopedagogicheskoi podgotovki prepodavatelei vysshei tekhnicheskoi shkoly [Designing content for university teacher training]" (V.G. Ivanov, 1997), "Proektirovanie i realizatsiya podgotovki spetsialistov dvoinoi kompetentsii v tekhnicheskom vuze [Double-competency programmes at technical university: design and implementation]" (A.M. Kochnev, 1997), "Fundamentalizatsiya professional'nogo obrazovaniya spetsialista na osnove nepreryvnoi matematicheskoi podgotovki v usloviyakh tekhnologicheskogo universiteta [Fundamental professional education based on continuous mathematics learning at university]" (V.V. Kondrat'ev, 2000), "Mezhdistsiplinarnaya didakticheskaya sistema bazovoi lingvisticheskoi podgotovki perevodchikov [Interdisciplinary didactic system of fundamental language training for translators]" (E.R. Porshneva, 2003), "Intellektualizatsiya professional'nogo obrazovaniya v tekhnicheskom vuze [Intellectual professional education at technical university]" (N.P. Goncharuk), "Adaptivnoe proektirovanie i realizatsiya obrazovatel'nykh tekhnologii v usloviyakh dopolnitel'nogo professional'nogo obrazovaniya inzhenernogo vuza [Adaptive design and implementation of educational technologies into additional professional education provided by engineering university]" (F.T. Shageeva, 2009).

Numerous times the Government of the RF awarded the educators of the centre with national bounties for education: Ibragimov G.I., Osipov P.N. (2005); Bogoudinova R.Z. (2006); Ivanov V.G. (2009); Kirsanov A.A. (posthumously), Kondrat'ev V.V., Gur'e L.I. (2013); Kudryavtsev Yu.M. (2014).

Scientific papers by the educators of the centre became laureates of the competition for the best scientific book held by the National Education Development Fund: Kondrat'ev V.V. "Metodologiya sistemnogo issledovaniya [Methodology of systemic research]", Osipov P.N. "Innovatsionnaya vospitatel'naya deyatel'nost' v tekhnicheskom vuze [Innovative educational activities at technical university]" (2007), Gur'e L.I. "Poslediplomnoe obrazovanie prepodavatelei vuza v usloviyakh innovatsionnykh protsessov [Postgraduate education for university teachers at the time of innovation implementation]", Shageeva F.T., Ivanov V.G. "Sovremennye obrazovatel'nye tekhnologii v inzhenernom vuze [Modern educational technologies in engineering university]", Khannanova-Fakhrutdinova L.R., Khatsrinova O.Yu., Ivanov V.G. "Proektirovanie i realizatsiya didakticheskikh igr v tekhnologicheskom vuze [Didactic games in engineering university: design and implementation]" (2008); Gur'e L.I. "Proektnaya deyatel'nost'

STUDENTS, POST-GRADUATE STUDENTS, AND TEACHERS IN INTERDISCIPLINARY PROJECTS AND TEAMS

ENGINEERING EDUCATION 20'2016

preprodavatelya vysshei tekhnicheskoi shkoly [Project activities performed by engineering university teacher]" (2010).

The educators of the centre are the members of IGIP (International Society for Engineering Education) and collaborate with ASEE (American Society for Engineering Education). In compliance with ASEE resolution, Kazan National Research Technological University participated in the plenary session of the International Forum held in Seattle, Washington, in June 2015.

Further development of teacher training and continuous professional development systems imply:

- new methodology to set and concord the objectives of educational, research, and manufacturing activities;
- development and testing of cutting-edge scientific, educational and methodological, regulative, administrative, and other facilities;
- focus on high-level personal and professional development of staff employed in science and culture sectors;
- development of the skills to integrate and generate ideas from different fields of science and industries, operate interdisciplinary categories when solving complex integrative tasks;
- connection between teacher training and professional development programmes and technical and economic prospects of university, as well as industrial and regional demands for new educational services;
- favorable conditions for professional development with regard to society interests and personal qualities and abilities.

Therefore, the changes in the system of university teacher training and professional development are attributed to the shifts in the system of engineering education; integration of science, education, and manufacturing; and increased demand for highly-qualified staff.

Modern paradigm of higher education stipulates development of an adequate teacher training system. It is obvious that the system of teacher training, which integrates technical, technological, and humanitarian knowledge from the fields of pedagogy and psychology and meets all the requirements for engineering and pedagogical activities, necessitates further development of methodology and theory.

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ENGINEERING EDUCATION 20'2016

V.I. Shvetsov

S. Sosnovsky

Improved Teaching of Mathematics as an Important Component of Interdisciplinary Engineering Education

Lobachevsky State University of Nizhni Novgorod
V.I. Shvetsov
German Research Center for Artificial Intelligence (DFKI)
S. Sosnovsky

The paper considers the outcomes of the project "Modern Educational Technologies for Math Curricula in Engineering Education of Russia" (Tempus), implemented by the consortium of European and Russian higher education institutions. Having analyzed the national and international experience in teaching mathematics, the authors suggest a new method to enhance math teaching thus improving the quality of engineering education. The method implies using the intelligent system of e-learning.

Key words: mathematics in engineering education, engineering education, mathematical background, programme improvement, e-learning system, TEMPUS-METAMATH, mathematics and engineering education, content-related competencies.

The Russian system of engineering staff training has been widely recognized. During the Soviet period this education system was a basis for success in cosmic explorations, development of heavy industry and building, etc. In the 1990's the economic crisis and social transformations led to radical changes in the Russian higher education. Inadequate funding of universities, brain drain etc. resulted in deterioration of engineering training in Russia. At the beginning of the 21-st century the economic growth of Russia conditioned high demand for the new generation of engineers capable of improving economy. The old system of engineering training failed to meet new requirements to the full extent, therefore, the demand for modernization of this sphere was recognized at the state level. One can enumerate a number of government measures focused on improving higher education: adoption of the new law on education; universities' differentiation with various missions including changes in financing policy; implementation of federal programmes aimed at improvement of education; development of new state education standards, etc. Among those measures it should be noted № 2506-p "The concept of development of mathematical education in the Russian Federation" of 24.12.2013 developed and approved by the Government of the Russian Federation. In particular, it states that without high level of mathematical training it is impossible to accomplish the mission of innovative economy development, achieve long-term goals and objectives of social-economic development of the Russian Federation.

Mathematics is a fundamental base for the entire range of curricula in engineering training. At present, the issue of mathematical training quality is acute in higher engineering and natural-science education in Russia. The experience in teaching mathematics at the undergraduate level allows for conclusion that nowadays there are serious problems both from the teachers' point of view and that of students.

Contemporary students have significant difficulty with learning traditional mathematical disciplines, which is reflected in lowering students' academic achievement, high expulsion rate or transferring to other (economic, juridical, humanitarian) departments (up to 40%). Such a problem is typical not only for Russia. In the US nearly 40% of engineering students do not finish their studies or change their profiles, whereas in Europe the share of engineering students being expelled from the university ranges from 15% to 40%. In Russia, this problem is closely connected with poor school training in mathematics. Besides, the transition to the new education standards and two-layered education system have led to reduction of mathematics class hours. In different engineering profiles such a reduction may reach up to 50% as compared to previous requirements of the state education standard. For example, the state education standards of the second generation for training specialists in applied informatics provided about 800 hours for basic mathematical disciplines, of which up to 500 were class hours. The tentative basic education programmes of the third generation standards for the same profile of applied informatics provide the volume of initial mathematical training in 18 credit units (648 hours), of them not more than 59 % are given for class hours.

To address the challenge of mathematics education quality effectively in new conditions, it is necessary to review the methods of teaching mathematics.

To solve the enumerated problems of mathematics training in contemporary higher engineering education system is the primary goal of the international TEMPUS project "Contemporary educational techniques of teaching mathematics in engineering education of Russia" 543851-TEMPUS-1-2013-1-DE-TEMPUS-JPCR ("Modern Educational Technologies for Math Curricula in Engineering Education of Russia"), or MetaMath (2013-2016) for short [1] performed by consortium of Russian and European universities. The primary goal of the project is to develop methods of increasing students' motivation in learning mathematics, improve the quality of mathematics education, transform mathematics into clear and understandable subject for students. The consortium includes 2 universities of Germany (Saarland University, Saarbrьcken and Chemnitz University of Technology), Universite Claude Bernard Lyon I (France), Tampere University of Technology (Finland), 5 universities of Russia (Lobachevsky State University of Nizhni Novgorod – the coordinator of the Russian project participators, Tver State University, Kazan National Research Technical University, Saint Petersburg Electrotechnical University "LETI", Ogarev Mordovia State University, and Association for Engineering Education of Russia.

The key objectives of the projects are:

- To perform a comparative analysis of the best European and national practices in teaching mathematical disciplines for science profiles.
- To improve mathematical courses of ten different curricula of science profiles. In the course of improvement, the curricula and practice of the Russian and European universities will be combined for the academic achievements to be recognized and to implement the best European techniques in teaching mathematics.
- To introduce electronic system of teaching mathematics support Math-Bridge [2] developed by European universities consortium into learning process. It will permit implementing different pedagogical strategies and teaching scenarios. Math-Bridge is an intellectual training system that allows teachers and students to interact with thousands of mathematical learning objects available in seven languages. Math-Bridge users may choose one of numerous prerequisite courses or dynamically generate mathematical courses adjusted for a specific student's needs, preferences, abilities, and current knowledge. Math-Bridge fosters extensive training

experience using different types of learning objects: definitions, theorem, evidences, examples, and interactive exercises.

- To develop new university competences in developing and providing access to updated online mathematics courses.

The following disciplines studied by all engineering students were chosen for analysis of mathematical courses: linear algebra, geometry, analysis, differential and integral equations, probability theory elements, bases of mathematical statistics.

To assess the quality of mathematical training within the project, the international standard of European Society for Engineering Education (SEFI) [3] is used. SEFI standard "A Framework for Mathematics Curricula in Engineering Education" (the latest edition of 2013) indicates the qualification scope of mathematical curricula, contains the levels and tasks of training, section on teaching mathematics, assessment forms, description of learning outcomes. The analysis of this document and comparison with the learning outcomes prescribed by curricula of the Russian universities in the Federal State Educational Standards and standards independently established by the Russian research universities has shown their conformity. Nearly all aspects of learning mathematics mentioned in SEFI are reflected in mathematical disciplines of the Russian universities.

The analysis of contemporary condition of the education performed on the course of the project included comparison of the Russian system of engineering education with that of European partners. The experience of all foreign universities-project partners was analysed. Of two major alternatives in teaching mathematics in the course of engineering training (to teach students "how to do this"; or to teach students "to understand how to do this"), the second option was chosen in the project taking into account the traditions of Russian higher school. In the course of the project, the following trends in improving mathematical curricula were developed based on the analysis of the current problems and experience of the European partners.

1. Introduction of remedial courses on elementary mathematics for the first-year students (to fill in the school gaps) due to changes of some parts in the relationship between class and self-study hours in favour of the latter in some parts. The curriculum includes "Introduction course of elementary mathematics" and independent work with libraries of mathematical objects in the Math-Bridge platform.

2. Transformation of curriculum structure. Instead of traditional lectures (which are, as a rule, not enough to give the necessary information) the curriculum comprises summarizing lectures and tutorial lectures. The purpose of summarizing lectures consists in problem statement on the selected topics and review of the methods for its solution as well as defining tasks for independent work on the stated problem with necessary recommendations on its performance. Tutorial lectures are aimed at assisting students to perform independent work and overcome learning difficulties both found by students themselves and revealed by the teachers when managing the independent work.

3. Enhancement of student independent work in learning subject. It is achieved by upgrading methodical support for student independent work, using project technique and e-learning systems, monitoring over independent work. In contrast to traditional approach, a part of learning material is not delivered at lectures, but given for self-study using recommended aids and electronically managed course. In this case students are instructed by the teachers at summarizing lectures, assisted at tutorial lectures and report on independently studied material during the test period. The focus in learning discipline on student independent work allows sufficient expanding of learning material, which is impossible in case of traditional lectures.

4. Application of project method. The primary objective of the project method is to give students opportunity to learn independently in the course of solving practical problems that require integration of knowledge from different subject area. The project tasks are of applied significance to demonstrate the importance of mathematics in solving real-life problems and, in this way, increase students' motivation to its study. The projects are performed under teacher's supervision. They also involve teacher's tutorials and final project defense.

For example, the course "Mathematical modeling" includes the following four compulsory projects: "Use of dynamic systems for mathematical model building", "Mathematical models of selection processes", "Mathematical models of chemical processes", "Mathematical models of biological systems/ Mathematical models of social-economic processes". Each project is performed by the group of 3-4 students that gives them the experience of team work.

5. Using e-Learning in academic process. For example, to support learning process in UNN synchronous electronic courses in all disciplines of the major were designed. They are on the website http://e-learning.unn.ru/) and include students' electronic test to check their performance and independent work.

6. Enhancement of teachers' monitoring of students' independent work skills. In this case the algorithm of independent work, forms and criteria of assessment, volume of work, deadlines, and tutorial assistance are clearly defined. It was also planned to carry out four electronic tests (within a term) and defend four compulsory projects. In case of student's effective performance during the term he/she does not have stress within the examination period.

The next stage of the project was assessment of improved curricula. For this purpose, the students studying the course were split into two groups: students learning traditional curriculum and those learning the improved one. Splitting into groups was made in such a way that the average Uniform State Exam results in the groups were nearly equal. i.e. students of both groups were similar in their initial levels. At the beginning of study there was pre-testing to determine the level of students' competencies prescribed by SEFI standards in the sphere of elementary mathematics and simple calculus (Zero and elementary levels). At the end of the term there was testing again (post-testing) with similar tasks. The goal of the testing was to reveal the changes in basic mathematical knowledge level at different forms of learning.

The example of testing outcomes on mathematical analysis is given in Tab. 1. More detailed results are given in [4]. SEFI competencies are presented in large groups. The test results are presented in percent of tasks correctly completed.

The test results show that the improved curriculum shows higher level of knowledge in absolute indicators in a number of competences. This is, for example, "Sequences and Series".

It is even more noticeable that improved curriculum shows better outcomes in the relative indicators – changes between pre-and post-testing results. This is, for example, "Differentiation".

The traditional curriculum shows decrease in the outcomes in a number of competencies (for instance, "Trigonometric functions"), whereas the improved curriculum does not show any decline. This effect can be explained by the fact that the improved curriculum allows upgrading school knowledge due to remedial course on elementary mathematics, intensive independent work and continuous relations of studied material with the applied issues.

Thus, the current study has shown that trends in improving curriculum are effective tools to increase quality of mathematical training. The results obtained may be a basis for solving urgent problems of engineering education.

Table 1. Relative level of SEFI competencies at the beginning and end of the course

№	SEFI competences (large groups)	SEFI level	1 group (traditional curriculum)		2 group (improved curriculum)	
			Pre-testing (%)	Post-testing (%)	Pre-testing (%)	Post-testing (%)
1	Real number arithmetic	0	87,36	83,81	88,41	92,16
2	Linear equations	0	96,55	94,29	82,61	94,12
3	Trigonometric functions and their applications	0	57,47	40,95	44,93	54,90
4	Trigonometric identity	0	82,76	80,00	65,22	94,12
5	Functions and reversed to them	0	51,15	51,43	61,59	82,35
6	Sequences and Series	1	43,97	76,43	40,22	86,76
7	Progressions	0	69,83	65,71	68,48	69,12
8	Logarithmic and exponential functions	0	52,59	63,57	70,65	75,00
9	Differentiation	1	75,86	82,86	65,22	94,12
10	Stationary points, maximums and minimums	0	70,11	58,10	60,14	76,47
11	Function study and graphing	1	48,28	94,29	45,65	97,06
The number of tested students			29	35	22	19

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UDC 378

Interdisciplinary-Based Additional Professional Education for Students of Technological University

Kazan National Research Technological University
F.T. Shageeva, V.G. Ivanov

F.T. Shageeva

V.G. Ivanov

The article describes the project of National Research University. It has been revealed that additional professional education based on the interdisciplinary approach enhances interdisciplinary competence of students, thus, increasing their competitiveness. Such a training requires not only application of universal education technologies, but also search for numerous alternative solutions.

Key words: interdisciplinary research, additional professional education, students of National Research Technological University.

Reflecting the integrated character of the current science and knowledge acquisition, interdiciplinarity or interdisciplinary approach does not only imply a synthethis of knowledge, methods and approaches of various fields of science, but also suggests a certain degree of integration. It is regarded as an innovative methodology that definitely has indisputable value due to its synergetic character.

As a number of researchers stated, "division of contemporary science more likely rests on various scientific problems of disciplinary character than on the disciplines themselves [1, p.13]. Educators and phycologists suggest transfer of knowledge from one field of science to another one as one of the methods to develop way of thinking [1, p.12]. Most of the recent scientific advancements and discoveries have been made at the confluence of two or even more disciplines.

Interdisciplinary connections [2, p.27] are didactic equivalent of interscientific connections. According to the opinion of a number of scholars, the highest level of the interdisciplinary connections is integration stipulated by the objectives of the scientific knowledge and assumptions that reflect the unity of the real world [3,p.162].

The mission of Kazan National Research Technological University is to develop as a Russian Engineering-Training Center of Chemical Technologies which would provide training, scientific, design and manufacturing services and, thus, contributing to the complex development of the industry in the interests of the region, country and the whole world. The increase in the competitiveness of the University as a training and scientific center due to interdisciplinary professional teams is one of the priorities of the university.

In order to achieve the above-mentioned goal, the project "Additional Professional Education for Students as a Career Perspective (from student bench to the position of supervisor)" has been launched. The project itself is based on the interdisciplinary principles.

In the current context of ever-changing professional activity content when a modern engineer should be able to switch from one activity to another one and perform various professional functions, revision of engineering training system is of particular urgency. In this regard, the issue of additional training becomes especially important [4, c.103-106].

Additional professional training can be offered within various education programmes and completed in several stages in parallel with basic degree programmes. A student can choose additional professional programme according to his/her interests and needs, and it can be additional language programme, programme in general sciences and mathematics, humanitarian programme or specific engineering training. The following programmes are the most popular among students:

- Staff Management.
- Business Management.
- Legal Fundamentals of Business Activity.
- Business Economy and Management.
- Translation in the Field of Professional Communication.
- Psychology of Professional Activity.
- Pedagogy of General and Professional Education.
- Information Systems and Technologies.
- Industrial Product Marketing.
- Design of Forest Products.
- Social Communication.

Additional professional training is based on a number of didactic principles of interdisciplinary character: interconnection between basic and professional education, integration and differentiation, intellectualization of professional training, reflection of professional activity, personality development by means of activity, communication, humanitarization of education, etc. The content of additional professional education for students is based on the basic principles of engineering and socio-humanitarian training being regarded as mutually reinforcing systems.

Making a decision whether to complete such a programme or not, a student is basically governed by internal motives directly relating to education programme and future occupation. This kind of motivation is rather strong and drives students to satisfy their spiritual needs which are often beyond the education programme frame.

The education of the Russian students are characterized by stronger psychological and managerial training. This fact is proved by the analysis of the most valuable skills and competences, which is carried out according to the well-known methodology [5]. Students were asked to complete the questionnaire in order to identify the following skills and attributes: **goal-orientation, businesslike manner, leadership, self-confidence, conservatism, negativism, flexibility, dependence, conformism, generosity.** To create a personality profile, coordinate plane was used: the x-coordinate axis shows attribute number, the y-coordinate axis illustrates attribute intensity ranked as 1-4 – nominal, 5-8 – potential, 9-12 – perspective, 14-15 – super zone.

The mean values of students' attributes involved in such additional programmes as "Business Management", "Pedagogy of General and Professional Education", "Translation in the Field of Professional Communication", "Legal Fundamentals of Business Activity" are given in Tab. 1.

As shown, goal-orientation and businesslike manner are the strongest attributes. This fact proves students to be leaders. At the same time, if future engineers-managers are very confident and dominant, future engineers-educators are more goal-oriented and kind-hearted. The attributes of students completing the programme "Translation in the Field of Professional Communication" are almost all equally strong with only exception of such attributes as conformism and conservatism. Students who complete engineering programme in parallel with the additional training in Legal Fundamentals demonstrate very strong negativism and low level of conformism. Thus, the attributes of students who complete additional professional programmes reflect the peculiarities of the chosen professional domain and are in accord with so-called "multi" competence.

The survey of teachers' opinions allowed us to draw a "portrait" of a student. In general, students are rather intelligent, versatile, and creative demonstrating high potential for leadership. They are initiative, goal-oriented and are willing to acquire new knowledge and competences. In addition, they are quite independent,

Table 1. Mean Values of Students' Attributes

Sudent's Attribute	Additional Professional Programme			
	Business Management	Pedagogy of General and Professional Education	Translation in the Field of Professional Communication	Legal Fundamentals of Business Activity
Goal-orientation	9	12	9	10
Businesslike manner	12	8	8	11
Leadership	8	8	6	9
Confidence	10	10	7	7
Conservatism	7	8	4	8
Negativism	2	2	2	5
Flexibility	4	4	4	4
Dependence	3	3	3	3
Conformism	5	6	10	4
Generosity	7	12	8	7

responsible and diligent. They respect teachers and maintain good relationship with them. They are able to work with information, analyze it in terms of social needs, moral and ethical values making difference between facts and opinions. It is these attributes that distinguish them from other students.

The staff selection has been also changed: basically, teachers who deliver additional professional programmes have knowledge both in engineering and humanitarian sciences. Besides, they should possess the following qualities: kindness, loyalty, tactfulness, willingness to help, ability to listen and understand a student, etc.

When pursuing addition professional programme, a student cannot avoid using knowledge and skills acquired as a result of basic programme completion. That is precisely the way how interdisciplinary approach works. Thus, "translators" do not just acquire information that is unrelated to anything, but gain insight both into engineering and foreign language, theory and practice of translation. As a result, they obtain qualification that is currently in high demand. The same can be said about the programme "Pedagogy of General and Professional Education". The combination of knowledge in engineering, pedagogy, and psychology allows students in future to teach general science within the system of professional education.

Interdisciplinary approach can be successfully implemented by the teachers who possess deep knowledge in various instructional methods, demonstrate commitment to constant improvement in teaching technologies and are actively involved in interdisciplinary research.

The question arises whether it is necessary to apply unusual teaching technologies in additional professional programmes? Trying to find the answer, we turned to the interdisciplinary approach. We have proved the efficiency of using methodology of strategic planning and management in pedagogical design [6, p. 16-19]. In this case, the design of teaching technology would acquire adaptive character which allows reacting quickly to any changes, both internal and external, maintaining the integrity and efficiency of the designed technology and ensuring compliance with consumers' needs and requirements of the labor market [7,p.137-140].

It includes the following stages: the mission statement and definition of the strategy for educational institution development; formulation of both learning objectives and outcomes; analysis of external conditions; analysis of internal potential of educational institution to implement the designed programmes; development of strategic alternatives; selection and use of teaching strategy; results analysis and assessment; new trends examination and implementation of corrective actions.

The process involves generation of numerous alternative solutions among which a teaching technology will be chosen with regard to internal capacities of the educational institution and certain implementation conditions. Generating alternative strategic solutions is the final purpose of external analysis. Educational potential (internal environment) of the educational institution and educational climate (external conditions) have a decisive influence on teaching technology. The assessment of educational potential includes analysis of teaching staff competence, level of education services and financial resources spent on teaching process itself. In addition, selection of teaching technology is also dependent on the following: experience in implementing teaching technologies; risk of failure in learning outcomes achievement; university management's policy; time required for teaching technology implementation.

Additional professional education for engineering students is so-called elite education intended for best students. It can be regarded as an element of engineering graduate's professional perspective. Professional competence of an engineer is gradually developed at the university. When pursuing the basic education programme, a student acquires a number of competences which are typical for the chosen professional domain and absolutely required for the professional activity. When completing additional professional programme, students can easily improve the acquired competences which become their core distinguished attributes. In fact, additional professional education which is implemented on the basis of the interdisciplinary approach leads to the interdisciplinary result, i.e. enhanced competitiveness of the graduates of Technological University.

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R.G. Abdeev


E.R. Abdeev


E.V. Bakieva


M.A. Lobanov

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Improving Young Employees Training at Engineering, Repair and Installation Enterprises

Bashkir State University
R.G. Abdeev, E.R. Abdeev, E.V. Bakieva, M.A. Lobanov

The article considers the implementation of network as a form of training in the higher school. It highlights the necessity of implementing this form of students training for engineering enterprises involved in repair and mounting of the equipment. The authors offer a model of interaction between engineering enterprises in the framework of network industry educational programs.

Key words: network for of training, engineering staff, professional competencies.

One of the main goals of higher education institutions involving engineering staff training is the modernization of the educational activity itself which, in its turn, is aimed at professional competence development. Such modernization is possible only by improving and reconstructing the higher education system in accordance with the global trends, labor market demands, employers' demands and students' educational needs, as well as the development and implementation of upgraded educational programmes and specific educational modules focused on innovative activities, including joint education programs.

The basic mechanism to achieve the above-mentioned goal is network interaction. Network education programme implementation as stated in the Federal Law on Education in Russian Federation, adopted on 29 December 2012 [2], allows:

- involving the resources of two or more education institutions, including foreign ones to improve the quality of training and unique professional competence development;
- introducing education programmes in collaboration with foreign and Russian education and scientific organizations to further science-technical and intellectual potential development;
- upgrading students' and teachers' academic mobility level.
- Network education tasks are:
- training specialists with unique competences in accordance with priority labor market demands;
- improving education quality based on partner organizations resources integration in priority profiles of industrial, cross-sectoral and regional development in accordance with international standards;
- introducing best local and foreign experience into educational process for industrial and regional experimental research development.

The Federal Educational Standards also embrace the possibility of network educational programme implementation. Prior to the Methodical Recommendations on Bachelor's degree network education programme implementation, there was no idea about the mechanism of network interaction. The main objective of the network form is common training of specialists within the framework of several organizations. These organizations are divided into three types:

1. Basic education organization (here – Bashkir State University).

2. Education organizations (Autonomous Non-commercial Organization, Special Secondary Education Establishments, Higher Education Establishments and other establishments having educational license).

3. Resource organizations (manufactures, laboratories, industries, etc).

The functionality of innovative educational centers and departments including CPE (Continuing Professional Education), teaching councils, teacher training centers, regional competence centers, marketing and graduates' employment services expands during the implementation of network education programs. Network education programmes could be:

- competence development – oriented to enhance highly qualified specialists for priority industrial and regional economy sectors;
- science-innovation – directed to applied research development for industrial and regional needs;
- industrial – directed to highly qualified specialists training for the priority branches of industrial, cross-sectoral and regional economy in accordance with international standards.

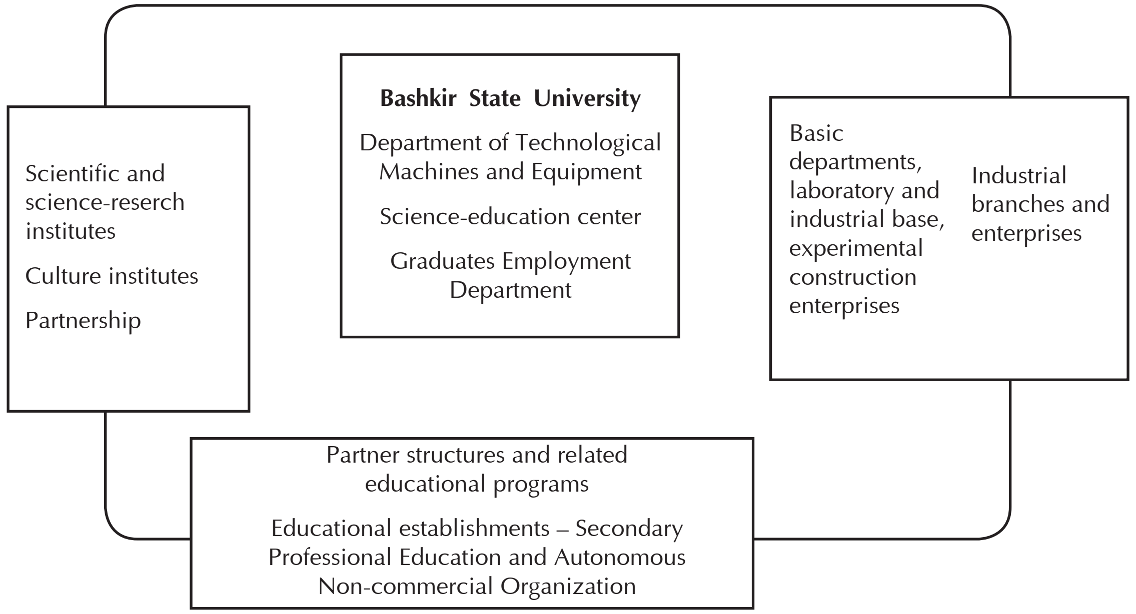
The realization of competence-oriented network education programmes implies the development of pre-university tutorial centers, career centers and vocational classrooms for developing unique pre-professional competence.

Science-innovative network education programme implementation includes the resources of education-research centers, research facilities centers, career centers and vocational training centers, which would develop science-education environment where the higher education institution is an inseparable member [1].

Our model of network education is industry-oriented and implies close interaction with real economy sector enterprises (Fig. 1).

The updated Law on Education introduced the term "structural unit of high education institution at basic enterprise of real economy sector". This term means the interaction between high education institution and the enterprise during laboratory and practical work, on-site

Fig. 1. Model of enterprise interaction within network industrial education programs



training, research works and etc. The leading high education institutions like Moscow Institute of Physics and Technology use the term "basic department", but still there is no common law and methodological background for the development and activity of basic departments.

In 2011, Engineering Department of Bashkir State University established basic departments which are responsible for enrollment and engineering specialists training (full and part-time education). Here, the engineering enterprises are the customers for education service provision. Currently, there are 4 basic departments: BashSU-GMZ at LLC "Gribanovskiy mashinostroitel'nyy zavod" in Voronezh-skaya oblast, BashSU-KP at Open joint-stock company "Krasniyproletariy" in the republic of Bashkortostan (Sterlitamak), BashSU-UTS-THM at LLC "Uraltekhnostroy-Tuymazykhimmash" in the republic of Bashkortostan (Tuimazy) and BashSU-BMZ at Bugulma mechanical plant PGSC "Tatneft" in the Republic of Tatarstan (Bugulma).

More attention should be paid to the autonomous non-commercial organizations having education training license on categories requiring additional education license.

The existing laws, standards, and orders were studied in details, as well as the items on common business processes of all organizations and structural branches in order to develop the following provisions:

1. Bashkir State University:

Regulation on Science-Education Center.

Regulation on Network Interaction.

Regulation on Basic Departments.

2. Autonomous Non-Commercial Organization of Continuing Professional Education "Education Center"

Regulation on Network Interaction.

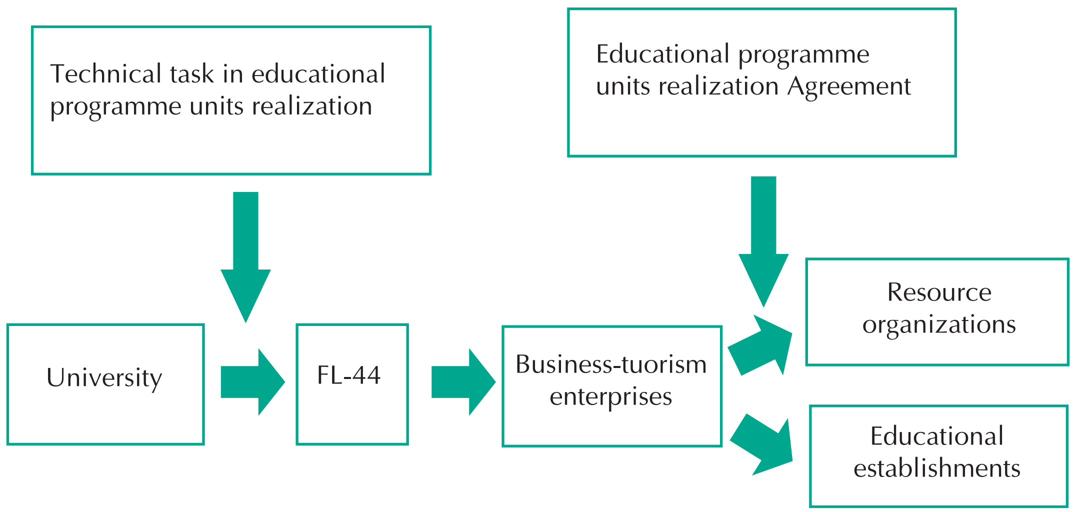
3. Engineering enterprises:

Regulation on Basic Departments.

The main issue of network interaction is the education institutions and resource organizations service payment for the implementation of education programmes units. Currently, the network form is considered as indexes and according to the principle «we give you a student – you give us a student.» Thus, the network form is implemented between universities with the individual plan of a particular student training.

A mechanism of network interaction participants service payment based on the Federal Law № 44 (FL-44) (Fig. 2) is proposed.

Fig. 2. Mechanism of network interaction financial provision



ENGINEERING EDUCATION 20'2016

This mechanism implies technical task development to achieve the didactic goals by the executives regarding the consu-mers – students. The units of education programmes are noted in the technical task as credit units, as well as the specified competences related to them. Terms and cost of education programmes implementation are also specified. These technical tasks are grouped in lots by the types of training activities and then are released to the public auction in order to find the service provider. The maximum cost of education programme units is determined in proportion to the credit units spent on its implementation considering the announced admission quotas of the engineer training cost.

During the bidding process the service provider is defined for each lot among business and tourist enterprises. The task of a winning bidder is to organize business training, workshops, seminars, internships, and other types of activities similar to educational establishments. Thus, the following issues could be resolved:

1. Transfer of money from subsidy assignations into income-generating activity.

2. Receiving of compensation for external students' accommodation and admission.

3. Control of students' didactic goals achievement and competence development. This is performed by science-educational center, which is also responsible for technical task design. Such a center should possess permission for rendering service acceptance on behalf of Bashkir State University. This allows withholding the payments from business-tourist companies in case of their low-quality, incomplete or late service rendering. The basic share of students for network education is supposed to be the ones who live in the region of engineering companies' operation. This is defined by the fact that such companies are the members of network interaction and the major employers of Bashkir State University Engineering Department graduates.

After students' assignment at the engineering enterprise, the chief of the basic department helps them to choose the field of the study. Depending on the study field, a student gets the profession and starts working.

The methodological recommendation requirement analysis for the implementation of applied Bachelor degree in accordance with the Federal State Education Standards (FSES) resulted in the following assumptions:

1. After the first-year study of the applied Bachelor degree (according to training-oriented program) a student should obtain the corresponding profession.

2. After the second-year study a student should defend his/her graduation thesis for secondary vocational education diploma (working qualifications).

3. After the third-year study a student should defend the graduation thesis of secondary professional education (mid-level professionals).

4. A fourth-year student should defend the graduation thesis of higher education (Bachelor degree).

After the completion of the applied Bachelor degree programme a graduate is to have a Certificate on Working Profession (1st year), a Diploma of Primary Vocational Education (2nd year), a Diploma of Secondary Professional Education (3rd years), a Diploma of Higher Education (4th years). The list of such documents is necessary because, in accordance with FSES, to implement the applied Bachelor degree program, the higher education system should correspond to the Secondary Vocational Education (SVE) programme for mid-level professionals. Further SPE should correlate with the programme for mid-level professionals, which should implement professional standards corresponding to the branches selected for applied Bachelor degree of higher education program. Correlation of different education requirements (higher education and secondary vocational education) and professional standards includes competences, professional activities and disciplines correspondence. Also, in accordance with the Labor Code, a student who studies full-time is entitled only to part-time work and only if the employment corresponds the specialty.

To achieve the above-mentioned requirements, 50% (not less) of network education programme should be implemented in collaboration with engineering enterprises. We have developed the mechanism of students' labor time management to study in terms of the network interaction. This mechanism implies spending the second half of the study day on practical and laboratory work at the enterprise. In this case, the student must be under the supervision of a professional.

The fundamental difference between students' training at the engineering enterprise under supervision and students' training at the university is in the individual training instead of mass classroom training. No company, even a large one could employ a group of graduates (28 engineers) every year. The logical solution to this problem is the application of the network form of training that allows splitting 28 students into subgroups at four basic departments. In this case, there are 7 students of one year in each enterprise. If 7 students are distributed to company's structural divisions, then there are 1-2 students for each division. Considering the fact that each student will be entitled to independent work at the end of the first year, and, by the graduation, will become a professional employee with a four-year experience, as well as a specialist who can understand the difficulties of junior students (succession of generations), it is possible to establish a self-monitoring reserve personnel unit in the company.

Such features of the network education as part-time employment within practical and laboratory work are a kind of students' motivation to work and study, as the evaluation of students' performance by instructor or supervisor is considered at the credits and examinations. Failure in labor responsibilities fulfillment disables the student to study in accordance with the applied Bachelor degree program. This partially solves the problem of money return spent by the company on students' training.

Thus, the presented type of networking interaction is aimed at improving the quality of education, graduates' competitiveness, and students' mobility. Network education programmes are a common practice in the world education system and have good prospects in the system of national higher education.

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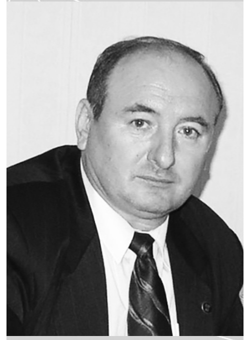
UDC 378

Cross-cultural Interdisciplinary Study of Learning Motivation of Engineering Students in Russia and the USA

Purdue University, USA
Ph.A. Sanger
Kazan National Research Technological University
I.M. Gorodetskaya, V.G. Ivanov


Ph.A. Sanger


I.M. Gorodetskaya


V.G. Ivanov

The paper addresses cross-cultural analysis of the learning motivation of Russian and US students majoring in engineering. The study is carried out with the use of psychological and pedagogical methodology. Empiric analysis has not revealed significant differences between the Russian and US groups, however some peculiarities in the hierarchy and structure of motivational sphere were found and should be taken into consideration in organizing international mobility programmes.

Key words: interdisciplinary study, learning motivation, cross-cultural peculiarities, psychological-pedagogical analysis, engineering students.

Globalization, particularly in the sphere of professional communication, as well as knowledge economy, has provided researchers' and practician's unfailing interest in the issues of academic mobility and cross-cultural communication. The universities worldwide focus on the programmes of students' and teachers' mobility development, establishment of international working groups and projects. For example, Purdue University implemented a unique project of students' integration into the world community working at senior capstone project [1]. Kazan National Research Technological University has also great experience in international projects [2]. International teamwork allows future engineers to be integrated into international professional environment at the training stage.

Due to the increase in significance of cross-cultural communication in the professional engineering environment, it is of great interest for researchers as well. Cross-cultural communication is studied at the interdisciplinary level and is an object of culturology, psychology, pedagogy, linguistics, ethnology, anthropology, sociology, and some other sciences. The given study implements interdisciplinary approach at the level of psychology-pedagogic relations to investigate cultural-related peculiarities of students' learning motivation in engineering universities of the USA and Russia.

Motivation, being one of the basic components of any activity and, to a great extent, defining its efficiency, is of interest for many humanitarian sciences. Interdisciplinary psychology-pedagogic approach to learning motivation considers a goal-oriented process of learning motivation development as a basis of learner's personal psychology. "Dynamics of personality development, – as V.G. Aseev puts it, – …includes those steady regularities, study of which is a basic purpose of psychology. The most important among them are regularities of motivation development as a top form of psychological process regulation and moving force of human activity" [3, p. 334].

Besides, when considering learning motivation from the standpoint of mutual impact of personal, situational, and social factors, it is necessary to take into account the fact that social-cultural environment, where a person forms and develops, as well as actual living situation have a direct impact on the content and structure of motivation. Cross-cultural analysis is not only to answer the question what development of a person's motifs, demands, and attitudes are, but also why just these, but not other motifs, demands, and attitudes are developed in a person, to what extent they depend on cultural environment, where this person lives.

Motivation is the most significant aspect of learning. Analyzing the essence of thinking process, L.S. Vygotskiy wrote [4] that thought is not produced from other thought, but from the motivating basis of our consciousness that covers our inclinations and demands, our interests and impulses, our affects and emotions. E.P. Il'in [5], underlining the significance of motivation in learning process, said that the factor of motivation appears to be more essential for its efficiency than the factor of intellect.

Learning activity is multi-motivated, i.e., as A.N. Leontiev stated [6], may be based on several broad, generalized, and meaningful motifs. It may not be reduced to only cognitive and thinking activity and, consequently, cognitive motifs. The issue of learning motivation structure is one of the most complex questions.

The literature review shows that in the structure of learning motivation most authors distinguish motifs directly connected with learning activity or intrinsic motifs, and extrinsic motifs influencing learning process, not directly, but immediately connected with it. Such a classification is suggested in works by P.Ya. Gal'perin (1976), V.F. Morgun (1976), V.E. Milman (1986), M.G. Rogov (1998) and others. Besides, it is noted that intrinsic motivation leads to more productive activity. As E.P. Il'in [5] indicates, good students show their demand for mastering a profession at high level, whereas low-performing students have mainly extrinsic motifs in the motivation structure. Distinguishing extrinsic and intrinsic types of motivation is typical for most foreign psychologists. American psychologists E.L. Deci, R.M. Ryan [7] developed theory of self-determination and intrinsic motivation of behaviour. These researchers also showed that intrinsic motivation contributes to proficiency development, creativity, more efficient conceptual learning as well as memory improvement. Intrinsic motivation has a positive effect on cognitive flexibility and enables to derive pleasure from activity.

Intrinsic motivation is not limited by cognitive motifs only. V.E. Milman stated that "motivation of intrinsic type characterized by social personal meaning is a real intrinsic motivation of development … In case of dominating extrinsic motifs there is inadequate, inverted subject structure of learning activity" [8; p. 131]. In other words, it is intrinsic motivation that allows achieving the main purpose of learning – a person's development. In this connection D.B. El'konin wrote: "Learning activity …is to be induced by adequate motifs, they may be only motifs directly connected with its content, i.e. motifs of generalized action acquisition or, simply put, motifs of self-development, self-perfection" [9; p. 46]. He calls the described motifs learning-cognitive ones (in contrast to broad cognitive interests). Y.M. Orlov's (1976) and M.G. Rogov's (1998) investigations confirm that motifs of person's development play an important role in learning motivation structure.

In our study the self-determination concept developed by E.L. Deci, R.M. Ryan [7] was used as a methodological basis as it meets the requirements of cross-cultural research to the greatest extent and is reflected in the empirical technique The Academic Motivation Scale (AMS-C 28) (College version) [10]. The given questionnaire is based on distinguishing three self-determination attitudes: intrinsic motivation, extrinsic motivation, and amotivation. The questionnaire contains 28 statements, the degree of agreement

with which is suggested to estimate using seven-point scale.

171 students took part in the empirical study:

- 86 students-future engineers (81 boys and 5 girls of 18–23 years old) of Purdue University (USA);
- 85 students of engineering profiles (39 boys and 46 girls of 17–25 years old) of Kazan National Research Technological University (Russia).

As it is seen from the sampling group, the demographic features of Russian and American groups are of particular interest: the most part of the students from the American University (94.19%) are boys, whereas more than half of the Russian respondents (54.12%) are girls. These figures correspond to the general data on the sphere of national engineering education systems: in contrast to many Western countries, in Russia a sufficient percent of girls study in engineering universities [11]. However, one should take into account the gender when analyzing the research results, as some features of motivation may be explained not only by cultural, but also gender factor.

Tab. 1 shows the results of comparative analysis of motivation specificity of Russian and American students. Using seven-point scale the students determined to what extent the given factors correspond to the reasons for their choice of studying at the university.

As Tab. 1 shows, there are some differences between the sampling groups in a number of factors, for example, American students regard such motifs as "Because higher education will permit me to better prepare for the career I have chosen", " Because it will help me to enter the job market in the profession I like", "Because I am sure that some additional years of study allow me to enhance my professional capacities", "To feel satisfied when improving my knowledge of subjects that I like" etc. more significant, whereas Russian students – such factors as "For pleasure I have when reading new authors", "Because I want to live well in future", "For the pleasure that I have when reading books by some authors" and so on. Regarding all enumerated factors the statistical differences (Student T-test) are more significant at the levels p ≥ 0.01 and

Table 1. Cross-cultural differences of engineering students' learning motivation in the USA and Russia.

Motivation factors	the USA		Russia	
	Mean	Rank	Mean	Rank
1. Because having school certificate only will not give an opportunity to have a highly-paid job	5.7	5	5.54	4
2. Because I enjoy learning something new	5.2	9	5.13	6
3. Because higher education will permit me to better prepare for the career I have chosen	5.88	3	5.11	7
4. Due to strong emotions I have when discussing my ideas with the others	3.26	21	2.29	24
5. To be honest, I do not know. Actually, I feel I'm losing time	2.02	26	1.82	26
6. Because of the pleasure I have every time I surpass myself in learning	3.9	20	4.32	18

7. To prove myself that I am able to get higher education	4.74	14	4.38	16
8. To have prestigious job in future	6.01	2	5.87	2
9. For pleasure I have when discovering something new, unknown for me before	4.94	12	4.79	12
10. Because it will help me to enter the job market in the profession I like	6.05	1	5.2	5
11. For pleasure I have when reading new authors	2.76	23	3.21	22
12. Some time ago I had a big cause to enter university, but now I am not sure I have to go on studying	2.15	25	1.88	25
13. For the pleasure that I have when improving my achievements	4.38	17	4.84	11
14. Because I feel important and significant when I am successful at university	4.47	15	4.35	17
15. Because I want to live well in future	5.52	6	5.99	1
16. To feel satisfied when improving my knowledge of subjects that I like	5.12	11	4.58	14
17. Because it will help me to make better choice in planning career	5.17	10	5.09	8
18. For the pleasure that I have when reading books by some authors	2.69	24	3.15	23
19. I don't see any reason to study at university and, to be honest, I don't care of it	1.8	28	1.51	28
20. To be satisfied in the process of solving complex problems	4.24	19	3.94	21
21. To prove myself that I am a clever man	4.45	16	4.07	19
22. To have high salary in future	5.72	4	5.82	3
23. Because my learning allows me to continue learning much interesting	5.24	8	4.89	10
24. Because I am sure that some additional years of study allow me to enhance my professional capacities	5.5	7	4.91	9
25. Because of excellent feeling that I have studying different interesting subjects	3.0	22	4.02	20
26. I don't know; I can't understand what I am doing at university	1.84	27	1.6	27
27. Because university helps me to feel satisfied when improving in study	4.29	18	4.42	15
28. Because I want to prove myself that I can be successful in study	4.9	13	4.59	13

STUDENTS, POST-GRADUATE STUDENTS, AND TEACHERS IN INTERDISCIPLINARY PROJECTS AND TEAMS

$p \geq 0.001$. Hence, the American sampling group is more focused on the labour market in future, whereas the Russian students are less prudent discussing more common topics.

Interesting conclusions can be also made having compared the ranks occupied by different motivating factors in learning motivation hierarchy. According to calculation of Spearman rank correlation coefficient ($rs = 0.952$, $p \geq 0.01$), on the whole, there is a statistically significant correlation between the sampling groups, i.e. the differences in ranks are not sufficient. In other words, while there are some differences in significance at the level of comparing definite factors (Tab. 1), in general, the system of learning motivation hierarchy is not sufficiently different when comparing Russian and American engineering students, which allows forecasting success in joint education programmes. Learning motivation may be considered as a universal meta-cultural system.

A more generalized picture can be produced in comparative analysis of motifs' groups (Tab. 2).

Tab. 2 shows that all respondents, independently on their ethnic-cultural background, are motivated to study engineering majors, which is evidenced by low amotivation values, i.e. students understand the significance of study.

Both Russian and American students are more motivated by extrinsic factors (extrinsic regulation: high salary, prestige, "good life"), i.e. social factors to a more extent than their desire to gain professional knowledge (intrinsic motivation). Interpreting this fact it should be taken into account that intrinsic motivation is traditionally considered to result in higher learning outcomes and more creative approaches to learning. But in the self-determination theory terms underlying the given technique it is stated that extrinsic motivation does not always point to underdevelopment of motivation and often is a more complex, indirect mechanism of stimulating learning activity [7]. In our case one may suggest that respondents of both groups do not regard engineering profession as an inherent value, but as a means of achieving social success in their worldview.

The intercorrelation analysis gives deeper understanding of learning motivation specificity (Pearson's coefficient). In both sampling groups a great number of significant correlations among the factors were established, which shows high integration of motivation, where most

Table 2. Cross-cultural analysis of learning motivation

Motivation	the USA		Russia	
	Mean	Rank	Mean	Rank
Intrinsic motivation – knowledge	5.7	5	5.54	4
Intrinsic motivation – achievements	5.2	9	5.13	6
Intrinsic motivation – stimulating motifs	5.88	3	5.11	7
Extrinsic motivation – identification	3.26	21	2.29	24
Extrinsic motivation – introjection (self-identification)	2.02	26	1.82	26
Extrinsic motivation – extrinsic regulation	3.9	20	4.32	18
Amotivation (absence of motivation)	4.74	14	4.38	16

factors mutually reinforce each other. On the other hand, it may also mean that there are no strong independent motifs in the learning motivation structure of both groups, which determines learning activity and may reflect the lack of "maturity" in the respondents' motivation sphere. Negative correlations with other motifs showed only factors of amotivation, which is quite understandable: the higher amotivation is, the less a person is motivated.

It should be noted that the statistical analysis has revealed any gender differences between the American and Russian sampling groups neither in the hierarchy (Spearman rank correlation coefficient), nor in specific values (Student T-test), which means that features described above are not gender-specific. In this case we consider the fact that the number of girls is too small among the surveyed American students to make some final conclusion.

Thus, the performed psychological-pedagogical study in learning motivation of Russian and American engineering students have not revealed any cross-cultural differences, which may reflect the process of globalization in engineering professional community and is a factor inspiring the success of Russian-American academic mobility programmes.

The high value of extrinsic motifs related to future prestigious, highly-paid job and competitive position in the labour market is to be taken into account in designing curricula: to increase motivation students are to have clear idea of how knowledge and competences acquired may be used for their professional and social growth. In addition, it should be taken into account that surveyed sampling groups have differences as well in spite of many common features. For example, the Russian students more often regard successful learning as a means of boosting their self-confidence and social status. Those features should also be taken into account when implementing academic mobility programmes.

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V.V. Likholetov

B.V. Shmakov

Interdisciplinary FCA- and TRIZ-Based Projects: Experience and Prospects in Training Teachers

South Ural State University (National Research University)
V.V. Likholetov, B.V. Shmakov

The paper analyzes the ways to improve the quality of engineering training in Russia. It proves the importance of using Russian experience in problem-solving and project-based learning, as well as, it necessitates introduction of training course for teachers to be involved in interdisciplinary FCA- and TRIZ-based projects.

Key words: CDIO initiative, interdisciplinary projects, thematic plans of innovative and inventive activity, experience in international training of specialists, TRIZ-FSA phenomenon, cross-professional training of teachers in Russia, prospects of TRIZ-FSA-based training of engineer-businessmen.

Due to difficult social and economic situation in the country, the representatives of science and education should actively generate ideas to eliminate the possible disproportions in economic and cultural life, and also take steps on training qualified personnel in advance.

Today, scientific and pedagogical community actively discusses the International initiative of CDIO (Conceive – Design – Implement – Operate) [1]. A number of higher education institutions of the country have already implemented this innovative educational framework. It is oriented to eliminate contradictions between the theory and practice of engineering education. A new approach implies giving greater focus to practical training and implementation of problem- and project-based education. Its purpose: as a result of training, future engineers shall be able to think out new products (new technical ideas), to design (or to give the necessary instructions to those who will be engaged in this process), and also to produce [2].

While analyzing the publications concerning the problem of CDIO initiative implementation, the desire of scholars to look at it more widely («to pass in supersystem») is noticeable. The representatives of Astrakhan State University agree on the idea to introduce cross-cultural communication in the competences of a modern engineer and even suggest developing additional 13th CDIO Standard [3, p. 87]. The scholars of Penza University of Architecture and Construction fairly believe that in order to implement CDIO standards successfully not only engineering specialists are required – managers will be also necessary. Otherwise, a great number of unnecessary products will be produced, or someone else will make profit of the proposed ideas [4, p. 42].

The need to «break» disciplinary barriers persistently leads us to training future specialists who are able to solve non-standard problems. According to G. S. Al'tshuller's classification, interdisciplinary decisions are the third level of inventions which can hardly be made without superprofessional knowledge [5].

This idea is not new, 130 years ago the president of the Yell and Town company Henry R. Towne provided the report «The engineer as an economist» at the meeting of the American society of mechanical engineers. According to his opinion, engineers of new generation should also possess the qualities of production managers. The engineer should be in charge of organizing and supervising the work, as the power of the organized efforts prevails over professionalism of a worker. "There are many good mechanical engineers: there are also many good 'entrepreneurs'; but the two are rarely combined in one person", – Towne wrote [6].

Here is an idea about the uniqueness of the past: the fact is surprising but past has everything for the future. Therefore, when searching for the models how to change the current engineering education system into the system of training specialists able to work in interdisciplinary teams and projects, it is important to consider both Russian and foreign experience.

However, at the same time the problem of subject area of these interdisciplinary projects arises [7]. The international learning standards provide educators with an effective mechanism that allows them to "grow" the graduates who meet the requirements of real workplaces – the mechanism of "workplace-related competences" [8]. Its essence is that the professional organizations representing the interests of entrepreneurship regularly publish the lists of real workplace-related tasks which graduates should be able to do. At the same time, these tasks («workplace-related competences») are rather specific and differ from the qualification requirements stated in the domestic professional standards [9].

In Soviet time, regular thematic plans (rules) of rationalization and inventive work were used as equivalents of the contemporary "workplace-related competences" lists. Sometimes, the quality of the task description left much to be desired, but they took into account numerous particularities and could form a basis to plan technical, social, and economic development of the enterprise.

The thematic plan of SPA Tsellyulozmash developed via TRIZ methodology is case in case in point of task description [10]. The proper description of the technical tasks and also organization of the system for its performance (motivational, information, consulting, legal) allowed overcoming all the challenges mentioned above. As a result, the design engineer G.I. Slugin registered 13 inventions, and the engineers I.M. Golubev and L.T. Los – 7 and 5 inventions, respectively.

If we turn to the classification of innovation process models by Roy Rothwell [11], it is easy to notice teamwork of different professional (designers, technologists, economists, marketing specialists) within the fourth integrated model (referred to as Japanese or best practices). According to this model, the task can be solved more efficiently by teams rather individual engineers.

This model is applied in Japan and the USA [12]. At the Texas University, a prominent American scientist of the Russian origin George Kozmetsky revealed inefficiency of the existing system of engineers training and developed the system which strongly reminded the technology and organization of work of the Soviet military establishments, where the groups of experts developed the best World War II military technologies in the shortest possible time.

The results of G. Kozmetsky's system are impressive. Thus, the contribution to the regional economy made by the entrepreneurship incubator for technology commercialization of Texas university, Austin, which works with the companies at primary stages, accounts for one billion US dollars over 25 years [13, p.51].

According to I. Kant, "there is nothing more practical than a good theory", the idea which was also supported by G. Kirchhoff and L. Boltzmann. It is fully applicable to the national theoretic and technological developments which are generally referred to as the theory of inventive problem solving (TIPS or TRIZ). Though the invention technique originated from G.S. Al'tshuller's works in the late forties, the development TRIZ theory is supposed to begin with the publication "About Psychology of Inventive Creativity". It declared that "any technical task can only be solved in accordance with the laws of science, which is conditioned

ENGINEERING EDUCATION 20'2016

by current technology advances" [14]. This article became a manifesto of TRIZ. 25 years after, the publication of the book "Creativity as Exact Science" gave the status of "exact science" to TRIZ [5].

In the 70-80s, the techniques of the functional and cost analysis (FCA) were united with TRIZ at leading Leningrad enterprises (ETL "Elektrosila", PA "Izhorskii zavod", etc.) based on the works by experts in TRIZ V.M. Gerasimov, A.N. Zakharov, B.L. Zlotin, S.S. Litvin, A.L. Lyubomirsky, and others. By the 80s, there were a lot of enthusiasts nurtured by G.S. Al'tshuller's training seminars, who developed the ideas of TRIZ-FCA and applied them for new technical inventive solutions funded by the commercial agreement and state budget Researches and Development. They also provided students, graduate students, and academic staff with the basic TRIZ tools.

Modern theoretic and technological approaches of TRIZ and FCA allow making a "set" of tasks, a comlex of problems to be solved in the course of professional training and prospective professional activities [15]. Any practical challenge is a problem situations (PS or «putanka»), overlapping technical, social, and economic issues taken as undesirable effects (UE) (Tab. 1).

Non-inventive and inventive tasks correspond to standard and non-standard ones. In the first case (routine tasks), the reasons are not expressed – these tasks

Table 1. Task system classification

Characteristics		Components (information about the models)						
		IC "Given"					FC "Needed"	Pr "Procedure"
		Reasons type						
Type	in terms of TRIZ, FCA	Contr	UE	A group of UE	Transfor-mation means (MFIR)	Opera-tion mode (OM)	Purpose of transfor-mation and its orientation (I = F/C)	Ways of MFIR involve-ment – system develop-ment laws (SDL)
Routine	Non-inventive	Not expressed			+	+	+	–
Non-routine (with difficu-lties)	Non-inventive	Not expressed			–	+	+	–
Educa-tional (IT)	Inventive	+			+	+	+	–
Transi-tional (IS)	Inventive		+		+	+	+	–
Real PS – "putanki"	Inventive			+	–	+	–	–

describe an equilibrium condition of a system. When training, any procedures (formulas) are usually fulfilled. To create complicated situations, teachers «hide» the means of transformation – resources from the trained (see non-routine tasks).

Inventive tasks, on the contrary, are the models to describe unstable, developing real systems. In terms of information completeness, there are different types of models given in Tab. 1. PSs are characterized by the highest uncertainty. The abbreviations are used: UE – undesirable effect; Contr. – contradiction; OM – operation mode(s); I – ideality; F and C – sets of functions and costs; SDL – system development laws; PS and IS – production and inventive situations; IT – an inventive task; MFIR – material and field information resources. The names of task system components (initial (IC) and final conditions (FC) describing the task in terms of statics and also procedure (Pr) of change from IC to FC that makes the task dynamic) correspond to the terminology accepted in the literature on task systems.

The thin arrows in Tab. 1 describe the procedure of problem solving in production, while the thick ones illustrate educational tasks. The "educational" inventive problem solving (IPS) have the characteristics as follows: 1) contradiction; 2) the described principle of a problem component operation (UE); 3) the conversion purpose («a decision portrait»); 4) the means of communication conversion determined by the solver (first of all, «cheap» intrasystem MFIR). After the correct description of the inventive problem solution (IPS), the solver should choose the transition procedure from IC to FC – an algorithm of resources involvement depending on their accessibility and contradiction type (SDL). Therefore, IPS is a final model of task description to separate the task from the problem situation (PS).

The case in point is the activities performed by the academic staff of Chelyabinsk higher education institutions to promote TRIZ-FCA. Institute of Mechanization (later Institute of Mechanization and Electrification of Agriculture) is the first technical college in South Ural (1930). The authoritative scientific schools appeared there as a result of tractor industry development. In 1937 Ya.V. Mamin (the pioneer of national tractor industry) came to the Chelyabinsk Tractor Plant (CTP); he actively worked at the department of tractors and cars.

In October, 1941, CTP turned into Tankograd where the outstanding tank designers worked (N.L. Dukhov, Zh.Ya. Kotin, etc.), later the nuclear and thermonuclear weapon and missile systems were produced in the region (N.L. Dukhov, E.I. Zababakhin, V.P. Makeev, K.I. Shchyolkin, etc.). In 1944 N.L. Dukhov headed the department of tank construction (track laying vehicles) at the Chelyabinsk Mechanical Engineering Institute (later ChPI).

In 1960-1981 V.P. Makeev, the founder of the Soviet scientific design school of sea strategic rocket production, was a professor of the department "Flight vehicles" in the polytechnic institute.

Over the post war years, the technical higher education institutions of Chelyabinsk – ChPI and Chelyabinsk Institute of Mechanization and Electrification of Agriculture (ChIMEA) turned into powerful vocational schools of the country with a strong scientific and educational potential. In the late 1970s, 21 thousand students studied in ChPI, 2.3 thousand educators and scholars worked there. There were many inventions designed and patented and the roll scientific school was intensively developing (V.N. Vydrin, L.M. Ageev, etc.) is known. More than 500 inventor's certificates of USSR and more than 120 foreign patents prove the novelty of engineering procedures and milling equipment developed by this school. The Chelyabinsk rolling school sold two licenses to the leading firms – "Schloemann-Siemag" (Germany) and IHI Corporation (Japan) for 3 million US dollars. Thus, figuratively speaking the "seeds" of

TRIZ and FCA fell on well fertilized soil in Chelyabinsk.

By the beginning of the 80s, a set of TRIZ-based educational and methodical guidebooks was published (from 300 to 1000 copies), which was resulted from TRIZ-based academic activities of ChPI and ChIMEA faculty staff who had participated in G.S. Al'tshuller's seminars [16–21]. The TRIZ and FCA tools were provided for students, young academic staff at the Public Institute of Patent Science (PIPS) of All-Union Society of Inventors and Rationalizers and Ratsio club in ChPI.

The faculty of ChPI (then ChSTU and SUSU) and ChIMEA (then ChSAU), most of them being graduates from the state advanced training courses in patent science and invention and also mastering TRIZ techniques (E.G. Shchepetov, B.V. Shmakov, N.I. Gorbunov, V.A. Kislyuk, V.V. Likholetov, Yu.F. Prokhorov, S.V. Strizhak, B.V. Barichko, B.M. Berezovsky, Yu.P. Galishnikov, etc.), began to introduce TRIZ in educational and research work in the 1980-90s years. It brought good results: 15 students of B.V. Shmakov became coauthors of the USSR inventor's certificates. 12 students of V.V. Likholetov from ChPI were the coauthors of the inventions which were defended with the USSR inventor's certificates and GDR patents.

In 1982, in collaboration with the regional technical creativity center, B.V. Shmakov and E.G. Shchepetov initiated the regional Olympiad on technical creativity for students of secondary vocational schools that existed till 2013. TRIZ and FCA tools were also effective in academic activity of vocational schools. As a result, in the 1980-90s, several students from vocational schools lyceums of Zlatoust, Magnitogorsk, Chelyabinsk registered the patents for inventions and useful models.

The dissemination of TRIZ and FCA ideas throughout the country was triggered by the international project "Inventing Machine" (IM) in 1989 in Minsk. Since 1991, the Ural office of research laboratory of the Inventing Machine (URLIM) was in charge of staff retraining and professional development (both for industry and professional education, first of all, for high school).

Our experience show (in Moscow, Kiev, Irbit, Ivanovo, Tolyatti, Orsk, and other cities) that, when using TRIZ, FCA, IM in educational and research process, people involved in these activities tend to change their way of thinking and become organizers of innovative activities rather than their users.

By the middle of the 1990s, the project was almost closed in Russia due to social and economic reasons. However, the project "appeared" de facto in the companies and universities of the USA, the countries of Europe and Asia where innovative activity is supported.

Since 1994, some faculty of URALNILIM introduce TRIZ experience to advance analytical training at the faculty "Economy and entrepreneurship" of ChSTU. At that time (before the introduction of State Education Standard), they developed a model to combine methodological and information and analytical subjects with economical and managerial ones (Tab. 2). The professional development course was designed for engineering experts and leaders and provided the specialization "Analysis and problem solving in social and technical and economic systems (STES)" of the specialty 071930 "Management".

8 groups of "analysts" or 39 specialists graduated from the courses. They became top managers of the largest regional and national companies, commercial banks, regional ministries. It led to development of original and adapted TRIZ FCA, IM – based methodical support for different university courses including non-engineering ones [22].

Since the end of the 1990s, these practices have been used for professional development of faculty of all SUSU departments [23]. Since 2008 (by the order of Federal Agency for Education No. 2270 adopted on 12/10/2007 via Institute of additional education of SUSU (as basic

Table 2. Training model of manager-analysts

<table>
<tr><th colspan="6">Subject areas</th></tr>
<tr><td colspan="5">Content</td><td>Technology</td></tr>
<tr><td colspan="6">ECONOMICAL AND ADMINISTRATIVE</td></tr>
<tr><td colspan="5">Levels of functioning and management</td><td>Technologies</td></tr>
<tr><td colspan="3">National economy</td><td>Enterprise</td><td>Person</td><td rowspan="8">Methods and technics of specific economical and managerial disciplines (EMD)</td></tr>
<tr><td rowspan="9">Abstraction levels</td><td rowspan="3">High</td><td>Macroeconomics</td><td>Microeconomics</td><td rowspan="3">Praxeology</td></tr>
<tr><td colspan="2">Economic theory</td></tr>
<tr><td colspan="2">Management theory</td></tr>
<tr><td rowspan="6">Low</td><td>Finances</td><td rowspan="2">Economic analysis and account</td><td rowspan="6">Entrepre-neurship fundamentals
Labour</td></tr>
<tr><td>Money and credit</td></tr>
<tr><td>Insurance</td><td rowspan="2">Financial and economic activities analysis (controlling)</td></tr>
<tr><td>Statistics</td><td rowspan="3">Computer technologies (CT) of documents electronic control</td></tr>
<tr><td>Stock-exchange industry</td><td>Management</td></tr>
<tr><td>Branch economies</td><td>Marketing</td></tr>
<tr><td colspan="6">LAW</td></tr>
<tr><td colspan="5">Constitutional and tax law</td><td rowspan="2">Protection of right and intellectual property (IP)</td></tr>
<tr><td colspan="3"></td><td colspan="2">Economic, labor, administrative law</td></tr>
<tr><td colspan="3">Financial law</td><td colspan="2">Social development, author's and patent law</td><td>CT of economic activity and IP protection</td></tr>
<tr><td colspan="6">INFORMATION AND ANALYTICAL</td></tr>
<tr><td colspan="5">Logic (logical laws of correct thinking)</td><td>Uses of logic laws</td></tr>
<tr><td colspan="5">System modelling</td><td>Modelling</td></tr>
<tr><td colspan="5">Systems functional and cost analysis (FCA)</td><td>Structurally functional modelling</td></tr>
<tr><td colspan="4"></td><td>CID</td><td>Development of Creative imagination (DCI)</td></tr>
<tr><td colspan="5">Theory of inventive problem solving (TRIZ)</td><td>Description and solution of tasks</td></tr>
<tr><td colspan="5">Theoretical bases of computer systems to support thought process</td><td>Analysis of task systems and its solution</td></tr>
<tr><td colspan="6">SOCIAL AND PSYCHOLOGICAL</td></tr>
<tr><td colspan="3"></td><td colspan="2">Theories of team formation and development</td><td>Technology of team designing</td></tr>
<tr><td colspan="3" rowspan="2"></td><td colspan="2">Conflict management</td><td rowspan="2">Technology of businessman self-survival</td></tr>
<tr><td colspan="2">Communication psychology</td></tr>
<tr><td colspan="4"></td><td>Information culture</td><td>Technology of a manager's personal work</td></tr>
<tr><td colspan="3"></td><td colspan="2">Information influence on demand (advertizing)</td><td>Technologies of advertizing</td></tr>
</table>

higher education institution), the author's programme of professional development of PTS of linear higher education institutions "A possibility of potential use of TRIZ and theory of creative person development (TCPD) for modernization of higher education institutions disciplines" has been implemented for some years (see: http://www.susu.ru) in the profile "Innovative Activity" (72 hour). The summary of the programme is given in Tab. 3.

The trainees were from all over the country: Moscow and St. Petersburg, Barnaul and Yuzhno-Sakhalinsk. Their feedback is available in the Internet [24].

While defining the prospects of faculty retraining for interdisciplinary projects, it is necessary to overcome negative tendencies «flourishing» in modern national education. It is obvious that graduates of economical and managerial specialties do not know engineering and technology, while prospect engineers are not competent in promoting technical solutions to the market. Neither of them developed such professional skills at universities. It means that the teams of future innovative enterprises should be "cultivated" since student years in the mode of multi-level extra training and joint activities. All departments of a university should be involved in joint efforts to train prospect leaders of high technology industries. It implies training engineers-entrepreneurs who would be able both generate technical and technological innovations and assess the market potential of the product.

The faculty trained within the framework of TRIZ and FCA techniques, in collaboration with business community represented by the regional office "Opora Rossii" (Support of Russia), can facilitate training such kind of engineers-entrepreneurs.

Table 3. Content of the programme "TRIZ and TCPD to improve academic subjects"

№	Content
1	The general review of TRIZ practices and their importance in the modern world
2	Characteristic of the theoretic and methodological block: 2.1. Empirical basis of the theory. 2.2. Initial theoretical basis. 2.3. Logic and heuristic tools of the theory. 2.4. Logic and heuristic rules for revealing consequences (methodologies).
3	Characteristic of the technological block: 3.1. Modifications of the inventive problem solving algorithm (IPSA) with fight of a task solver against psychological inertia. 3.2. Technologies of problem identification in production situations. 3.3. A technique of research task solution (including diversionary approach). 3.4. Techniques for forecasting system development. 3.5. Technology of social problem solving by a creative person ("Life strategy of a creative person").
4	Characteristic of the social and cultural block of TRIZ: 4.1. Register of Science fiction Ideas (RSFI) and G. Altov, V. Zhuravleva, P. Amnuel's science-fiction works, etc. 4.2. Works in TRIZ pedagogics. 4.3. Research results of TRIZ approach in different areas (science, technology, economy, ecology, medicine, visual art, and music).
5	TRIZ-FCA-based software products: 5.1. Logic of software products and their trends.

We have offered "The concept of engineering entrepreneurship support in South Ural State University (SUSU)" to the administration of the university. It is based on the experience of the leading higher education institutions and provides a number of organizational steps (Tab. 4).

As the first step, the subject "Engineering entrepreneurship" is offered to be introduced to the engineering education programs, which will allow disguising engineering students who would like and be able to develop business skills. The second step implies launching the system of additional training and motivation on the basis of innovative structures of higher education institution to train engineers-entrepreneurs. Higher education institutions, including SUSU can establish structures like "Test site for engineering entrepreneurship" based on the experience of Institute of engineering entrepreneurship of Tomsk Polytechnic University. Nowadays, the term "engineering entrepreneurship" is widely spread in different subject areas and structural divisions of some Russian and foreign higher education institutions and has positive public image.

The developed concept is based on the experience of training engineers-entrepreneurs in Tomsk Polytechnic University, TUSUR University, Bauman Moscow State Technical University, and other technical universities. The systems of cross-cutting activity in engineering entrepreneurship are developed on their base (from pre-university to postgraduate spheres).

The systems include the elements as follows: 1) work with seniors high school students [25]; 2) multi-level work with students when studying at higher education institution (including the Olympiads on engineering entrepreneurship [26], summer schools of engineering business in BMSTU [27] and summer Lean schools "Economical Production" in TPU, club activity like "Kaizen" club in Tomsk or "KLIP" club in BMSTU); 3) interactions with the graduates who have become entrepreneurs and able to act as experts, consultants, and also business angels of the students' entrepreneurial projects.

The "Test site of engineering entrepreneurship" was opened as educational and scientific laboratory of Institute of engineering entrepreneurship of TPU in 2010 [28, 29], and became an efficient element for the training systems of engineers-entrepreneurs.

The concept of engineering entrepreneurship support in SUSU offers the similar steps (see Tab. 4). However, as distinct from the models developed in the above mentioned universities, our model contain the following ideas: 1) support from TRIZ-FCA-trained faculties from the different departments; 2) closer interrelation of innovation idea search technology with technology of problem identification and solution in the existing systems based on TRIZ and FCA; 3) application of technologies of parametrical optimization of the TRIZ-FCA devices based on planning extreme experiments; 4) application of theory of creative person development (TCPD) for teambuilding in small innovative enterprises (SIE), which involves laws of team development and TRIZ ideas; 5) long experience of holding the training, consulting seminars, innovative designing, innovation commercialization, and complex engineering based on TRIZ and FCA under the conditions of market formation at national enterprises and also effective consulting activity of TRIZ experts at leading companies of Europe, America, and Asia [9, 30].

Table 4. Stages of the concept-project implementation to support engineering entrepreneurship in SUSU

№	Actions (steps)	Realized functions (F)	Expected results (R)
1	Introduction of the subject "Engineering entrepreneurship" into engineering education programst	F1. To introduce the bases of innovative business to students. F2. To encourage students to work in high tech industry. F3. To select students for innovative structures of higher education institution.	R1. Identification of students interested and able to be engaged in business. R2. Employment of motivated staff for innovative structures of higher education institution.
2	The launch of additional training, foundation of the educational and scientific laboratory "Test site of engineering entrepreneurship"	F2. To motivate students to work in the high technology business F4. To provide additional. knowledge and skills necessary for engineering business activity. F5. To involve students in innovative activities of the "Test site" and other innovative structures of higher education institution F6. To involve faculty of the university in the "Test site" activities.	R3. Improved status of the engineering education. R4. Presentation of the projects which are brought closer to reality on Olympiads and exhibitions held in higher education institution with R5. Increase in the number of small businesses (SIE) established while and after training. R6. Extent the scope of Research and Development of higher education institution.
3	Organization of summer and winter schools of engineering entrepreneurship	F2. To give greater focus to motivation of students for high tech industry. F7. To develop a number of practical skills of innovative activities. F8. To encourage students to develop innovative products and open small enterprises for their implementation.	R7. Improved status of the engineering education provided institution. R8. Organizations and people interested in innovative projects. R9. Stable performance of small businesses.
4	Organization of trainings on team building for engineering entrepreneurship	F9. To develop team work skills the sphere of high tech. industry. F10. To build teams for innovative business. F11. To develop business for a team F6. to involve more faculty in the activities of the "Test site".	R10. Increased number of SIE established while and after training. R11. Increased number of active young engineers with developed leadership skills. R12. Increased number of faculty involved in innovative entrepreneurs.
5	Organization of consulting support for opened enterprises of small business	F12. To ensure support for young businessmen within the project framework. F6. To involve more faculty in the activities of the "Test site".	R13. Developed strategy to regulate small business enterprises involvement in the project (as well as designing them out). R14. Intensive Research and Development at higher education institution. R15. Phase of system sustainability.
6	Development of the system to train regional small innovative business	F13. to develop key competencies used in the sphere of the national innovative economy.	R16. Community of business angels, system of crowd funding and charity performed by successful entrepreneurs.

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STUDENTS, POST-GRADUATE STUDENTS, AND TEACHERS IN INTERDISCIPLINARY PROJECTS AND TEAMS
ENGINEERING EDUCATION 20'2016

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ENGINEERING EDUCATION 20'2016

R.Z. Bogoudinova

V.G. Ivanov

D.N. Mingazova

O.Yu. Khatsrinova

Student Satisfaction with Education Quality as a Synergy Factor

Kazan National Research Technological University
R.Z. Bogoudinova, V.G. Ivanov, D.N. Mingazova, O.Yu. Khatsrinova

The article provides a method to evaluate the quality of educational process. The authors suggest evaluating the quality of education in terms of consumer satisfaction, taking into consideration the weight-of- coefficient for each quality indicator. The analysis has revealed the dependence between positive tendencies in classroom management and satisfaction level of students.

Key words: questioning, quality of education, quality indicators, quality management system, quality of educational process.

Currently, the numerous approaches in determining the quality of education embrace its complexity and multi-factor character which could be conditioned by different evaluation criteria. However, it is the education process that is still the basic process in any university. According to the TQM concept and international standard regulations ISO 9000, every process should involve one customer and be focused on performing his/her requirements. The customers of the university education services are enrollees and their parents, students, post-graduates, PhD students, specialists of continuing and retraining education, teachers and department staff, graduates and their potential employers, the government and the society itself [1]. However, the main consumers of this education process are, of course, students and teachers who are not only actively involved, but also those who know the inside out of this process. In this case, to identify the basic factors influencing the quality of the education process and, it is relevant to include the above-mentioned consumers-students and teachers into the indexes characterizing it. In view of this, a questionnaire-survey was conducted in Kazan National Research Technological University (KNRTU). This questionnaire included questions related to the quality of the learning process. It should be noted that the basic indicator showing the degradation of the learning and teaching process quality is a growing number of students who receive unsatisfactory marks in different professional disciplines. So, the first anonymous question was – why a student receives unsatisfactory marks (or marks which he/she considers unfair). 21 students gave 44 answers.

Based on the survey results, they can be classified into 5 indicator groups: teacher activity; student activity; social-welfare conditions; organization of teaching and learning process, and education program. The most significant conditioning factor is the teacher activity (38.6% of all answers). Almost 2/3 of respondent answers stated "subjective assessment of their knowledge" (27.2%). The following explanations were given: interpersonal relationship between teacher and student, teacher's mood, and even type of assessment - exam or test. The respondents also emphasized such a fact as: lectures are not interesting (9.1%), the lecturer is less interested in a favorable outcome of his/her activity.

Based on the question – answer analysis, it could be concluded that students consider the existing knowledge assessment system to be rather subjective and does not fully reflect the real results of the cooperative teacher-student interaction in joint educational activities. It should be noted that the respondents were more or less self-critical, as 31.8% of the respondents agreed that their unsatisfactory result was a consequence of his/her personal unpreparedness, unwillingness, and even laziness; while 11.2% of the respondents explained it by lack of time due to study-work overlapping (economic reasons). Only 9.1% of respondents related their unsatisfactory marks to the bad management of the education-learning process, i.e. insufficient time for pre-exam preparation (6.8%) or vast amount of extra learning material (2.3%).

However, those respondents could also be included in the group of students who recognized their faults. As in many universities, the assessment rating tool was also implemented into KNRTU education system. This system involves 100 scores, 60 of which a student should accomplish during a semester. The student who did nothing or practically nothing throughout the semester, i.e. turning in take-home assignments in time and/or has high absence rate could result in the unsatisfactory mark in a discipline, including the exam. The fifth smallest group of students (6.8%) associate their unsatisfactory mark with the education program, which, accordingly, includes either disciplines inconsistent with their specialization (4.5%) or of no profession profile (2.3%). It should be noted that no student mentioned such negative factors as lack or low quality of courseware, poorly material-technical equipped training workshops, or even shortage of computers and computer classes.

At the same time, all above-mentioned aspects were reflected in the respondent answers to the second question:" What actions should be taken to improve the quality of education?" Students submitted 46 proposals.

These proposals could also be divided into 5 categories. However, two answers were significantly different from the previous answer-content. In addition to such an aspect as material-technical and information support of the education activities (17.3% of all answers), the most important proposal was updating the teaching methods and technologies (15.2%). As the teaching methods and technology basically depend upon the teachers, according to students' opinion, the teaching activities should be recognized the main factor in determining the quality of both learning process itself and its outcomes. In other words, the respondent answers to the first two questions (concerning teachers) are in good agreement with each other unlike the responses about student activities. Respondents admitted that more than 30% of unsatisfactory marks are conditioned by their personal weaknesses. At the same time, these students do not believe that it is necessary to work hard, but would rather speak about lack of their motivation and necessity to stimulate their activities, i.e. it is the government, university, or teachers that should do something ("stimulate learning activities", "increased educational scholarship", "sponsor activities focused on student community unity") to increase student motivation.

Ultimately, it should be noted that the present target is to enhance student learning motivation. According to student opinion, this could be accomplished by improving the learning process through different class activities, such as stimulation exercises and debating; enhancing the professional training; application of visual and teaching aids, including computers. The students consider that stimulating their motivation throughout the semester is of vital importance for them. An excellent motivation stimulator could be the assessment rating tool. Probably, upgrading this system and intensifying its efficiency would involve developing publicly accessible information of current student ratings in all subjects, for example, via university website. This would allow students to compare their achievements with those of other students, compete as individuals and encourage them for personal growth. However, this is only a question for debating now, as according to the law of "Personal information", a student has the right not to disclose his/her academic progress. The student considers that a good learning motivation stimulus is a high educational scholarship and it is interconnected with the attained marks of this or that student. The students are not satisfied with the existing education scholarship sum and its gradation which includes three categories: high, average, and no scholarship. They do not consider it to be a motive in the learning process. It is an interesting fact that there were such students' unpopular answers as "toughen the deadline condition of expelling for underachievers." This fact is sure to be taken into account as this is a really effective motive: only exact achievement of the academic schedule in set deadline would further the acquisition of this or that discipline. Everyone knows that, objectively or subjectively, there are students who do have academic failures (failed exams or tests) and still study for one, two or even more semesters (or even to their qualification paper). The students know this and it negatively influences their attitude to learning. The questionnaire revealed that "a desire to study" arises when there are good interpersonal relationships within a student group, when a tight-knit community of kindred spirit is gradually shaping. It is necessary to organize student leisure activities focused on student community unity. A rather effective motive to boost student activities and enhance their interest in the learning process is to further their professional development, including future job placement through university-enterprise agreements.

As it was earlier stated, teaching process is the most significant factor in organizing the learning process, and, accordingly to student opinion, some actions should be taken. First and foremost, the teacher outwardness should be enhanced. This is possible through testing techniques which are being widely implemented into the KNRTU learning process. The students of this University understand and perceive this method very well. However, some of the respondents stated:" students should be able to speak out more in seminars, debate and not listen to boring reports"."The students do not like when a teachers subdivides them into "smart or clever" and "untalented" and, respectively, the teacher's attitude is different in each case. The best result can be achieved when the teacher and student establish good and kind relationships (students appreciate this and show their respect to the teacher), but it is preferable, when the teacher and student become"solemates" and participate in the learning process as one whole. Without doubt, upgrading the teaching methods and methodology ("more interest, more motivation to study", and "love your subject and know it") is one of the basic activities which, according to student opinion, should be motivated.

Despite the fact that university material-technical and information support is not interrelated with the concept of an unsatisfactory mark, the students consider that improving this sector (i.e. updating library resources, increasing the number of computers and IT classes, new laboratory equipment) would significantly influence the quality of rendered education services in KNRTU. According to student opinions, improving the quality of the learning process could be facilitated by a more convenient timetable which would not irritate or even evoke the desire to miss classes ("the timetable should exclude gaps"; "lectures should start not at 8 am"; "there should be a 5-minute break in the lecture, as one and half lecture is dead hard").

It can be concluded that most students responses reveal only their emotional attitude, such as: "like-don't like", "want-don't want" or "will-will not." Thus, one of the most important tasks of the university administration and staff is to create such an atmosphere that students would like to study and find it not boring but interesting and challenging. In this case, the set education goals could be achieved – training highly-qualified specialists who possess knowledge, skills, professional competencies, and innovative thinking and become "marketable," i.e. those who could guarantee qualitative education through education process quality management. Accordingly, one of the criteria for the education process quality could be student satisfaction relevant to the above-mentioned factors [2].

Based on the research results, the authors designed a questionnaire which could be used as the quality evaluation of the education process itself consistent with the satisfaction of student and teacher who are the basic consumers and participation of this process.

Brainstorming, involving different experts: students, post-graduates, and teachers, resulted in the designed questionnaire. This questionnaire included 9 basic indexes characterizing the quality of the education process: staff qualification, information support, organization of undergraduate research, material-technical support, social welfare, learning activity motivation, education process organization, administration management of the learning process, and student interpersonal attributes. Each of these above-mentioned indicators include from 4 to 9 factors.

Procedures in completing the questionnaire:

1. Respondents had to arrange the quality rating and included factors in order of their significance, i.e. their influence on the quality of the education process, beginning with the most important and essential factor (i.e. assign indicator b_{ti} and factor – b_{tij}, to each questionnaire item where, $b_{ti} = 1 \div n$; $b_{tij} = 1 \div m$).

2. To determine the so-called statistical level reflecting the satisfaction of the respondents, this or that factor was assigned a relevant value from 1 to 10. If one of the above-mentioned factors is satisfied, then it is assigned a value of 10, while the remaining factor in order of descending are assigned up to 0.

Designed questionnaire could be considered as a tool to identify the consumer attitude to different aspects of the education activities and determine the most effective learning indicators in the university; and determine the respondent satisfaction relevant to this or that factor and quality index, respectively.

However, the information on the student satisfaction level could be insufficient in the management decision-making focused on quality improvement. To exclude this uncertainty, it is necessary to introduce additional quality index levels revealing the quality context through the included factors. The students will assess the degree of fulfillment of their requirements (satisfaction) of each included factor, while their satisfaction of individual factors should be an arithmetic mean of measured satisfaction value to the factors.

The proposed method should include one specification. The main point is that each factor component contributes to the quality of rendered services being proportional to its significance and reverse. Therefore, in calculating the arithmetic mean for each individual quality factor, the following weighting factor coefficient k_{ij} is applied:

$$U_i = \sum_{j=1}^{m} U_{ij} \cdot k_{ij}$$

Respectively, in calculating generalized quality characteristics, the weighting coefficient of each factor should be multiplied by U_i and k_i. In this case, generalized quality characteristic is calculated as:

$$Q = \frac{U_1 \cdot k_1 \cdot U_2 \cdot k_2 + U_2 \cdot k_2 \cdot U_3 \cdot k_3 + U_3 \cdot k_3 \cdot U_4 \cdot k_4 + \ldots + U_n \cdot k_n \cdot U_1 \cdot k_1}{(k_1 \cdot k_2 + k_2 \cdot k_3 + k_3 \cdot k_4 + \ldots + k_n \cdot k_1) \cdot 100}, \%$$

Thus, generalized quality characteristics of the education process will reflect student satisfaction as a percentage of ideal polygon area, where satisfaction of each described factor is 100%.

Based on the research results, the education process quality assessment method was designed. This method includes calculated generalized quality characteristics as a radar chart of limited student satisfaction values for each of the factors, and where generalized quality characteristics reflect a percentage of the student requirements.

To exclude information uncertainty on the student satisfaction reflected in this or that factor, additional detail quality index level was introduced revealing the quality context through the included factors.

Formulated methodological approaches in designing the list of quality indexes are reflected in the above-described method. Proposed method is based on the questionnaire involving focus-group students. The results showed the parameters influencing the quality of the education process, the satisfaction of which was reflected in the respondent answers.

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UDC 378

Professional Identity as a Factor of Professional Mobility

Samara National Research University
M.G. Reznichenko, V.I. Stychkova

M.G. Reznichenko

V.I. Stychkova

Professional mobility is an important factor of engineer's career development. The authors emphasize that the developed status of professional identity is a pre-condition for the professional mobility. The article provides the results of the tests that revealed a negative trend of professional identity development. Contextual education approach is proposed as a solution to the existing problem.

Key words: professional identity, internal motivation, professional mobility, contextual education.

The current processes of globalization and integration force modern people to be more socially mobile and flexible in order to deal with rapidly changing conditions and interact with absolutely different cultures and communities. Therefore, readiness for territorial, social, and professional mobility, is considered one of the key attributes of a modern personality.

Professional mobility is of great significance for engineering graduates since engineers should remain abreast of current trends in the related fields and demonstrate commitment to life-long professional development under the conditions of continuous informatization of the society and emergence of knowledge-intensive technologies.

Development of student professional mobility should be based on stimulation of student motivation, which directly influences the quality of the final result. This applies primarily to the internal motivation, absence of extrinsic stimuli.

The work motivation model that is designed by R. Hackman and G. Oldham and intended to enhance internal motivation of the employees is particularly popular among managers of big companies. The model is based on the idea that the task itself, including the final result and responsibility assumed by a person, is a key to employee motivation. This model can be also applied in higher professional education. The work or future profession must be experienced as meaningful and valuable, which, in its turn, would define the professional identity.

Professional identity is defined as professional self-concept which rests on attributes, beliefs, emotions, and conscious actions related to a certain job or field. It is continuously fashioned on the way a person performs a job or pursues certain qualification within a career field.

Being a key feature of human personality, professional identity helps adapt rapidly to new working conditions. The shaped professional identity serves as an internal stimulus for professional development and personal growth.

In order to test students' professional identity, a special technology designed to examine statuses of professional identity (A.A. Azbel) was applied. The questionnaire contains 20 items (questions) each of which implies four possible answers. Based on the answers of respondents, it was possible to identify four types of statuses of professional identity, i.e. the stage of self-identification.

Undetermined professional identity: the profession or future job has not been chosen yet; there is no clear vision of career; a person does put forward such a task as to choose the professional path.

Imposed professional identity: a person

has certain understanding of his/her future profession, but it was molded by someone (for example, parents) and did not result from his/her independent choice.

Moratorium (the crisis of choice) of professional identity: a person is aware of problems with choosing a career, however, the final decision has not been made yet.

Developed professional identity: as a result of independent decision, professional goals have been determined.

In addition, there are 5 varying degrees of each status: absence of status, lower-than-average status, average status, higher-than-average status, and extremely high status.

In order to get insight into the phenomenon of professional identity, we carried out a survey of first-year (1 semester) and third-year (6 semester) students. The survey involved 62 students of Institute of Aircraft Construction, Samara National Research University.

Among the third-year students of three departments, 6% have undetermined professional status. Relating to the first-year students, only 2% have the same status. The status of almost all third-year students (94%) is low-than- average or even absent. The imposed status was not revealed either among first-year or third-year students.

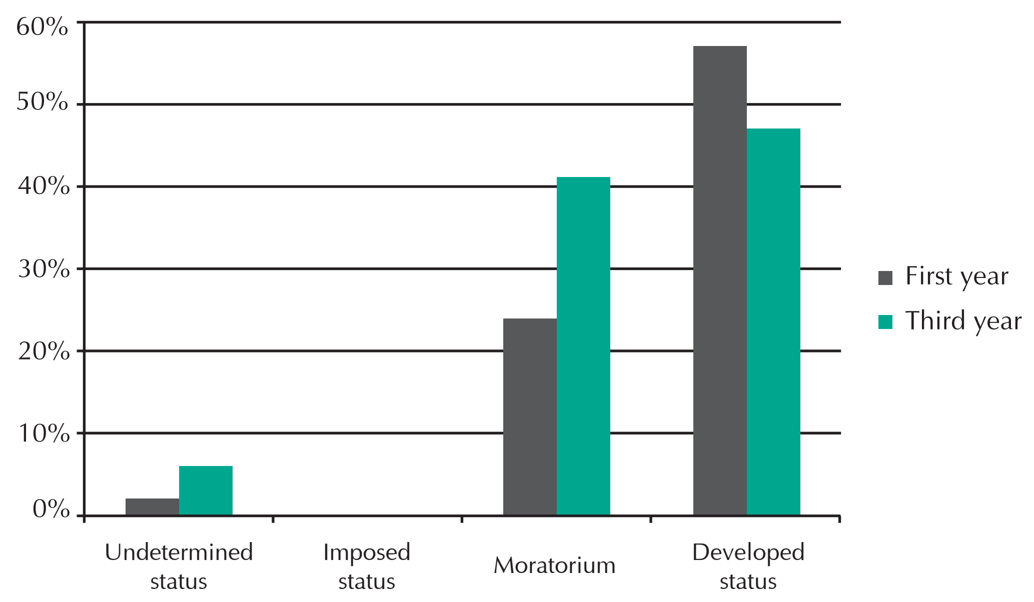
The number of students who cannot make a career choice increased: 24% of first-year students and 41% of third-year students. In addition, the moratorium status of over a third of third-year students (38%) is higher-than-average.

The number of students who demonstrate the developed professional identity decreased from 57% in the1st semester to 47% in the 6th semester.

Among the third-year students, only 6% have several statuses of professional identity, which is three times lower than that of the first-year students (17%). The obtained results are graphically presented in fig.1.

In general, there is a negative trend in developing a professional identity: the number of students with the developed professional identity has declined by 10%, while the number of students who cannot make a career choice has significantly

Fig 1. Professional identity statuses of first-year and thiird-year students



increased. Such a negative trend can be caused by the following factors: professional identity crises (this fact actually increased the number of students who have "moratorium" status), complexity of senior curricula, awareness of the mistake being made regarding the career choice.

Based on the survey results, it is essential to reinforce professional training emphasizing development of professional skills and competences. This would enable students to try various professional roles and make the final decision on their professional path, thus, shaping professional identity. Such a strategy can be applied on the basis of the contextual education (A.A. Verbitsky).

The task is "to disclose the reality of professional life, "disguised by didactic clothes" and reduced by sciences to the relevant sign system, and, thus, unveil it by means of adequate teaching forms and bring it back to life with a new theoretical perspective" [2, p. 72].

In Verbitsky's opinion, contextual education (symbolic-contextual) is defined as a system of didactic forms, methods and tools which model the interior of future profession by means of overlapping theoretical knowledge and workplace reality. It is important that the teaching process itself should not turn inward (education is for education), but it should stimulate a person to become active, which, in its turn, helps shape the required professional and social attributes and skills.

Serving as a tool to reconstruct the interior and social context of the future profession, active teaching methods allow students to perform quasi-professional activity that can be regarded both as a part of teaching process and workplace setting. Thus, students are trying to apply theoretical material in real-life situations including decision-making, project development, and modeling.

It is worth noting that High School provides all necessary conditions to implement contextual education. Profession-related knowledge is gained throughout the whole education period, and students learn how to apply the fundamentals of basic sciences in a workplace context. Various simulators allow the acquisition of professional skills through deliberate practice. At some universities, there is a trend to invite foreign professors to deliver courses. This does not only contribute to developing foreign language competence, but also helps students understand how they should work in a different socio-cultural environment.

In addition, being a part of higher education establishments, modern libraries and media centers allow students not only to gain new knowledge but also practice new methods and tools to search, store, and process information shaping relevant computer skills. In discussions with teachers, students become aware of social importance of their future job. The psychologists help students estimate their strengths and weaknesses, define the ways how to refine themselves.

Undergraduate research is also of great importance in developing students' professional identity. Precisely, it gives students an opportunity to investigate whether the occupation they have chosen is a good fit and how they can advance their careers. Participating in various scientific workshops and conferences, students can present their work, estimate the obtained results and chat with graduate students, postdoctoral researchers, and faculty members. Communication is an integral component of such meetings.

Internships, both in domestic companies and abroad, enable the application of theory to practice. Participation in an internship programmes makes the student a more attractive candidate who demonstrates commitment to continuous self-development and improvement. In addition, when doing an internship abroad, students can apply knowledge of foreign language, practice translation of scientific and technical texts, and gain experience in networking and foreign language communication.

ENGINEERING EDUCATION 20'2016

Thus, active learning methods and contextual education are proved to contribute to professional identity development. Students become aware of the importance of education and regard it as one of the stage of a long professional path. Understanding the importance of future job would definitely contribute to increasing job performance.

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Synergy in Interdisciplinary Teaching of Humanities

Kazan National Research Technological University
L.M. Bogatova

L.M. Bogatova

The paper deals with synergy effect resulted from interdisciplinary teaching of humanities. The author identifies homogeneous and heterogeneous synergies and pays particular attention to interdisciplinary aspect of the humanities. The analysis of interaction between moral and legal components of the education process in high school reveals that the synergy effect has a profound social and cultural context connected with the development of personality of a certain type.

Key words: synergy, interdisciplinarity, education, personality formation, humanities.

The notion of "synergy" was first introduced in philosophy by Aristotle, when he was speculating on entelechy, and then used to denote one of the fundamental methodological principle of science. According to Aristotle, "the whole is greater than the sum of its parts", since the whole results from synergy, which implies the benefit through cooperation.

There a lot of examples of combined effect of cooperation in everyday life, and educational process is not an exception: the educational forms and approaches are numerous and synergetic. Here we mean such approaches as multi-pronged, systemic, integrative, interdisciplinary – all based on interaction between different disciplines. These approaches implemented in education lead to synergetic effect, which implies not only an increase in the amount of knowledge, but also the knowledge of a particular quality. This effect is of particular interest when teaching humanities.

In compliance with W. Windelband's classification, all science can be split into nomothetic and ideographic, therefore, interdisciplinary links can be of two types – the links resulting in homogeneous synergy and those leading to heterogeneous synergy. Heterogeneous synergy results from interaction between humanities and natural science. It should be emphasized that until the end of the 90-s Soviet engineering education enjoyed pride of place worldwide. The reason for this leadership was a humanities component in the system of higher technical education, which ensured educating highly-qualified graduates. Humanities not only contribute to forming a worldview and developing versatile personality, but also facilitate many intellectual processes – imagination, abstracting, logical thinking, abstract modeling – as well as develop scientific thinking and analytical skills. The interconnection between humanities and sciences within higher technical education in Soviet time resulted in a strong synergetic effect called "Soviet engineering education".

Homogeneous synergy is the result of interdisciplinary correlation between humanities united by the mutual system of beliefs and ideas, which multiplies the intellectual impact on personality development. In this regard, it is of particular interest to consider synergetic effect caused by moral and legal components within the educational process.

Today, one of the main objectives of national higher education is to develop a moral personality with ethical principles and highly developed legal culture. These objectives achieved, the higher education system is considered an adequate instrument of socialization.

In terms of a particular historical, social and cultural situation, personality development is complex, controversial, and multi-phase process, which includes various social subdivisions more or less contributive for nurturing personal characteristics. One of the social institutes inseparably connected with "inculturation" is the system of higher education with its educational facilities, powerful information resources, highly-qualified academic staff, and reliable scientific and methodological support for personality development. Currently, there is an urgent issue of the dependence between the effectiveness of social changes and the adequacy of education system. The pace and intensity of social changes undoubtedly depend on individual's morals and legal culture, personal maturity, professional competencies, and civil responsibilities, as well as an ability to orient oneself in ideologically diverse social environment resulting from democratization of Russian society. Today's higher education focuses on forming, (or "producing") a personality with social qualities in demand.

In this regard, the investigation into synergetic effect caused by philosophical and juridical disciplines overlapping is particularly interesting since these disciplines aim to develop a personality able to cope with current historic, social, and cultural tasks.

It should be noted that there is a profound theoretical and methodological basis for philosophical and juridical disciplines overlap, which can be explained in terms of social and philosophic analysis. Dialectic interconnection between morals and law, which are historical components of social structure, is of genetic type. The morals, as a form of social consciousness, is the predecessor of law and basis for legal regularities for social relations, which are institutionalized and controlled by government. To explain dialectic interconnection between moral and law, K. Marx suggested a clear definition as follows: "law is legislated morality". The interrelation between morals and regulations is due to similar structure and functions. Congruency of morals and law structures implies that there are three levels as follows: a) moral and legal awareness comprising a wide range of components (knowledge, norms, principles, estimations, ideals, beliefs, etc.), which together form personality's worldview and civil responsibilities; b) moral and legal activities performed by the personality with particular morals and civil responsibilities; c) ethical and juridical relationships formed and changing due to socially significant activities performed. The philosophical belief that morals and law, as two major estimative and regulative civil mechanisms, are inseparably connected, is a theoretical and methodological basis for interdisciplinary links between ethical and juridical knowledge, which can be effectively implemented into the system of higher education.

However, today's higher education system lacks opportunities to reach the objective of developing a personality with ethical principles and highly developed legal culture. Higher education school is currently under the influence of government institutions and civil organizations, which set its objectives, determine the development strategy, and involve it in different national processes. In term of the efficiency of higher education system, the effects are ambiguous.

It is necessary to point out the factors reducing synergetic effect within higher education system, which is supposed to ensure interdisciplinary links between ethical and juridical knowledge acquired by the youth.

The synergetic effect is significantly reduced by the **deficit of knowledge of humanities.** Currently, there is a great demand for sciences in manufacturing sector, which boosts the development of many fundamental and applied sciences. Theoretical frameworks of many disciplines are updated every five years. This results in challenges in the system of higher education and professional training of highly qualified specialists. The system of today's higher education implies not only limited amount of scientific and theoretical knowledge (in other words, effective knowledge selection), but also ideological perspective and a particular worldview. Technical and engineering universities curricula include numerous disciplines of natural sciences and engineering cycles, which inevitable leads to the deficit of humanities.

In the course of civil society development, the categories of human rights, freedom, and justice are becoming more and more valuable, and as a result, law as a discipline within the higher education programmes is gaining importance. Although there are some achievements (for instance, "Fundamentals of Law" is among compulsory subjects within higher education programmes at all departments and universities), the situation with teaching humanities in general, and at engineering universities, in particular, is far from being satisfactory. For example, the discipline "Fundamentals of Philosophy", which is principle to shape an adequate worldview, is reduced in the number of hours, becomes elective and can be taught only as an introductory course. Other humanities, such as "Culture Studies", "History of World Art", "Religion Studies", "Fundamentals of Cultural Behaviour", are only optional courses, while "Fundamentals of Ethics" and "Esthetics" fail to be included into education programmes of engineering universities at all.

The experts believe that the deficit of humanities has negative impact on personality development, worldview formation, and ethical maturity [1, 2]. There is no exaggeration to say that the deficit of humanities eventually leads to moral inferiority, ethical poverty, and ignorance.

Moral maturing is a complex and controversial process, which many social and cultural aspects have impact on. One should keep in mind that humanities contribute to this process and together lead to synergetic effect with a significant social impact which can hardly be overestimated. Being various but united, humanities facilitate personality development, form a worldview, and provide knowledge necessary to orient oneself in ever-changing life. Humanities not only provide the student with knowledge, but make him/her speculate. Today, this function of humanities is of particular importance since many social problems in Russia are attributed to the lack of morals and legal culture, moral inferiority. Humanities courses are focused on discussing urgent issues and addressing the most topical questions, which allows students to broaden their mind and deal with current ethical and legal problems.

Social and cultural situation in contemporary Russia necessitates filling gaps in ethical and juridical education, which will make it possible for a personality with definite beliefs and ideas to live in polycentric world. We suppose it will become clear soon that interdisciplinary links within humanities, which cause synergetic effect, are a topical issue of education, methodology, and social culture. The modern life proves that it is impossible to develop a personality, bring up an active and mature individual of democratic society, without profound knowledge of humanities.

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E.N. Tarasova

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Moral Education of Students in the Framework of Humanities Provided By High Engineering School

Kazan National Research Technological University
E.N. Tarasova

The paper discusses the results of the study devoted to moral education of students in the framework of humanities provided by high engineering school. The aim and content of humanities in terms of moral education has been identified. The issues specific to interdisciplinary relationships in the framework of humanities provided for engineering students are studied. Educational potential of humanities for development of student moral qualities is defined. The paper also provides a brief review of the theoretical model of moral education of engineering students, which incorporate teaching of humanities in higher technical school.

Key words: moral education, student's personality, educational environment of higher engineering school, educational potential of humanities, interdisciplinary relationships.

Relevance of research of a student moral education problem in higher engineering school is caused by modern sociocultural, economic conditions of society evolvement, development of new values, strengthening of attention to culture, spiritual and moral bases of education.

The analysis of scientific works has shown that issues of student's moral education, in particular, in higher engineering school were always topical, at each temporary stage; there were the problems and ways of their solution. Now these issues are acute, as before.

The educational environment of higher engineering school provides great opportunities for moral development of student identity, including different types, forms, and principles of educational activity, aimed at individual development of every student, satisfaction of his/her informative, social, emotional, and other needs.

Moral education of students in the system of teaching humanities disciplines takes a certain specific place in personal, civil and professional development of an individual. Meanwhile, the ways and methods of this problem solution are insufficiently reflected in scientific researches. Attention of teachers mainly to educational process, insufficient educational focus on forming student professional and moral personal qualities, needs, scientific outlook, ethical standards, and commonly accepted rules of conduct in society make a problem of moral development of student identity in technical college in the system of teaching humanities disciplines especially topical. Need for development of effective model of educational activities based on interdisciplinary communication which would provide training harmoniously developed, morally oriented specialists, has increased.

The research objective is development and theoretical justification of student moral education model in higher engineering school in the system of teaching humanities disciplines. A methodological and theoretical basis of research is: the theory of morals (A.A. Guseynov, S.F. Anisimov, A.I. Titarenko, etc.); main ideas of the theory of moral education and development (E.V. Bondarevskaya, I.S. Maryenko, I.F. Kharlamov, etc.); humanistic approache (Sh.A. Amonashvili, R.A. Valeeva, G.B. Kornetov, etc.), axiological approache (T.B. Sergeyev, L.K. Ivanova, I.A. Lipskii, etc.), synergetic approache (V.I. Arshinov, N.G. Savicheva, V.V. Gorshkova, etc.), ideas of personal activity (B.G. Ananyev, V.V. Serikov, A.N. Leontyev, etc.), polysubject approaches (dialogical) (G.S. Trofimova, M.M. Bakhtin, V.S. Bibler); theory of the personality (A.G. Asmolov, B. S. Bratus, A.A. Bodalev, etc.), the theory of mental development of the personality in ontogenesis (L.S. Vygotsky, D.B. Elkonin, L.I. Bozovic, D.I. Feldstein, etc.); the studies devoted to modeling educational processes (V.P. Bespalko, N.M. Borytko, V.V. Krayevsky, V.M. Monakhov, V.V. Serikov, etc.); issues of the theory and practice of educational process organization in technical college (A.M. Novikov, V.I. Baydenko, P.N. Osipov, etc.); the studies devoted to educational potential analysis of subject, training process (G.G. Gabdullin, L.A. Volovich, I.E. Yarmakeev, etc.).

Content and target aspect of student moral education is considered in the course of general education as special, indissoluble unity of processes of forming their professional outlook, system of value and moral culture which are subsystems of complete process of forming a future specialist's professional competence.

Therefore, study of such aspects of moral education of students in the system of teaching humanities disciplines as development of a future specialist's complete moral and professional picture of the world, his/her acquaintance with professional and universal values of humanistic and humanities character, his involvement into general and professional competence development in their internal unity is seen as the most productive from the view point of research problems.

The specificity of humanities subjects in moral development of student identity from the perspective of modern educational paradigm is that they cannot be understood by notions of values. Not explanation, but understanding of emotional experience, thoughts, and acts of a person, moral assessment of his activity has priority value for humanities education. "Essential learning criterion in this case is the sense, relation which are developed through dialogue, internal polemic with other subjects – the teacher, other learners, authors of the ideas, concepts, works forming the content of education. There is a valuable attitude towards the studied object on the forefront…" [12, p. 45]. Thus, there is a reflection of his/her own status, mental playing out situations and roles, knowledge through experience. All these directly address humanities subjects, reflecting the regularities of personally mediated, deeply creative in its character professional activity.

Use of interdisciplinary relationships in the system of training in humanities for specialists contributes to development of a student's world outlook and personal position including awareness of the professional public significance, conviction in the professional choice, development of the principles and humanistic values focused on social and professional activity, has a favorable opportunity to be combined harmoniously with development of its behavioral aspect.

In particular, the content of the discipline "Pedagogical anthropology" provides deep and close methodological and world outlook interrelations with philosophy, sociology, cultural science, ethics, psychology, and other disciplines of common cultural and professional training of the specialist. Only by learning these interrelations the single and complete scientific and philosophical, figurative and emotional picture of the world, moral and ethical outlook of the students may be formed. Integrating modern ideas of a human being, his development and education in space, time and culture, the most productive modern pedagogical ideology, strategy and technologies of education, this discipline has extensive, versatile opportunities of education of the harmoniously developed, morally oriented personality, development of his life and professional position. Various alternative approaches of professional and moral phenomena and processes give the chance to a future specialist not only to deeply comprehend them, but also to develop his own world outlook taking into account individual and personal moral experience.

In case of development of student moral education model in higher engineering school in the system of teaching humanities disciplines, it is reasonable to emphasize the use of their educational potential, promoting effective, in our opinion, approach to moral development of the student identity.

According to I.E. Yarmakeev's point of view, "the educational potential of a discipline" is a set of world outlook, axiological, culturological aspects and corresponding to them organizational and activity resources of educational and out-of-class work, creative updating of which allows not only realizing successfully educational function of training process, but also enriching considerably target, content, and procedural components of general and professional education of future specialists [11, p. 181]. Based on the above, we believe that educational units of disciplines represent forms, methods, educational tools, examples, situations, personal sense of professional knowledge and abilities intended for development students' professional and moral personal qualities.

The system of educational potential (EP) of the discipline (D) "Pedagogical anthropology" developed by us for moral development of students reflects: a) mechanism of educational potential (forms, methods, educational tools, examples, situations, personal sense of professional and moral knowledge and abilities); b) the moral personal qualities of the students formed in the course of the discipline. So, one of the modules of D "Pedagogical Anthropology" "A person as a subject of scientific study" may include such educational units as a debate "Why anthropological knowledge is important for a teacher?"; ethical conversation on the topic "Morality of a person as ability to be guided by the supreme values" (as students' judgment method of social experience, motivation of activity and behavior). It is possible to refer development of professional and moral consciousness, moral senses, and moral motivation of behavior to the developed moral personal qualities of the student. The module of the discipline "Culture as an anthropological phenomenon" allows including the creative work "The conditions of optimum interaction of a person and culture" creating moral values of the student concerning culture. The module "Education as Anthropological Process" includes emotional, activity-focused forms of pedagogical influence on the student, such as creative and pedagogical tasks, tests, situations of moral choice as methods for developing students' social experience; organization and carrying out of group educational activity. The moral attitude towards surrounding reality, moral ideal of the students, development of moral perception and experience, moral motivation of activity and behavior, etc. form the personal moral qualities of the students.

On the basis of research, we have developed the theoretical model of students' moral education in higher engineering school in the system of teaching humanities disciplines including target, content, procedural, diagnostics and productive components.

The target component includes the purpose, tasks, principles (general and private) of a student's moral education in higher engineering school in the system of teaching humanities disciplines. The purpose is moral education of student identity in higher engineering school in the system of teaching humanities disciplines. We have referred: development of moral consciousness (moral knowledge), moral values and values, development of moral qualities, senses, relations, and motivation of behavior to the main objectives.

Based on the scientific research by Sh.A. Amonashvili [3], M.V. Voropaev [6], I.A. Lipskii [8], V.I. Arshinov [4], E.V. Bondarevskaya [5], etc. we have determined the basic principles of moral development of student identity: the principle of humanization, students' values, personal principle, cooperation principle, differentiation and individualization of the educational process, activity principle, dialogicity principle, principle of professional orientation. We have referred the principle of relation of the studied material with life, practice; humanities ethical principle of education content development to the private principles.

The content component of the model includes the main directions of educational activity consisting in enrichment of educational environment of higher education institution with target perspective of students' moral development in learning activity through special lessons, selection of means, methods, and forms. We have distinguished diagnostic, forming and control stages of the experiment.

The procedural component includes pedagogical conditions of moral education of student identity in the system of teaching humanities disciplines; and also methods and forms which are considered as the interconnected methods of activities of the teacher and student to develop students' morality according to the objectives.

The pedagogical conditions of moral development of the student identity in higher engineering school based on the analysis of the research in the system of teaching humanities disciplines are: 1) The accounting of students' age in the educational activity based on the peculiarities of their thinking, consciousness, relations, behavior. Moral culture of the teacher; organization of educational collective activity; creation of special "emotiogenic" situations for communication; development of young men and girls' identity; creation of favorable moral and psychological climate in student's group meet this condition. 2) Enrichment of educational process with moral and content aspect. This pedagogical condition is provided by moral education of students through a cycle of ethical conversations; emotional, activity-focused forms of pedagogical influence on the student, such as creative and pedagogical tasks, tests, etc.; moral content activities; individual exercises; writing the essay; traditions in student's collectives. 3) Emotional stimulation of students' moral content activity. The emotional incentives in teaching humanities disciplines are: game situations of moral and ethical content; problem and search incentive for pedagogical modeling of verbal and game tasks, emotionally significant for the student, based on active search of correct moral decisions in the situation of interested communication; emotional and figurative incentive in conflict situations of moral content; socially estimated incentive consisting in collective activities of moral and ethical content where, first of all, there is an estimation function of public opinion of the concrete facts and acts.

The educational methods considered by V.I. Andreyev [2], V.A. Slastenin [9], P.N. Osipov [10] and other teachers' works are divided in the following groups: common methods: 1) conviction method; 2) motivation method to empathy, development of emotional and positive responsiveness on positive and negative relation to the ugly things in the world around us; 3) methods of student's amateur performance. There are introspection method; self-criticism method; self-discovery method; methods of self-education, self-training, self-control, self-restriction, self-checking, and self-stimulation belong to this group of methods; 4) methods of pedagogical impact, correction of consciousness and behavior: subgroup of methods and tools of address and self-address to consciousness (example, explanation); subgroup of methods and tools of the address and self-address to feeling (appeal to conscience, sense of justice, vanity and honor, aesthetic perception, shame); subgroup of methods and tools of address and self-address to will and act (requirement, suggestion, exercise, encouragement, punishment). The private methods are step-by-step opening; wide associations; involvement of individual and common experience of students; individual and collective search activities; group work.

The important condition of moral education of the student identity in higher engineering school in the system of teaching humanities disciplines is implementation of such effective forms as trainings of moral conduct, participation in various socially useful activities at the humanities lessons, creative meetings, ethical conversations, discussions, debates, frontal conversations, etc. The special attention should be paid to innovative technologies of educational activities, such as the technology of group educational activity, project training, personally oriented training (humane and personal technologies, cooperation, and free education), information and communication technology, individual reflexive self-education, technology of education on the basis of project and paradigm approach.

Diagnostic and result component includes diagnostic tools of efficiency determination of student identity moral education in higher engineering school in the system of teaching humanities disciplines. Developing L.M. Abolin's [1], E.V. Bondarevskaya's [5], I.A. Kolesnikova's [7], etc. works, the components of good moral education are distinguished, they are development of moral consciousness (moral knowledge), moral values and values, moral senses, moral qualities of moral relations, moral motivation of behavior. The criteria block includes cognitive, emotional, value and motivational and behavioral criteria of students' moral development.

Nature of development and effectiveness of the personality features defining the content of his good education may be various. To specify these distinctions we use the concept of " development level". The levels of students' good moral education are high, average, low, unsatisfactory. The anticipated result of this model implementation is positive dynamics of increase in level of students' good moral education in higher engineering school in the system of teaching humanities disciplines.

Thus, the model is considered as a certain framework with the procedural aspect of pedagogical action – student identity moral education in higher engineering school in the system of teaching humanities disciplines.

ENGINEERING EDUCATION 20'2016

STUDENTS, POST-GRADUATE STUDENTS, AND TEACHERS IN INTERDISCIPLINARY PROJECTS AND TEAMS

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A.V. Szarka

UDC 378

Effects of Interdisciplinary Education to the Competitiveness of Engineers

University of Debrecen, Hungary
A.V. Szarka

Interdisciplinarity is discussed as one of the effective tools increasing young generation's enthusiasm for engineering; increasing motivation of engineering students; increasing collaboration efficiency between professionals of different fields. Paper includes history and new systems of interdisciplinarity in engineering education, dual education system preparing new graduates for real industrial environment of inter- and multidisciplinary activities.

Key words: interdisciplinarity, engineering education, soft skills, gender, dual education, practice oriented education.

Introduction

Two among the most acute problems of today's industries definitely are the lack of well-educated and experienced engineers and low professional and soft skills of new engineering graduates.

Traditional engineering is not the most fascinating profession nowadays, from year to year less young people choose electrical or mechanical technical fields at universities. What can be the reason of it? While people use more and more electronic devices in everyday life the youth feels less and less interest and challenge in knowing the fast developing technics. Engineering education (EE) and industries have to reflect together to these problems by finding new methods to attract young generation to engineering studies.

Besides of popularity decrease the other problem is the motivation of engineering students. Since the credit system is introduced, dropout rate in Hungary became very high, while industries interviewing new graduates very often unsatisfied.

This paper will not set up interdisciplinarity as the only solution to all our problems described above, but it aims to summarise possibilities and effects of interdisciplinary education to competitiveness of new engineering graduates.

Starting with a short statistics from the last years showing number of applications to EE in Hungary we can state that there were no significant changes in the total numbers of applications to engineering courses in the last 15 years, which means that about 15 thousands young people start engineering courses in Hungary every year. (Fig. 1.)

Fig. 2 shows contrasting of the three biggest HE fields in Hungary. Diagrams show that engineering fields are the second most wanted courses lagging behind economics and exceeding courses of law. From other statistics we know that nowadays Hungarian industries have ~ 6 thousands unfilled engineering jobs and all new graduates can select from 2-3 offers or even more if they speak foreign languages.

And finally Fig. 3. shows changes in number of engineering students of different fields in the last 10 years. In the figure we clearly see that only interdisciplinary mechatronic engineering is the course which could increase number of students. Traditional engineering fields, electrical and mechanical are losing their position. The question is why less and less young people choose traditional engineering? The answer of course is very complex including

Fig. 1. Number of applicants and first year students in EE in Hungary [1]

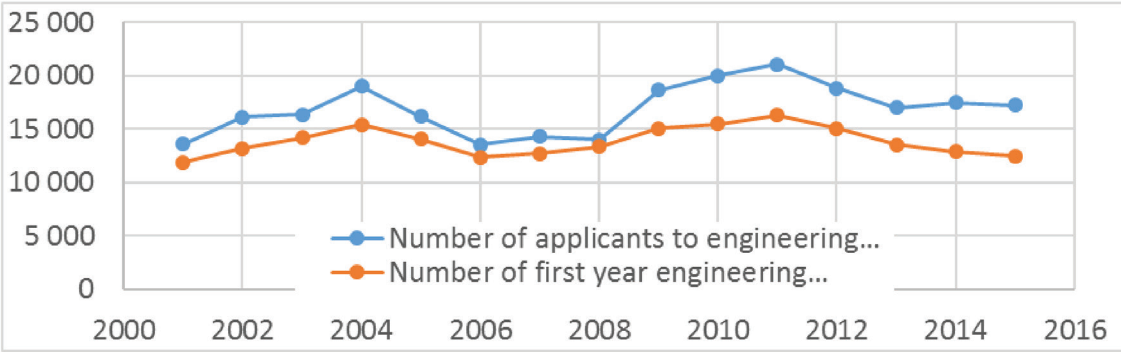
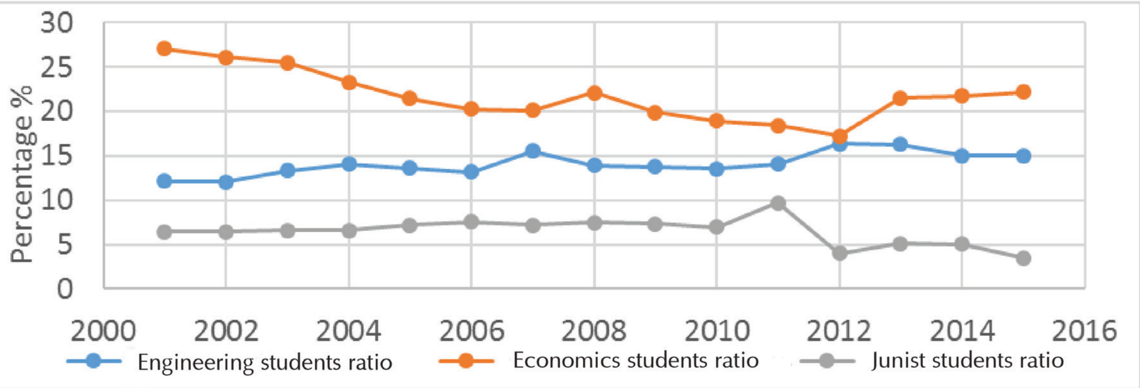


Fig. 2. Percentage of engineering, economic and jurist students in ratio of total number of first year students in Hungary [1]



effects of media, effects of decreased natural science orientation of schools, but also surveys prove that fear of highly specialised studies also causes popularity drop.

I. History of interdisciplinarity in engineering education

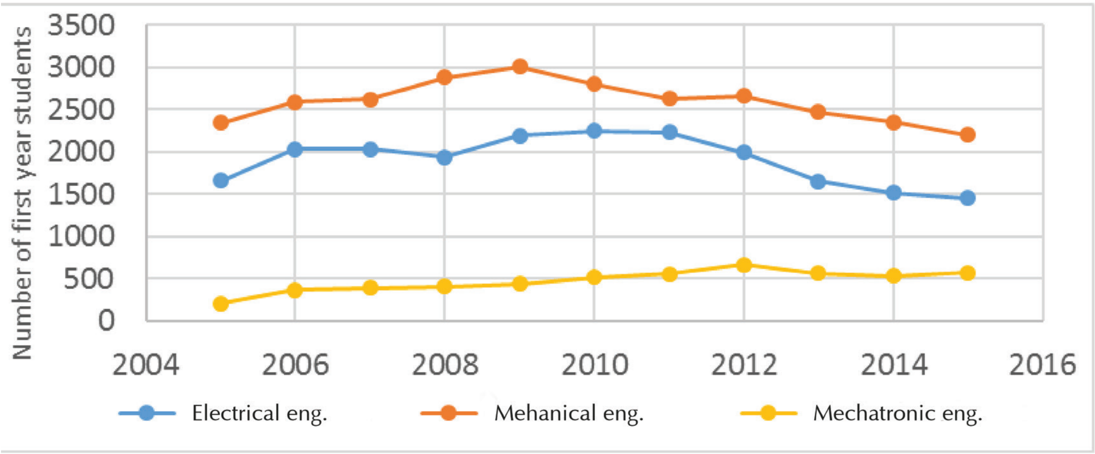
Interdisciplinarity in education has been a traditional method of developing intellectual professionals for centuries. Interdisciplinary knowledge and thinking provide interfacing among representatives of engineering, humanities, the natural sciences and/or the social sciences.

Looking back in history of EE we find that very first engineering educational academies were already deeply based on liberal arts, economy and law.

1.1. Interdisciplinarity of ancient institutes of technology

The world's first institution of technology, the Berg-Schola [2] was founded by the Court Chamber of Vienna in Schemnitz in 1735 in order to train specialists of precious metal and copper mining according to the requirements of the industrial revolution in Habsburg Empire. Maria Theresa nominated it to Bergacademie in 1762. Disciplines of the Bergacademie by today's understanding and definitions were highly interdisciplinary. The 2 years studies included 1 year Mathematics which is

Fig. 3. Number of first year students in different engineering fields in the last 10 years [1]



not the mathematics of today's definitions because it included also mechanics, hydraulics, cartography and other technical sciences and calculuses. In the second year 5 disciplines were thought: Regulations and law in mining; Mining measurements; Ore dressing-flotation; Metallurgy and chemistry; Coinage and gold processing.

In 1782 Emperor Joseph II established the Institutum Geometricum as part of the Faculty of Liberal Arts at the University of Buda. The Institutum, the direct predecessor of the Budapest University of Technology and Economics, is the first in Europe to award engineering degrees to students of land surveying, river control, and road construction. In this institution students could apply for 3 years course only after finishing liberal arts studies. EE included 1 major and 2 minor subjects. The major was applied mathematics, and the minors were mechanics and agriculture [3].

1.2. Interdisciplinarity in engineering education in the middle of 1900s

In 1900s years EE dramatically developed and strengthened all over the world. Slow specialization and field separation characterised the education until the 1970s. Electrical engineering course in 1950s at the Technical University of Budapest was merged with mechanical engineering. Tab. 1 shows structure of electrical EE plan from 1953-1958. Ratio of different fields in the education would entitle this education as a highly interdisciplinary education including humanities and economics 36%, mechanical engineering 19% just a little less than the major studies which is electronic engineering 23%. All over the electrical and electronic fields do not exceed 50%.

I.3. Interdisciplinarity in engineering education in the late 1900s

At the last third of XX. Century EE became highly specialised in several countries. It happened mainly in biggest countries where number of students made possible this type of specialization. Thus major studies included machine tool engineering, train engineering, bridge engineering, ship engineering, etc. with even more specialised minors. Tab. 2 shows an educational plan of an electromechanical engineering major course in Moscow's STANKIN University called "Automation and complex mechanization of machine tools" between 1980-1985.

From the Tab. 2 we can realize that in spite of high specialisation in machine tools the course of STANKIN is very close to today's mechatronic engineering courses and it can be easily called interdisciplinary.

Table 1. Educational plan in electronic engineering in 1950s [4]

Main fields of studies	Subjects	Number of subject semesters	Proportion %
Humanities and economics	Politics, Economics, Industrial management, Military studies and service, Foreign language	28	36
Mathematics	(10 hours per week!)	4	5
Natural sciences	Chemistry, Physics, Electron physics	5	6
Mechanical engineering	Descriptive geometry, Technical drawing, Machines theory, -drawing, -elements, -operation, Mechanics, Precision mechanics	15	19
Electrical engineering	Electrical materials, Alternating current, Electricity, High voltage technics, -transmission and -laboratory	8	10
Electronic engineering	Electron valves, Radiotechnics, Telephone technics, Low power transfer, Electroacoustic, Measurement and instrumentation, Impulse technics and remote vision, microwave technics, Automation	18	23
Thesis project		1	1

Moreover it was a project oriented course as 7 half year projects in the certain disciplines were included (they are signed by P). So the question is when we have lost interdisciplinary and project based character of our EE.

I.4. Changes in electrical and electronic engineering education in the first decade of 2000s

Comparing Hungarian bachelor level educational plans to above described two in electrical engineering, we realise that mechanical engineering disciplines are fully disappeared from the plans just as the chemistry. Humanities and economy subjects ratio is dropped to 16% while new fields like IT occupied only 9% of educational plan. The only possibility for including some interdisciplinarity into education is that 8% optional subject which can be selected by students from any scientific fields. Number of subject semesters are also dramatically decreased from ~80 to ~50.

Data of Tab. 3 underline that this is the education which cannot be called

Table 2. Educational plan of course in "Automation and complex mechanization of machine tools" in 1980 [4]

Main fields of studies	Subjects	Number of subject semesters	Proportion %
Humanities and economics	Politics and philosophy, Economics, Industrial management, Work safety, Foreign language	20	25
Mathematics		4	5
Natural sciences	Chemistry, Physics	4	5
Mechanical engineering	Descriptive geometry, Technical drawing, Basics of machine theory [P], Machine drawing, - elements [P], Mechanics, Hydraulics, Pneumatics, Material science, Material handling and transportation [P], Machine tools theory, - technology, - design [P], Cutting tools	24	30
Electrical engineering	Electrical materials, Electricity, Electronics, Industrial electronics [P], Digital technics, Electrical machines and drives, Measurement and instrumentation, Automation [P], Process control of machine tools [P]	18	23
Computer science	Computer technics, engineering and economical calculations, programming	7	9
Thesis project		2	3

interdisciplinary, and that is the reason why also industry and students miss interdisciplinarity from our education. The problem is realised in the last years and several action plans were worked out and new methods are being introduced into our education.

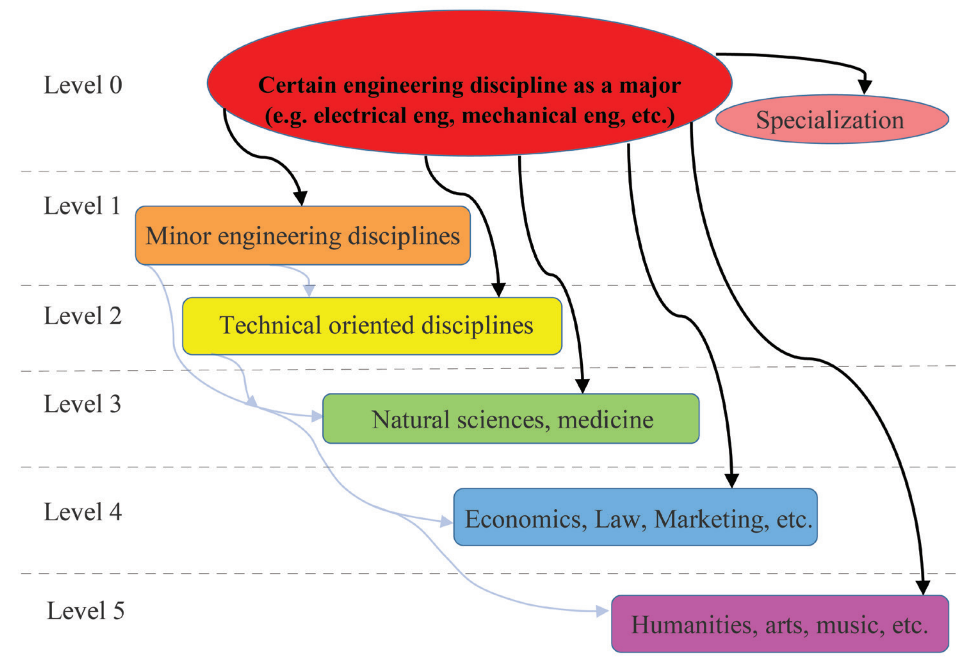
II. Boundaries and system of interdisciplinarity in engineering education

We can accept that education is interdisciplinary if two or more disciplines are included and combined with necessary interactions between each other. It means that putting simply together disciplines from different sciences will not result a real interdisciplinary knowledge. Disciplines should be built up on each other, they should incorporate, theories and practices of one disciplines should be elemental part of other disciplines composing a fully comprehensive system of knowledge. From the view of scientific fields 5 different levels of interdisciplinarity can be defined. The lowest level of interdisciplinarity includes disciplines of engineering fields close to each other and the highest level of interdisciplinarity includes engineering disciplines combined with arts and humanities. Fig. 4 shows

Table 3. Educational plan of 2000s in electrical engineering

Main fields of studies	Total number of semesters	Proportion %
Humanities and economics	7	16
Mathematics	3	6
Natural sciences	2	4
Mechanical engineering	0	0
Electrical engineering	25	52
Computer science	5	10
Optional subjects	4	
Thesis project	2	4

Fig. 4. Levels and interactions of interdisciplinarity in engineering



different levels of interdisciplinarity and the Nowadays uncountable different interdisciplinary engineering courses are offered by universities of the world. The level of interactions are very different and depends highly of the selected disciplines, also freedom of selection is varying in wide range. In some universities (mostly in USA) students have a full freedom to compose their studies from all the university's

Table 4. Typical interdisciplinary engineering professions

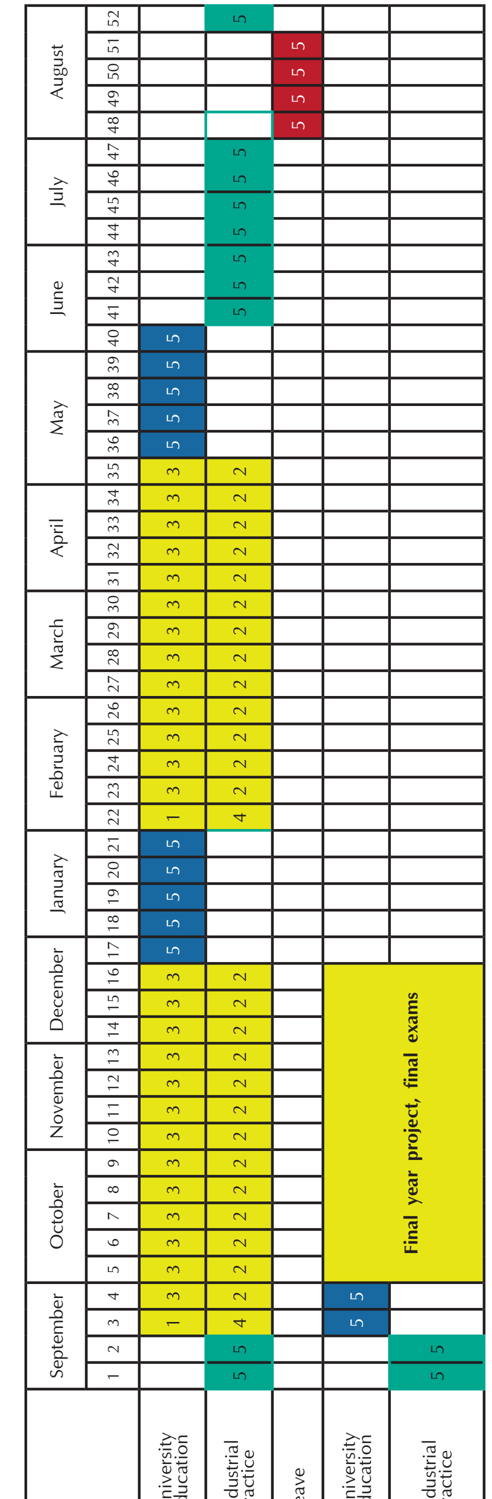
Level 0 +	Electronic engineering +	Resulting profession
1 + 2	Mechanical + IT	Mechatronic engineer
1	Vehicle eng.	Car electronics
2	IT	Computer Science Engineer
2 + 2	Logistics + IT	Process engineer
3	Biology	Bioengineering
3	Chemistry	Chemical process control engineer
3	Medicine	Medical engineer
3	Material science	Nano-engineer
3 + 3	Biology + Medicine	Biomedical engineer
4	Economics	Manager of technological innovation and entrepreneurship
4	Management	Engineering management
4	Law	Intellectual property engineer
4	Law	Safety engineer
5	Music	Acoustical Engineering
5	Performing art	Theatre engineering
5	Fine art	Industrial and Product Designer

discipline offers. In other methods pre-defined composition of fields is set-up in order to get a defined interdisciplinary professional at graduation. Such pre-defined compositions are widely used in Hungary.

III. Practice oriented dual education in engineering as a tool of interdisciplinary studies

Dual education in higher education is a new system in Hungary introduced by Mercedes Benz with cooperation of Kecskemйt College [7]. In the new system companies support certain number of students and provide them strong practical education in their field. Students applying successfully for dual education study together with non-dual students at the university, so they go through the same university courses as their non-dual colleagues, but while non-dual students' academic year includes 2x14 weeks active semester and 2x6 weeks exam session, all over 40 weeks, dual students have 26 weeks at the university plus 22 weeks at companies, all over 48 working weeks per year including study at the university and practicing at the industry. As companies compose their particular educational plan in close cooperation with the university, these plans are characterised by high added value in disciplines which are not included into the normal university education. Students learn standardized processes, working in team, in multicultural and multi-language environment, also they learn industrial planning, economics, production or design process management, communication, etc. Fig. 5 shows time share between university and company. Numbers in squares show number of working days per week to be spent at university / company / leave.

Fig. 5. Time share in duel education



Conclusion

Statistics of Hungarian higher education underline necessity of interdisciplinarity in EE. Traditional courses of EE encourage mostly male students, but the situation is much better at interdisciplinary courses. In this decade when the total number of the 18th year age population is decreasing none of the university courses can allow to acquire students only from the one half of the population. Besides of more female also a small part of males suppose easier interdisciplinary studies and sympathize with such courses. It means that from input side advantages are obvious, but acceptation of interdisciplinary graduates by companies is a question. The first experiences at least in Hungary are not very encouraging. Companies know well traditional engineering but they are not really familiar with abilities and knowledge of Computer science engineers, Engineering managers or Biomedical engineers. They state that developers of special fields (for example car electronics and -sensor developers) should be highly educated in the specialized fields. This view should be accepted, thus industrial needs will make a right selection of specialised or/and interdisciplinary professionals. Future research on experiences should be performed in coming years.

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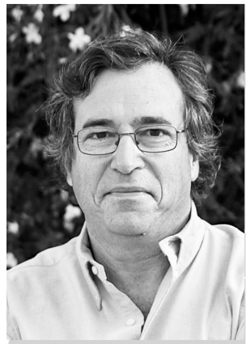
UDC 378

An Interdisciplinary Approach for Acquiring Competence for Social Responsibility

Universitat Politecnica de Catalunya
J.J. Perez



J.J. Perez

Graduate students should exhibit hard competences – specific knowledge- in their field of study and, also soft or transversal competences that provide complementary abilities to use the former in any specific environment. Social responsibility is among the list of transversal competences. This competence provides graduates a guidance to develop their activities as professionals within a framework of sustainable development, in such a way that projects include considerations concerning environmental, social and economic dimensions. In the present work we revise the concept of social responsibility and propose a quality assurance procedure to assess and improve the level of competence achieved by graduates.

Key words: interdisciplinary approach, higher education, sustainable development, social responsibility.

1. Introduction

The effective progress of humankind requires policymakers and leaders to be competent for social responsibility. Social responsibility provides an ethical framework to act with the vision needed to understand the strongly interwoven environmental, economic and social consequences of specific decisions taken, guaranteeing a vision of long-term strategies for the benefit of society at large. Lack for social responsibility competence by leaders in technology, government, business and industry may result in choices that can compromise the development of present and future generations.

Social responsibility is a transversal competence that should be acquired along a study program, requiring further development during the professional life. Accordingly, Institutions of higher education through their study programmes and Professional associations through the professional code of ethics have a direct responsibility to build up a solid competence for social responsibility of leaders in technology, government, business and industry.

The process of acquiring competence for social responsibility by graduates is connected to a holistic education for sustainable development delivered from Higher Education Institutions. A holistic education requires not only greening study programs, but involves greening the campus [1]. The present work aims to review different aspects connected to the implementation of a holistic approach on education for sustainable development and describes a quality assurance system to assess its degree of implementation by Institutions of Higher Education.

2. Sustainable development

Different studies suggest that with present population growth rate and use of resources, the Earth will reach its carrying capacity at the end of the XXI century [2, 3]. Fortunately, these studies also suggest that there is a model of sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs [4]. This model takes into account an expected increase of technological efficiency, but the most important requirement is a change in people's lifestyle. More specifically, citizens need to change their consumption habits increasing the use of renewable resources, increasing present recycling capacity and evaluating the impact caused by a product in terms of its lifecycle. Moreover, an effective future progress for humankind requires that these changes do not only involve resources and the environment, but economic development and social justice. This translates in a continuous improvement of the quality of life and wellbeing for present and future generations by taking into account the environmental, economic and social consequences of the activities carried out.

Awareness of the population is a key ingredient to bring humankind into a sustainable development track. This will generate pressure on policymakers to think in the long-term consequences of the actions undertaken at present. Globalization helps to increase the awareness of populations, stressing the consequences of non-responsible attitudes. A remarkable result in this pressure came with the rise of the ecologism or green political theory that has been regarded as a distinctive ideological tradition since about 1970s [5]. However, the need for humankind to follow a sustainable development track should be embedded in any policymaker. Population awareness is also necessary to urge states to work for a closer cooperation. In this regard, we are presently in the ratification process of the Paris convention [6], an ambitious plan to reduce greenhouse gas emissions to reverse global warming and its catastrophic consequences.

3. Social responsibility and education for sustainable development

As mentioned above, the desperate need for humankind to follow a sustainable development track should be embedded in any policymaker. However, choices made by leaders in technology, government, business and industry are sometimes taken without consideration broader perspectives neglecting the framework of a sustainable development. Social responsibility is a transversal competence that helps professionals to take decisions in a framework of sustainable development. It requires full awareness of the need to preserve the quality of life and wellbeing for present and future generations, by linking economic development, protection of the environment and social justice, together with a personal commitment to act in these lines through a responsible consumption, enhance the use of circular economy and follow an ethical behavior.

Social responsibility should be acquired by graduates along a study programme and reinforce during their professional life. A necessary condition to produce graduates competent for social responsibility is to embed students in a holistic educational process for sustainable development aimed at providing the necessary tools to increase knowledge and understanding, skills, and attributes needed to create a just and sustainable future. Education for sustainable development requires a multi-disciplinary approach that allows making connections, share knowledge, and work together on emergent areas [7]. It aims to develop students' ability to understand and evaluate connections between big issues, such as inequality, public health, global consumption, biodiversity loss and the limits of natural systems.

Higher Education Institutions are considered as key actors in the process of education for sustainable development as stressed in the report on the Decade of Education for Sustainable Development (2005–2014) led by UNESCO recently published [8]. They are viewed as the drivers of the education process since they are involved in training most of the professionals who develop, lead, manage, teach, work in, and influence society institutions, including the training of educators who provide education at both primary and secondary levels.

Higher education institutions have long been engaged in embedding environmental education and education for sustainable development into their functions including education, research and community outreach, but also in campus operations

[9]. Since the Talloires Declaration in 1990 [10], an increasing number of institutions have been engaged in activities to embed the principles of sustainability into their systems. Today, many institutions are interested in embedding sustainable development in their operations and activities, as well as on the consequence of their implementation including training social responsible graduates and creating a social responsibility culture in their institutions [11]. However, not all the initiatives reported by diverse institutions are in line with a holistic implementation of programs, research, outreach activities and campus operations embedding environment, society and economy. They range from those institutions that have implemented initiatives for greening campus to those that have incorporated social corporate sustainability in their strategic planning; from those that have included courses on environmental science in their programmes to those that offer a full integration of sustainability related topics into existing curricula or research [12].

4. Levels of implementation of education for sustainable development

As mentioned above, a necessary condition for graduates to be competent for social responsibility is that institutions have implemented a holistic education system for sustainable development including programs, research, outreach activities and campus operations. Institutions around the world exhibit a differential approach to implement such a system. It is important to have a way to assess the degree of completeness achieved by an institution to implement a holistic system of education for sustainable development. There are different approaches described in the literature for this purpose including the Auditing Instrument for Sustainable Higher Education [13], the Graphical Assessment for Sustainability in Universities [14], Sustainability Tracking, Assessment & Rating System [15] or the Quality System of Science and Technology Universities for Sustainable Industry [16], all of them based on the premises of quality assurance methods.

The first tool published was proposed by the Dutch committee for sustainable higher education who developed the Auditing Instrument for Sustainable Higher Education (AISHE). In this approach the idea is that organizations can be in one of several development stages with respect to a number of criteria. AISHE covers four fields: vision and policy, expertise, educational goals and methodology, education contents. The procedure involves an analysis of each of the four fields to end up with a self-assessment report that may be audited externally [13]. Another tool to assess the degree of development of universities in education for sustainable development is the Graphical Assessment for Sustainability in Universities (GASU) [14], based on the Global Reporting Initiative sustainability guidelines [17], designed to cover specific aspects of the activities carried out in the institutions of higher education including education, research, campus operations and community outreach. Its strengths lie in its multi-stakeholder approach and its number of indicators in the economic, environmental and social dimensions. The Sustainability Tracking, Assessment & Rating System (STARS) is a self-assessment tool designed for an institution to earn points based on the performance on diverse items related to sustainable development grouped in four categories: academic, engagement, operations and planning and administration. The final score permits to understand the degree of involvement of an institution in sustainable development [15]. Finally, the Quality System of Science and Technology Universities for Sustainable Industry (QUESTE-SI) is a quality assurance system, which supports quality improvement of sustainable development education in higher engineering education institutions. It requires the elaboration of an internal assessment report that is followed by an auditor team external evaluation. QUESTE-

SI assessment is based on the information gathered in four dimensions: Institution strategy, education and curriculum, students' involvement and research and innovation [16]. Similarly to STARS, after the evaluation institutions get a score that informs of the present institutional status in regard sustainable development and helps to identify weaknesses for improvement in the future.

Although these are tools designed to assess the degree of implementation of education for sustainable development of higher education institutions, it is expected that a more holistic approach of institutions in designing a system on education for sustainable development will provide a higher accomplishment of competent students for social responsibility, although this needs to be further studied.

5. Conclusion

Social responsibility is a competence that all our graduates should accomplish. It permits to act with a breadth and depth of vision needed to understand the strongly interwoven environmental, economic and social consequences of specific decisions acting for the benefit of society at large. A necessary condition for students to acquire such a competence is that institutions of higher education are committed for sustainable development in their strategic vision and provide a solid interconnected view of the environmental, social and economic components in their functions: education, research and community outreach, as well as campus operations. There are different tools available to assess the degree of implementation for sustainable development of higher education institutions. It is expected that stronger implication of institutions for sustainable development provide higher accomplishment of competent students for social responsibility.

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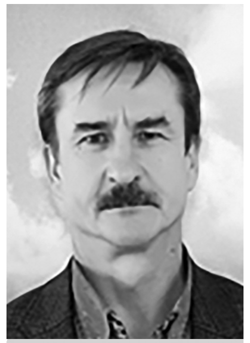


A.V. Bogdanov

A.S. Shatrova

O.L. Kachor

Development of Eco-Friendly Technology of Colloidal Deposit Utilization in Pulp and Paper Industry

Irkutsk National Research Technical University
A.V. Bogdanov, A.S. Shatrova, O.L. Kachor

Development of eco-friendly technology for intensive processing of sludge-lignin deposits, which is based on the best available utilization methods, is one of the urgent tasks to be addressed. The proposed technology to recover deposits in the storage pits of Baikalsk Pulp and Paper Mill on the basis of natural freezing allows reducing the costs and enhancing environmental safety of the project.

Key words: sludge-lignin, sludge storage pits, pulp and paper industry, Baikalsk Pulp and Paper Mill, utilization, freezing, best available technologies.

Today, the management of wastes including waste formation, utilization, and disposal is a critical issue that requires urgent actions. Annually, up to seven billion tonnes of wastes are produced in Russia, only two tonnes being recyclable materials. The waste of pulp and paper industry makes 15% of total waste amount. Sludge-lignin formed as a side product of biological and physico-chemical treatment of waste-water and disposed in sludge storage pits represent the base of the wastes that are not currently recycled. More than 30 million m^3 of sludge lignin is deposited within the territories of the enterprises located in Baikalsk region, near lake Baikal, Bratsk and Ust-Ilimsk Dams. These deposits cause severe damage to the environment. In worldwide practice, there are no data on recultivation of land degraded by sludge-lignin deposits [1, p. 7-8]. This fact is explained by the limited use of physico-chemical treatment in the pulp and paper enterprises and difficulties in understanding the principles of substance interaction during physical, chemical, and biological processes that take place in this anthropogenic substrate. In addition, the impact of environmental conditions (temperature, insolation, ground water, precipitation) on these processes has not been sufficiently studied. The absence of real decisions on sludge-lignin utilization is explained by its complex physico-chemical and dispersion composition, high wetting ability rates basically caused by bound water, and labour-intensive and rather complex treatment technology. The existing methods of sludge-lignin utilization, such as joint grouting, electrosmosis, iron sulfate-treatment, vermiculating, transpiration or simple dumping, are currently not applied.

According to the federal target programme "Protection of lake Baikal and the socio-economic development of the Baikal natural territory for 2012-2020", Baikalsk Pulp and Paper Mill is defined as one of the most well-known sources of pollution of lake Baikal. Considering the peculiarities of natural resources development within the basin of lake Baikal, which are defined by the need to conserve its unique ecosystem as a part of the World Heritage, development of eco-friendly technology of colloidal deposit utilization based on the best available utilization methods is one of the critical issues.

Colloidal deposits produced by Baikalsk Pulp and Paper Mill (approx. 8 mill. m3) are stored in the special pits with multilayered hydro-fuge insulation made of natural and synthetic materials and characterized by earthquake resistance up to 9 ball intensity in MSK. The proportion of various substances in deposits is as follows: lignin (40-45%), fiber (15-20%), sludge (15-20%), ash residue (10-20%). Since aluminum oxide and polyacrylamide are used as coagulant in chemical treatment of waste-water, their residual concentrations are found in sludge-lignin deposits [2, p. 60-63]. The deposit sample of 50 g includes: aluminum oxide (expressed as aluminum ion) up to 5 g, polyacrylamide – up to 1.2 g. The storage pits are located in two sites, close to Baikalsk city and Solzan, Babkha settlements. Solzan site covering 105 hactares of land includes storage pits № 1–10 (Fig. 1). The area of Babkha site is 33 hectares and it comprises storage pits № 12–14. Intermediate storage pit № 11 is located in the industrial site of Baikalsk Pulp and Paper Mill.

In order to evaluate the environmental changes within the landfill site where sludge storage pits are located, the samples of soil, plants, ground and above-sludge waters were collected and analyzed during 2009-2016. It was identified that the concentration of benzapyrene exceeds 3 times the MAC value, while concentration of heavy metals – 2-7 times. The toxicity test of soil via Lepidiumsativum, ChlorellavulgarisBeijer, DaphniamagnaStraus revealed that the wastes stored in the sludge storage pits influence the toxicity of soil which is categorized as moderately toxic.

In the samples collected in the observation wells of water intake, the concentration of the substances mentioned below exceeds MAC for fishery water: formaldehyde up to 1.3-2.9 MAC, petroleum products up to 6.2 MAC, aluminum 3.2-19.7 MAC, iron up to 8.9 MAC [3, p. 192-193]. The obtained data on the environmental conditions do not significantly differ from that obtained 5 years ago (average deviation does not exceed 5-8%). The analysis of plant samples (needles of Siberian pine (Pinussibirica Du Tour)) collected within the study area revealed that the concentration of heavy metals does not exceed the normative values.

Fig. 1. Location of Baikalsk Pulp and Paper Mill storage pits

Thus, the data obtained on environmental condition monitoring have revealed that concentration of pollutants in Solzan site has remains unchanged over the past 5 years, which, in its turn, shows that the pollution level has achieved a critical value. However, this fact does not indicate stability in ecological balance as it can be easily disturbed by various natural and technogenic phenomena (mudflow, earthquake more than 9 ball intensity in MSK, accidents caused by inadequate technological decisions, etc.). The results of the field work showed that deposits accumulated in Solzan site have different morphological and physico-chemical composition. The index of wetness ranges from 74% (storage pit № 5, average value) to 86% (storage pit № 8, average value). Based on the obtained data, 3-D image of colloidal deposit (storage pit № 2 with aluminum oxide) was created using software Surfer (Fig. 2). A great amount of aluminum oxide allows using ash of sludge-lignin as a sorbent to treat waste waters of different composition. In addition, it can be used as a component of raw material for water cement production [4, 5]. As shown in Fig. 2, concentration of aluminum oxide increases up to 25% with depth.

Fig. 3 shows 2-D image of deposit accumulation in storage pit № 2. As shown, the wetness index decreases from 98% to 83% with depth, which is certainly a natural result of compaction. Vertically, the wetness index of deposit is not homogeneous as well. Such a wetness profile and distribution of minerals are due to the pit filling technology used in Baikalsk Pulp and Paper Mill, i.e. liquid sludge is poured at the east side of the pit, and as it moves along an inclined bottom to the west side of the pit, it gets compacted.

Based on the existing and obtained data on morphological and physico-chemical composition, lignin deposits accumulated in the pits of Baikalsk Pulp and Paper Mill were classified. This allowed defining the utilization technology in accordance with NDT GOST R 55827-2013: "with regard to resource potential, need to protect environment and human health".

In our opinion, regardless of the technology used, first of all, it is essential to reduce the amount of sludge lignin, which, in its turn, will proportionally cut technical-and-economic costs [6, p. 99-107]. The conducted study has revealed that natural freezing is the most effective method to reduce the amount of sludge-

Fig. 2. Concentration of aluminum oxide (%) in sludge-lignin deposits (storage pit № 2)

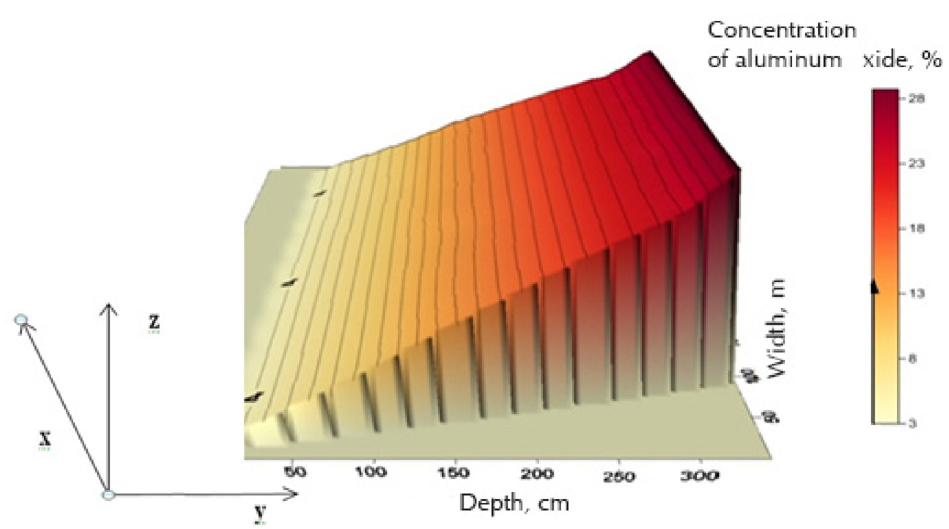
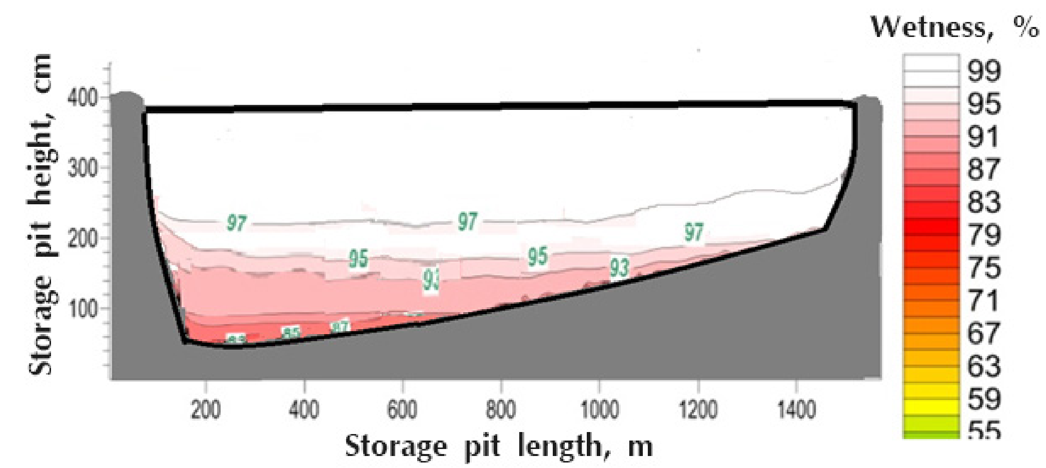


Fig. 3. 2-D image of wetness profile in storage pit № 2



lignin. Precisely, the amount is reduced due to the removal of snow cover from the storage pits (for example, via gas-jet wind machines) as it serves as a special screen that prevents complete freezing. In addition, various biological processes which are exothermal take place in sludge-lignin deposits.

The conducted office and field work has shown that freezing destroys the colloidal structure of the deposits and reduces the amount of sludge-lignin by 30-40% depending on the composition and wetness index by 6-11%. Besides, the technology contributes to reducing specific resistance of the deposits and leads to 4–7-fold decrease in the concentration of benzapyrene, the main toxic element.

The proposed utilization technology allows reducing the amount of sludge lignin produced by Baikalsk Pulp and Paper Mill due to the destruction of its colloidal structure. As a result of lignin degradation, three types of materials can be obtained: destroyed colloidal percipitate (35%), mineralized above-sludge waters (5%), demineralized above-sludge waters (60%), which flow into the prepared-in-advance storage pit № 2 (clarifier) due to the gravity force. Have residual pollutants precipitated, purified water is transported to the pond-aerator of Baikalsk Pulp and Paper Mill and, then, to Lake Baikal. The destroyed colloidal precipitate and mineralized water are pumped in cascade from pit № 7 to the downstream pits until the pits are full. In order to obtain eco-friendly concrete, ashes mixed with 10% concrete M400 are added to the precipitate from pits № 11,13,14 through the sluice-discharge line. Ash and concrete are mixed. Finally, eco-friendly engineering constructions – confinement – are built. To ensure gravity-driven flow of storm water, the surface of confinements should be inclined at an angle of 2 degrees. They should be also fitted with a system of drain pipes to drain water to pit № 2 for the preliminary treatment under natural conditions. Within the territory where confinements are located, such light constructions as hothouses, recreational sport facilities can be built. In addition, the empty pits can be used as ponds for fish farming and sport activities.

The proposed technology to recover deposits in the storage pits of Baikalsk Pulp and Paper Mill on the basis of natural freezing allows reducing the costs and enhancing environmental safety of the project. The expected ecological effect is projected to reach 6.5 billion of rubles.

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UDC 378

Formation of Professional Competences for Future Environmental Engineers Based on the Interdisciplinary Approach

Kazan National Research Technological University
A.E. Irismetov

A.E. Irismetov

The article discloses new requirements towards future environmental engineers, who will be conducting environmental protection under new socio-economic conditions. The definition of professional competency of an environmental engineer is determined.

Key words: professional competency of environmental engineers, World Trade Organization, international trade, ecological problems.

In the framework of Russia's accession to the World Trade Organization (WTO) the new rules concerning the process of international trade, new standards for trading products, norms and principles, requirements for ecolabelling of goods and products have been introduced. These changes concern the issues of international relations' regulation in the sphere of environmental protection with an aim to preserve rational management of natural resources. This is strongly tied with the fact that current ecological situation can be characterized by a high level of ecological disaster risks, an increase of anthropogenic influence on nature, that require constant attention to the ecological problems and their efficient solution [1, pp. 216-218]. The most essential part of ecological problems' solution is the interdisciplinary approach to those phenomena of material world that are based on the biological laws, but are getting more and more involved in the spheres of social, technological, economical and political interests.

The accession of Russia to the WTO sets new requirements towards specialists, who are working for the environmental protection and are assuring environmental control of goods and products. These specialists are prepared by engineering universities, among which is the Kazan National Research Technological University. The topical issue of training environmental engineers is the need to foster professional competency as a holistic integrative ability of a specialist that ensures his/her readiness for the efficient resolving of appearing problems.

In order to follow the new requirements set by the WTO, environmental engineers have to focus on the new standards, norms, by-laws, statutory regulation of the environmental state, methods and means for assessing the current state of the environment and its protection from anthropogenic influence. Thus, their professional competency has to include new knowledge, skills and professionally important personal attitudes that ensure efficient professional activities under the new conditions and allow for the environmental engineers to constantly develop their competency in the framework of dynamically changing conditions of the professional activities.

The World Trade Organization guides countries to follow and implement international standards – International Organization for Standardization (ISO), which assure an integrated international system of requirements towards the quality management of goods and services. One of the most important international standards is the ISO 14000. The subject of this standard is the environmental management system (EMS) that allows to efficiently balance economic increase of the company's income and preservation of the environment. One of the requirements towards future environmental engineers is to know the ISO standards and to be able to apply them within an organization [2].

The literature analysis and the analysis of regulatory sources permitted to determine that a modern environmental engineer has to:

- Possess knowledge of the environmental management system, environmental audit, environmental certification and licensing.
- Possess knowledge of the key definitions, terms and laws concerning international trade and ecology.
- Master the methods of environmental control, methods of environmental safety of produced goods.
- Understand the role of international trade in assuring global economic development.
- Understand the international system for environment protection.
- Apply the rules and norms of the WTO and mechanisms of the international economic cooperation for developing individual strategies in conflict resolution, etc.

Besides that, graduates should have fostered the following competences: the ability to apply modern informational technologies, the readiness to justify certain technical solutions, when developing technological processes, the ability to choose technical means and technologies aimed at minimizing anthropogenic influence on the environment. Professional competency of an environmental engineer, in the author's opinion, can be described as an integrative ability that assures readiness for efficient problem solution concerning rational environmental management, that includes the strive for mobilization of professional competences based on updating personal expertise for successful conduction of activities on the environmental protection in the process of professional work.

Based on the interdisciplinary approach, the integration of sciences, social sciences, legal, ecological and economic knowledge, the training materials for "International trade and ecology" have been developed and implemented within the study course "Environmental management and environmental audit".

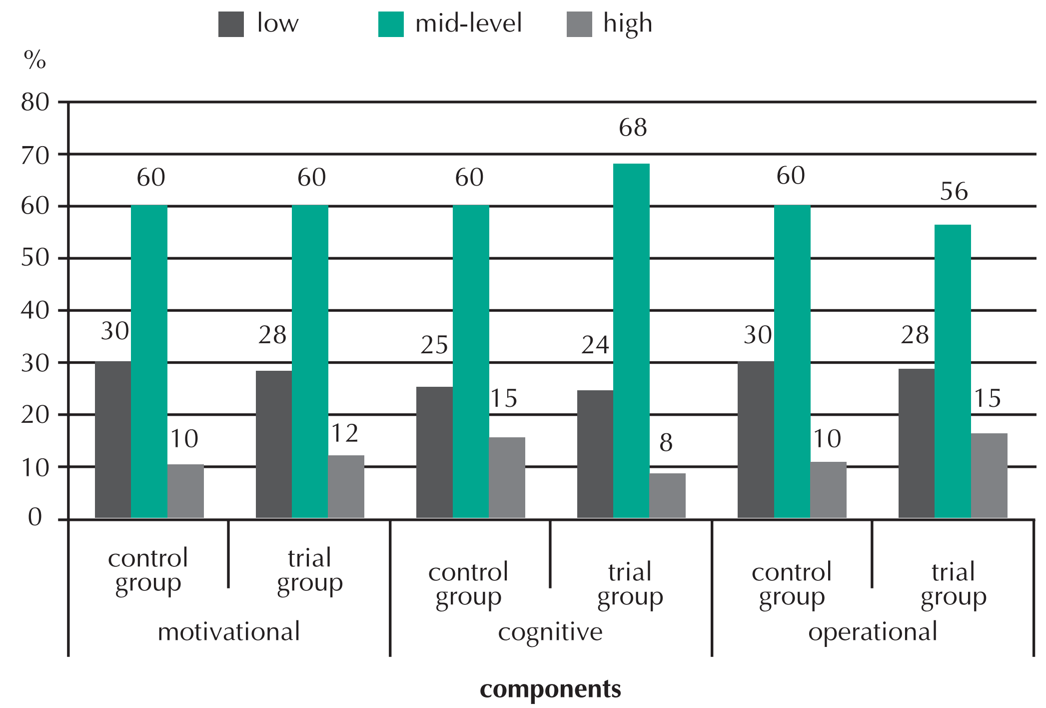
Moreover, an e-learning course "Virtual laboratory of an environmental engineer" has been developed and implemented. The course allows using informational and communicational technologies with an aim to increase the efficiency of students' continuing self-education, to create individual educational paths for future environmental engineers.

The trial work has been conducted during 5 years and has involved 4 stages. Aiming to determine the level of students' environmental culture a wide spectrum of diagnostic instruments has been used: an upgraded method for students' motivation diagnostics (S. Pakulina, M. Ovchinnikov), a questionnaire for determination of environmental culture level, a test "International trade and ecology" consisting of tasks on evaluating the level of ecological knowledge, understanding of international environmental standards and norms, specific tasks on understanding environmental problems, evaluation of projects according to the developed map of expert evaluations.

The results of this summative research showed that the level of professional competency of students in the trial and control groups turned out to be quite similar. A high level of motivational, cognitive, operational components of professional competency in both groups has a low value (Fig. 1).

On the summative stage students of the major «Environment protection and rational environmental management" and the major "Engineering environmental protection" participated in the trial. On

Fig. 1. Level of formation of students' professional competency components on the summative stage, %



this stage the structural functional model and the pedagogical conditions for fostering professional competency of future environmental engineers have been tested.

Students of the "Engineering environmental protection" major (20 people) followed the traditional educational program.

At the end of the study year there has been a secondary evaluation of the intensity of all the components that characterize professional competency of students from the trail and the control groups.

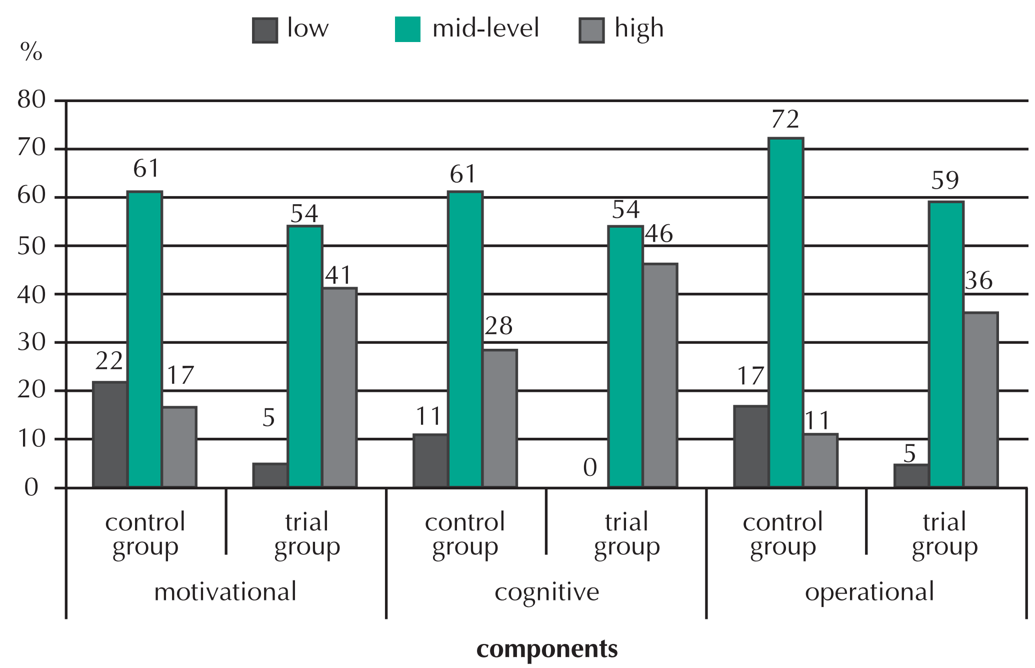
A high level of motivational, cognitive, operational professional competency component in the trial group has increased. A low level has increased significantly in the trial group (Fig. 2).

During the comparative educational experiment the contents of extracurricular modules have been updated, a set of disclosed problems has been extended, problems for project-based activities have deepened.

This experimental work served for the purpose of analyzing the results of a 3-year diagnostics of professional competency components' level of formation. Picture 3 shows the evaluation results of professional competency components' formation of the 4^{th}-year students (Tab. 1).

One of the unbiased indicators of the developed model's and pedagogical conditions' efficiency for fostering professional competency of future environmental engineers is the students' participation in scientific conferences on environmental problems, their participation in environmental campaigns. On the summative stage of the research only 7% of students acknowledged participation in scientific research and conferences devoted to the environmental problems, and only 6% of them have taken part in environmental campaigns. On the formative stage of the experiment their number has increased to 24% and 12% accordingly. On the final stage of the

Fig. 2. Level of formation of students' professional competency components on the final stage, %



experiment 26% of students acknowledged participating in research activities, 12% stated taking part in conferences and more than half of students acknowledged participating in environmental campaigns more than two times within one year.

Table 1. Level of formation of professional competency components of future environmental engineers, %

	Motivational				**Cognitive**				**Operational**			
groups	control		trial		control		trial		control		trial	
2011-2012 study year												
level	before	after	before	after	before	after	before	after	before	after	before	after
low	26,3	15,8	25	4,2	26,4	15,8	29,2	4,2	26,3	10,5	25	4,2
mid-level	63,2	73,7	62,5	62,5	52,6	57,9	50	62,5	57,9	68,4	58,3	50
high	10,5	10,5	12,5	33,3	21	26,3	20,8	33,3	15,8	21,1	16,7	45,8
2012-2013 study year												
low	31,6	15,8	30,4	4,3	26,3	10,5	26,1	4,4	26,3	10,5	26,1	4,3
mid-level	63,2	68,4	65,2	60,9	52,6	63,2	52,2	60,9	57,9	73,7	56,5	43,5
high	5,2	15,8	4,4	34,8	21,1	26,3	21,7	34,7	15,8	15,8	17,4	52,2

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INTERDISCIPLINARY PROJECTS ON RESOURCE-EFFICIENT TECHNOLOGIES SUSTAINABLE DEVELOPMENT

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UDC 378

ENGINEERING EDUCATION 20'2016

A.A. Dul'zon

Project Managers: What Should They Be Like?

National Research Tomsk Polytechnic University
A.A. Dul'zon

Try to create with e'en the smallest jots.
In other case, why are you a magician?
In humane race, you bear Almighty's mission,
Then try to say the word in which lives God
K. Balmont

The article discusses working conditions and basic duties of project managers in comparison with those of linear managers. It provides the main duties of project managers and basic requirements for their professional, communicative and personal characteristics and competencies. It also discusses the issue of project manager salary.

Key words: project manager, project mania, project manager's responsibilities, requirements for a project manager.

Introduction

The current methodology of project management and was successfully developed in the second half of the twentieth century while developing large and complicated construction projects, designing nuclear weapon, combat ships, and space systems. The accumulated experience appeared to be applicable for civic life by the end of the century, which led to the explosion in popularity of project management in most of the developed countries. The project took place in almost all problem solving processes in any kind of human activities. This effect can be called a "project mania".

The methodology of project management is being actively used in Russia as well, mostly due to the activity of Russian Project Management Association "Sovnet".

Currently, the number of projects being implemented both in Russia and in the world exceeds the number of good project managers several times. Meanwhile, a central figure of the project is a project team leader, who is responsible for project's success to a great or even absolute extend. Despite the requirements for project managers described in details in textbooks, the issue of effective project management is still being under discussion in technical journals [1-3]. In this regard, it would be useful to study the content and conditions of successful work of a project manager, as well as the requirements that should be ideally met by the person in charge.

Specific conditions of project manager's activity

A project manager job in different organizations and projects can vary from a project team representative to a project team leader. In the first case he/she presents a project for an external environment, inside the team being an ordinary performer. In the latter case, he/she has the same authority as linear leaders, and is responsible for the process and results of the project.

Project manager's risks and responsibilities can be much higher than those of a linear manager, since they have to make decisions in conditions of uncertainty. The level of uncertainty is extremely high, especially at the beginning, for innovative projects related to development of cutting-edge technologies. A project team leader is responsible for his/her decisions, actions or **inactions**. The main spheres of the leader's responsibility are results, personnel, terms, material resources, and project budget.

Apart from this, a project manager should meet a number of special requirements. This position implies the functions of a mediator between project performers and the administration or a customer and other stakeholders. It requires the ability to lead people and ensure cooperation as well as well developed professional skills to understand the project content. Finally, the methodology of project management is an essential condition as well.

As a ***team leader***, a project manager should have the abilities inherent for any top manager: the ability to persuade, to "tackle an issue", to conduct talks and make decisions. They should have good stamina and teamwork skills, be reliable, responsible, communicative, creative, and self-motivated. The list can be continued.

A project manager should have excellent ***leadership skills***, which first of all implies cooperative management style. A project manager should be able to motivate the personnel and create comfortable working conditions for each team member to work to their utmost capacity and produce to the maximum of their abilities. It can be achieved if each team member, though working quite independently, feels the managers' support and is interested in the project tasks.

Professional qualification of a project manager includes all knowledge, experience and skills related to the project content. It is desirable for a project manager to be a professional in the project sphere, or at least not to be a layperson. As a rule, there are specialists in particular areas, though, but it is impossible to manage effectively without deep understanding of the project essence.

In the 90s of the XX century and some years after there was a widespread opinion that it is possible to manage organizations, projects and processes without being a professional in the sphere of their activity. Currently, the whole branches of industry are being managed by people having no professional training and experience in these spheres. The fallacy of such viewpoint is proved by the failures and accidents regularly reported by mass media.

The crisis of unprofessionalism has spread in many countries including the developed ones, and the crisis spiral keeps on spinning. The reduction of higher education quality, which is resulted from its mass character and decline in financing per student, leads to the reduction of teaching staff quality, which, in its turn, has negative impact on secondary and higher education quality.

The continuing reforms of Russian education system made the situation worse. As Malyi M. puts it in his book:" There are millions of people who pretend to be doctors, engineers, teachers, journalists, and politics. Many of them have a twenty-year experience of such acting. No wonder, there is not a lack of talents in theaters: many Russians play others' role in their lives" [4].

It is obvious that, in a large project, a project manager and a team cannot be specialists in all aspects of the project. But each of the team member should be a professional in a particular area, and the project leader should have basic knowledge in the sphere of the project implementation to clear up the project details and, if necessary, to understand and assess invited experts' opinions. The experience in IT-project implementation proves that only specialists in some of the IT areas can effectively manage such projects.

Finally, a project manager should have an adequate ***project management qualification,*** which means knowing the methodology and techniques of project management as well as practical experience in this sphere. Bearing the main responsibility for the project, a project manager should feel confident for the work to be organized and completed successfully.

Since projects are created to solve some particular problems, it is desirable for a project leader to be able to use ***applied system analysis.*** Besides, the subject "project management" can be regarded as a special case of applied system analysis.

It is also important for a project manager to know the methods of feasibility study, assessment of project solutions, economic and management accounting at least to understand adequately the corresponding documents and make correct decisions in these spheres.

High erudition in related disciplines of science and deep understanding of global challenges, political and economic issues also contribute to effective project management.

Project manager's tasks

There are a great number of tasks for a project manager to perform:

- to specify the set objectives in terms of quality requirements, terms, costs, resources, etc.;
- to register the coordinated objectives in a project specification and obtain customer's approval;
- to check feasibility of the project goals;
- to coordinate the organizational structure of the project and arrangement of the project performance;
- to arrange the system of planning, management and information according to the project type and scale;
- to plan the project;
- to control and manage the project;
- to make decisions on alternatives regarding the subject of the project and the implementation process;
- to arrange and make principle decisions, for example about laying-off;
- to provide necessary resources;
- to manage team members and their motivation factors;
- delegation of tasks and goal setting for counterparts;
- to coordinate the project members both inside and outside the project;
- to inform regularly the head of the enterprise and the customer about the project performance and needs.

All these tasks can be performed successfully only on condition that the project manager is supported by the head of the enterprise.

To choose a project manager is a complicated task mostly based on personal quality of a candidate rather than the project's content. In this case, a competency model could be an effective tool. This model can be created by the analogy with the competency model of a faculty member of University, since the sets of key competencies are practical the same [5].

The desirable features of a project manager's personality are the following [6]:

- flexibility and adaptability;
- leadership and self-driving;
- assertiveness, confidence, the ability to persuade, smooth tongue;
- ambition, strong will;
- effective communicator and integrator;
- wide scope of interests;
- consistence, enthusiasm, imagination, fidelity;
- the ability to coordinate technical solutions with terms, costs and human resource;
- good self-organization and self-discipline;
- the ability to be more a generalist than a specialist;
- the ability and wish to spend a lot of time planning and controlling;
- the ability to identify problems;
- decision maker;
- the ability to use time effectively.

Any project manager should possess at least 70–80 % of the features mentioned above. Perhaps, Imhotep, the first Egyptian pyramid designer and builder, must have met most of these requirements [7, 8]. In the XXth century in the USSR, the most effective managers were Kurchatov I.V. [9], Beriya L.P. [10], Korolev S.P. [11], Tupolev A.N. [12] and some other prominent programme and project leaders.

Specific requirements for project managers, their rights and responsibilities

It is crucial for the personal goals of a project manager be the same as the project goals. Though a complete overlap of objectives is unreal, too big difference between the project objectives and those of a project manager makes the project manager be unsuitable for the job.

To meet a big number of the requirements, project manager should be healthy and keep healthy. It is an uneasy task since their work-week often exceeds 60 hours. In addition, their responsibilities can imply business trips and work far from their homes. Kerzner H. notes that if a project manager tends to love his/her job more than his/her family, it can result in bad family relationship, loss of friends and, possibly, divorce [6].

Research proved that in the USA, the number of divorces in the families of project managers and leading specialists of the teams doubled the average number of divorces, when they were working on large space projects. They manifested the following typical features of work addiction:

- every Friday they felt to have two more working days before Monday;
- they felt 5 hours p.m. to be a noonday;
- they did not have time for rest;
- they always took work home;
- they always took work for holidays.

A creative component is quite important in innovative projects. To use a creative potential of the team members to full extend, a project manager has to know modern approaches to staff management and organizational behavior. The method of "sticks and carrots" is absolutely contraindicated for the team members since it leads to their demotivation.

As a rule, heads of big organizations do not participate in routine work of their staff. In regard to project managers, in our opinion and experience, they have to take part in developing project solutions. It is inevitable since they should directly influence the project results. The effectiveness of the influence is ensured by direct participation in the project, because the project results are less predictable than the results of linear manager's activity. It does not mean that project managers should deal much with details, but it is for them to participate in making conceptual decisions.

One of the complicated issues is to set a salary level for a project manager. It is reasonable that project managers have approximately the same salary as the people they have to regularly negotiate and collaborate with. As a rule, these are the heads of functional units. Experience shows that conflicts appear if project manager's salary is significantly more or less than the salary of linear managers. Linear managers often say that they cannot "control these prima donnes who are paid higher and have higher rank than the linear managers" in addition to their common responsibilities [6]. At the same time, organization of effective project team should not be impeded by salary and ranks. If necessary, a person with higher position can be subordinated to a person with lower rank for the time of a project performance.

To choose a project manager is an important top managers' responsibility. If a person seems to be a potentially successful project manager, there are some options for the top managers of the enterprise:

1. to increase salary and rank and offer him/her a project management job.

2. to offer him/her a project management job without a pay and rank raise. The salary and rank are increased in three-six months on condition of successful project progress.

3. to slightly increase salary without rank raise or to raise rank with the same level of salary. The successful project results ensure significant pay and rank raise.

Many top managers consider with reason that an employee entering project management has only two paths of the career development – promotion or dismission [6]. If an employee was given a pay and rank raise and failed, there is no position left for him/her in the previous linear structure. Thus, most top managers and employees prefer the latter option, since it ensures safety for both parts. It is quite natural for the employee to resist coming back with the stigma of having been a manager of a failed project. Many top managers become aware too late that a set of requirements for a project manager differs from that for linear managers. The first is based on communicative abilities while the latter is based on technical knowledge and skills. However, the author considers it applicable for a common promotion.

Project manager's possibilities are very dependable on his/her position in the organization and the project team. Thus, it is recommended to register his/her rights and responsibilities to avoid possible conflicts on this issue. Project manager's rights relating to staffing and decision making, disciplinary rights and others should not only be clearly defined but registered.

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UDC 378

Dependence of Interdisciplinary Project Management on Difference Between Corporate Cultures

National Research Tomsk Polytechnic University
P.A. Podrezova, V.M. Kizeev

P.A. Podrezova

V.M. Kizeev

The article discusses the influence of corporate culture on a large interdisciplinary project organization. In particular, the case when large organizations involved in a project have a vertical linear structure and unique corporate culture. The article describes the project "The opening of the research and educational center "Modern manufacturing technologies" as an example.

Key words: interdisciplinary projects, management, corporate culture, networking.

The world is rapidly changing due to development of new technologies. It primarily influences the management sphere. Nowadays, the management models which did not exist 50 years ago are used, the management theory itself appeared only in the middle of the previous century and since then has been developing at ever evolving pace.

For instance, to develop innovations a company needs a special reliable environment where one can promptly exchange ideas, thoughts, and knowledge. Besides, one of the premises for development is that in modern science the interdisciplinary issues are becoming more topical (biology, economics, philosophy, physics, etc.). Interdisciplinarity and cooperation are those keys to success for business development [5]. Thus, innovative developments in such spheres as medicine and IT do not surprise anybody, but nowadays, such sphere as bioinformatics (a discipline at the interface of mathematics, IT, and medicine) is being developed. The experts of this sphere process and analyze large amount of data in the medical laboratories, develop software to handle information, since ordinary medical professionals fail to process such a large amount of data.

Hence, it is clear that interdisciplinary projects are under development. **Interdisciplinary projects** (projects based on network cooperation) are projects uniting efforts and resources of several companies-partners on mutually beneficial terms to achieve innovative results [5].

For example, one of the interdisciplinary projects implemented in National Research Tomsk Polytechnic University (TPU) is "The arrangement of the research and educational center 'Modern manufacturing technologies' in Institute of High Technology Physics (IHTP), TPU.

The functions of "Modern manufacturing technologies" center are to develop and implement additive technologies of domestic production. The center makes complete production cycle of additive technologies: from ideas of new material development to investigation of final product. The developed technologies are demanded by aviation and space, automobile, machine-tool and ship-building industries, chemical production and nuclear engineering [6].

The project managers are both research-educational institutions, research institutes and large corporations: Institute of High Technology Physics (TPU), Institute of Strength Physics and Materials Sciences (SB RAS), All-Russian Scientific Research Institute of Aviation Materials, S.P. Korolev

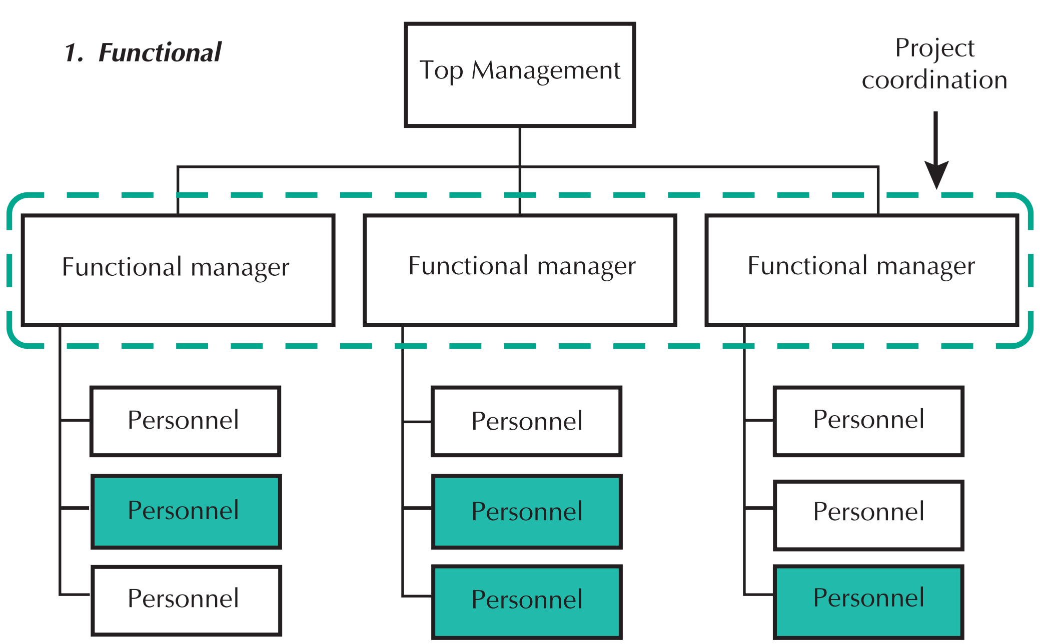
Rocket and Space Corporation "Energia", JC "United engine corporation", Department of Technology of Organic Substances and Polymer Materials and Department of Laser and Lighting Engineering (TPU) and others.

As it can be seen, the employees (in total, about 16 workers) involved from different institutions (from institutes of SB RAS, TPU departments, newly-employed staff from business companies) work in the center.

Every company or organization involved in the project has its peculiarities, its own corporate culture. Therefore, one of the major challenges is the difference in corporate cultures of participating companies. The former technologists accustomed to work in factory environment under tight time-restrictions, cannot cooperate with university researchers postponing the problem solution for an indefinite time period. Besides, the cooperation is not often established due to relative isolation of research teams, differences of cultures and traditions, lack of understanding the benefits of cooperation, and, as a consequence, reluctance to cooperate. In the course of traditional project6 it is possible to arrange a number of strategic workshops and meetings to establish common goals. Therefore, when performing such projects selection of personnel ready for cooperation is one of the key challenges on the way to success. In addition, very narrow staff specialization does not allow them to communicate in one professional language (chemists, programmer, physicists etc.). It can result in misunderstanding, which is managed by a special group within the project and, consequently, lead to absence of team spirit [2].

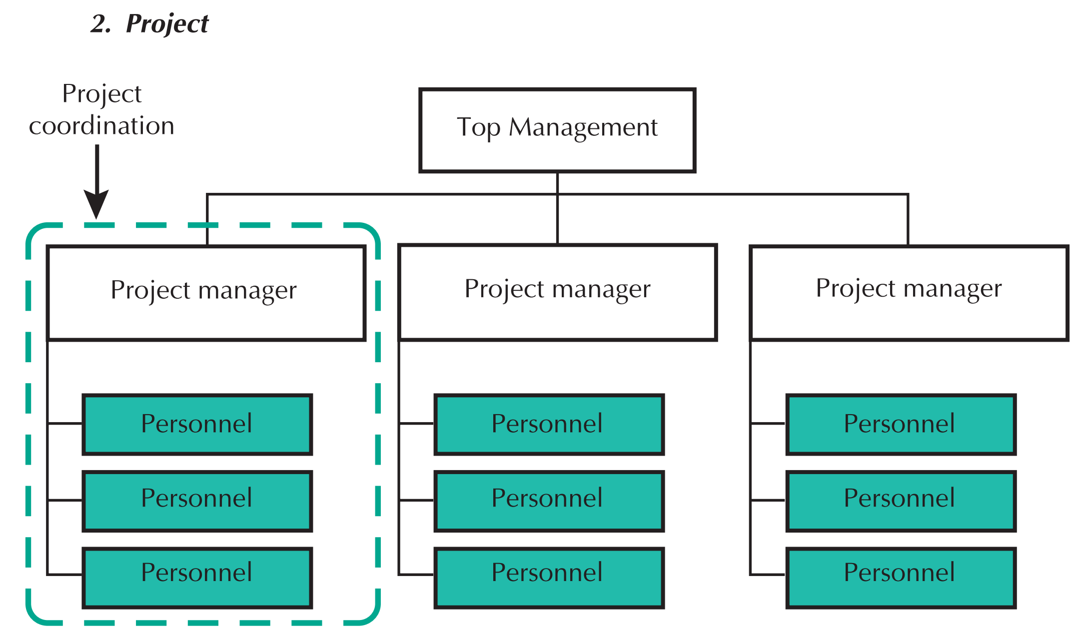
How does corporate culture influence the management of interdisciplinary project? To answer this question, one should know the different types of management structures. (Fig. 1-3).

Fig. 1. Functional management structure



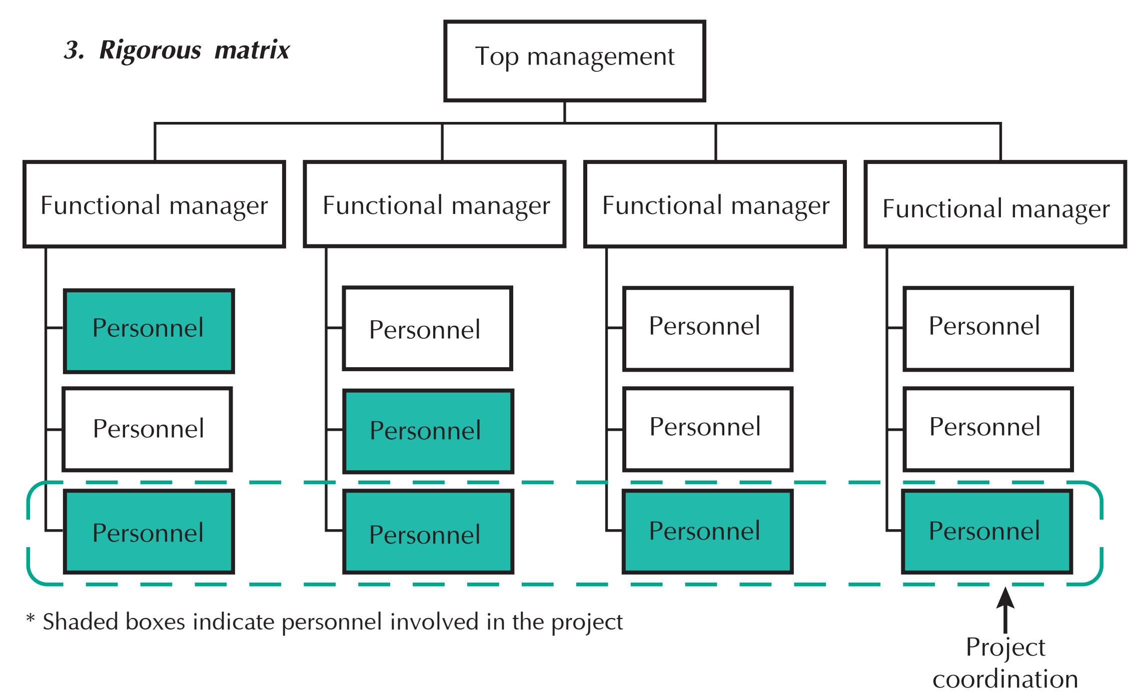
* Shaded boxes indicate personnel involved in the project

Fig. 2. Project organizational structure



* Shaded boxes indicate personnel involved in the project

Fig. 3. The example of organizational structure – rigorous matrix



* Shaded boxes indicate personnel involved in the project

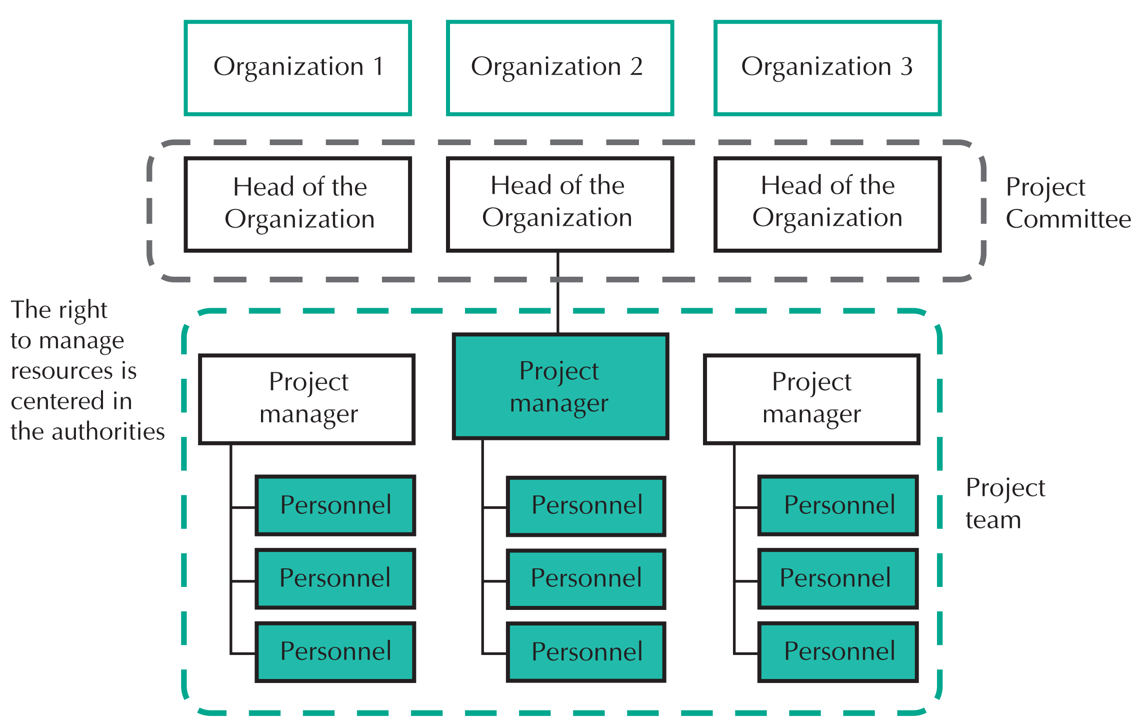
Performing the projects in the functional structure company there is a sufficient disadvantage: if a manager is appointed in one of the departments, but a project team consists of players from different departments, many problems have to be solved addressing directly to the functional manager who, in his/her turn, has to apply to the functional manager of another department. Only after that the decision is taken at the level of personnel. As a result, in such an organization structure much time is spent not on teamwork, but on solution of some bureaucratic problems via functional managers, and coordination of some issues may take too much time.

Project organizational structure is, to some extent, ideal or the most appropriate to implement interdisciplinary projects. Within the organization, a project manager is appointed. He/she has a direct supervision over project personnel, distributes the tasks. The personnel are involved into a definite project. Decisions are taken effectively. An intermediate decision is a rigorous matrix where there is a functional manager who performs definite blocks of job and supervisor of project managers who provides administrative support.

In this structure a project manager has more influence and control as compared to that in the functional structure. It should be noted that most structures, such as TPU, Rocket and Space Corporation "Energia" are of functional type. When we are in the frame of one structure, we have a number of challenges when performing project work. They are conditioned by the fact that structure of the organization is not often fully adjusted to the network cooperation. The process becomes even more complicated when we deal with several organizations.

Let us consider the project structure as an example, in which organizations implement interdisciplinary project (Fig. 4).

Fig. 4. Organization structure of interdisciplinary project



* Shaded boxes indicate personnel involved in the project

The companies implement project using a united pool of resources. The scheme includes heads of organization that are a part of in Project Committee and are project managers. Moreover, one of the organizations takes the primary responsibility in managing, the main project manager is selected, he has personnel involved in the project. The other organizations select their project managers from the organizations with delegated authorities and competencies, possessing required resources – a project team. The rights to manage resources and take decisions are given to top management, i.e. the Project Committee. Therefore, main project manager does not have an authority to manage resources of two neighboring organizations. To manage the resources, he has to appeal to the project manager of his organization for project manager, in his/her turn, to discuss the topical issues with the organizations-neighbours and give instructions to the project managers of neighboring organizations.

The chain is rather complicated and, what is more, the process described above takes much time which is highly valued nowadays. Project manager can easily manage his personnel, but to manage the personnel of the neighboring organization he has to deal with facilitators – project managers of this organization. The personnel do not have significant communicative resources to contact each other; therefore, knowledge management is often ineffective in the project [3].

Hence, it is seen that to implement project based on network cooperation is much easier that to do it alone. But there are some underdeveloped issues in network cooperation that impede successful project implementation.

In 2015 at the International Congress the urgent issues related to project management were discussed.

The Table 1 shows the principle criteria for successful project implementation which should be specially considered when organizing team network cooperation.

Professional community becomes remote from hierarchy, team, and control. They are replaced by authoritarianism limitation and interdisciplinary cooperation, flexible organization, and international supply chains [1].

When updating success criteria for interdisciplinary projects, one should take into consideration the corporate culture typical for an organization:

1. Clan (family) culture:

- Key value is team.
- Attention is paid to internal respect, friendship, traditions.
- Absence of official rules, the base of the culture is feelings and trust.

Table 1. Current trends in interdisciplinary project management

Yesterday	Today
▪ Hierarchy development ▪ Team and control ▪ Cost management ▪ Staff table management ▪ Project process management	▪ Authoritarianism limitation ▪ Interdisciplinary cooperation ▪ Flexible organization ▪ Leadership ▪ Expenditure ▪ International supply chains ▪ Time-table ▪ Project process management

Such a culture is often common for educational institutions, including university departments.

2. Adhocracy culture. It typical features are:

- Promotion of innovation and initiatives.
- Flexibility in decision taking.
- Willingness to take risk.

As a rule, such a culture is typical for start-ups.

3. Market culture:

- Developed, as a rule, at the stage of company rapid growth.
- Focus on the result, success.
- Competitive workplace.

The main thing in the given type of culture is to gain result. Therefore, if a team player does not have required competencies for a current position, he/she can be promptly replaced as a result of developed competitive system. In market culture there is hardly any "family" relations. An employee not meeting certain criteria and requirements for the position he/she occupies is treated by the company and staff as an unwanted element since he/she is not ready for achieving results.

4. Hierarchical (bureaucratic) culture:

- Regulation development.
- Formal processes.
- High control level.

The examples of hierarchical culture are authority organizations which are most likely to have administrative control, subordination and strict execution of instructions [4].

Thus, we can see that the head of interdisciplinary project has not only problems with access and management of project resources, but also faces the challenges of different cultures and, therefore, the project team should strive to build homogeneous corporate culture.

One may take three organizations in different spheres as an example: a university with its clan culture, commercial company with its market culture, and administrative corporation having developed bureaucratic culture. Hence, bureaucratic culture implies power; management is performed via written orders and instructions. In clan culture there is more loyalty to the staff, one can often experience paternalism or the case when one turns a blind eye to some staff's faults. Market culture is characterized by significance of deadlines, budgets, effective commodity promotion. The project manager used to work in one culture cannot understand the rules of interaction taken from other cultures. If it is common for the bureaucratic culture to consider an important question within a week, giving a lot of documents, signatures, and seals in advance, for the market culture it is believed to be unacceptable to put off consideration of important question for a week. Hence, there is a conflict of behavior patterns in different cultures resulting in misunderstanding of project participants. As a consequence, there is lack of confidence among the staff that can lead to a conflict.

Implementing the interdisciplinary project it is necessary to arrange a project office where the key issue is origin of a person and multiculturalism of supervisor, as he/she has to be able to work in different cultures [7].

Based on the project of manufacturing technology research and educational center, one can distinguish the following lessons learnt:

- **Changeability of goal statements in the course of project.**

It is quite a typical environment for research projects. Project team seeks to develop a definite innovative technique, has no idea if it is possible to perform because many parameters are unknown as they are implemented for the first time.

- **Centralized procurement of required materials and equipment for the project.**

The best option is investments by all project organizations-participants in a particular structure. Subsequently, this source is used to fund the whole project. If the project manager does not have an access to funds, the project is drawn out due to difference in corporate cultures and procedures.

- **Analysis of staff's parallel performance of other projects and tasks.**

Apart from work under a particular project, university staff have additional responsibilities, such as teaching or research work. They can often run counter to the project.

- **Information support.**

It is difficult for managers to monitor the project, particularly, if project manager is not from this organization.

- **Development of integrated IT-communication service.**

It is necessary to involve all participants in the project. For this purpose, one needs to create an integrated information portal where project news will be published and all project participants will have access to it. In this case both team and Project Committee will keep the track of events.

All lessons learnt are also the requirements for project manager's competencies and, as a consequence, for the interdisciplinary project management.

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M.S. Vaichuk

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Leadership and Corporate Culture, Their Impact on Company Growth

National Research Tomsk Polytechnic University
M.S. Vaichuk

The term "values" is no longer used only in a political context. The intangible factors become the key of stability and a driver of development. In this regard, the article provides the correlation of corporate culture development and the presence of a strong leader in a company with dynamics of companies' profitability ratios.

Key words: corporate culture, leadership, company growth, companies, management, values.

In our increasingly tangible world more and more researchers, teachers, businessmen and professional representatives are proclaiming the importance of cross-disciplinary research located at the intersection of subject knowledge and attaining a solid competitive advantage. Cross-disciplinary research involves not only the actual product development but also coordination, collaboration, target-setting associated with generating advanced knowledge. Accordingly, the reasonable question emerges – is the methodology for focused work management effective. This especially concerns the representatives of creative professions that are involved in multidirectional expert spheres and who have different visions in product and company strategic development.

In this case, one of the most urgently arising issues is corporate culture, and more exactly, consciously responsible behavior, embracing both commercial and non-profit companies throughout the world. This factor in itself is the major source of sustainable growth and protection from internal crisis development. Corporate culture includes basic and professional team building values, different in essence but not contradictory in general. However, shaping corporate culture depends, in most cases, on the leader and his/her applicable technology management and cross-disciplinary, which, in its turn, forwards new challenges. In view of this, it is institute leadership that is dominant including education establishments.

It should be noted that there is no unity standard in corporate culture. This could be based on such factors as official position, territory, age and discipline attributes shaping the so-called subculture of this or that company. At the same time there exist such risks as increasing business competition and growing ambition of enterprise representatives, government policy after-effect, changing market conditions and other obstacles resulting in the necessity of being ready for rejection reaction, remedial actions of internal and external challenges which could pose a threat for this or that company.

Summarizing the existing project implementation experience, the following required cross-disciplinary team characteristics could be identified:

1. knowledge assets;
2. leadership;
3. corporate culture [1].

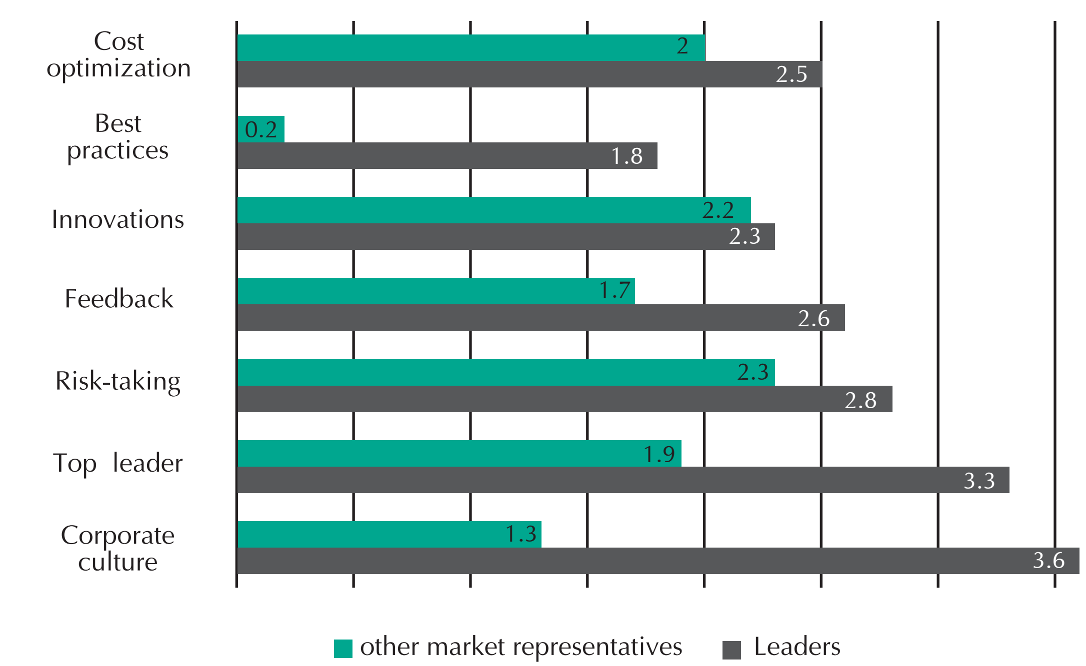
This fact has found confirmation in the conducted research of A.T. Kearney consulting firm which revealed the dominance of corporate culture and shaped leadership within the framework of project implementation and the company economic growth itself [2]. Unbiased leaders and other market representatives were questioned to define the factor sensitivity concerning their promotion and success. The grading was from 1– no strategic convictions in further development and 5 – obligatory commitments in perspective planning, the results of which can be seen in fig. 1.

There is a breakthrough in best practices as in most cases, they are cross-disciplinary products securing a company's leadership in this or that domain and, as a result, they are confidential excluding the possible competitive advantage. On the one hand, the first component- index is quite evident, while, on the other hand, the significant index difference in human resources requires rather full-sided study, especially in view of their influence on the development of personal best practices. The major "leader" differences, comparable to all market leader ones, are their focus on corporate culture values and institute leadership, the gap of which is 2.3 to 1.4.

It could be stated that both corporate culture and institute leadership are the main leverage over teamwork performance and team relationships. Definitely, developed and introduced advanced company product in the market could be successful; however, in the quest for a vigorous growth, dramatic failures inevitably forthcome, which poses risks to the existence of the product, while it is the selected human resources that are the backbone in the stable development opposing the external and internal reality challenges.

The importance of corporate culture is due to the awareness of the influence of value-conscious priorities and internal entity goals on corporation performance. Integrated and consistent progress towards the future would be impossible without the following aspects: favorably developed environment (reality), understanding, separation of company development strategies from the set goals, recognizing the importance of one's job, no goal-setting, no effective stimuli, no means of social mobility, and other problems. Identifying the workplace with one's home which one does not want to run away from or rapidly finishing one's work under the pressure of a competitive environment or even not coming to work at all – is a demonstrator of a favorable environment based on the

Fig. 1. Company evaluation of their growth factor



distribution of company values among the employees, project team members.

The main goal of the leadership institute includes the establishment and management of culture, providing effective activities in the implementation of the strategic goals and objectives. Specific cross-disciplinary feature stimulates a practical leader to be flexible and responsible, as well as have a willingness to unpredictable changes and capability for task-oriented changes. In this case, the leader should render the support of his/her employees in implementing projects and engage them as experts and consultants. The leader should be completely responsible for the final choice of this or that company action under new conditions, as well as the out-coming results of the company actions.

If the performed changes are positive, the organization repeats available results. It is the re-enforcement of this repetition that develops the company's awareness, further becoming the company's behavior stereotype in similar conditions and developing specific corporate culture values. The consequence is the identification and/or exclusion of basic and professional values. In the second case (exclusion) these values either drop out of the company or project team and encounter non-acceptable values of the leader and the team or become opposing element of the culture itself. This process greatly depends on the executive team and applicable management technology. In this case, leadership in modern economic relations plays an important role, being the guarantee of company success and prosperity [3, pp. 94-95].

Two trends, restricted to one case, have been identified as being not only similar but also different in the conceptual execution. Quite often corporate culture is considered the so-called cooperative entertainment activities, compelling dress code and attributes, expanded flags and mottoes. It is presumed that such activities could be resultant in the development of basic and professional values which, in its turn, could exclusively reveal only a surface demonstrative character; whereas the expected distribution does not occur.

This constitutes a ground for studying the effectiveness of corporate culture influence and the existence of leader “dominance” on the economic indexes of company functioning, the activity of which could be related to cross-disciplinary. The return changes of a company with an “ideal” internal environment (based on the opinion of current and ex-employees) and, respectively, a company where the employees “sonorously” described their leader were analyzed. Research database was the Internet portal of a consulting company Glassdoor.com [4]. Data source was comments and employee's interviews.

The research target was 15 top leaders, showing versatile activities, from each 2014 list. Information on the company returns of the investigated year including financial statements and official press information were analyzed. The first research target was focused on the corporate culture, reflected in the nomination “Best in work”. The results are depicted in tab. 1.

Only three companies showed an increase of more than 1 billion US dollars in 2014. This indicates such factors as relatively small amounts, employee's young age, as well as consequences of costly characteristics oriented on the internal environment (reality) and processes of shaping basic values. More relevant could be the comparison with average annual growth, the values of which usually correspond to the economic growth of a country. In 2014 this index was 2.4% annually, which is less than the average value of the considered companies – 9.57% [5].The indexes of strong leadership influence are illustrated in tab. 2.

Conspicuously, in the first and second cases the data were taken not only from IT-companies which are sweepingly attracting attention of the consumer, but also from retailer-representatives, consulting companies, producers, private clinics and others. Surprisingly, it was found that there are only two foregoing companies,

Table 1. Growth indicators of a company with developed corporate culture

Company	Corporate appraisal	Increasing revenues, %	Absolute deviation, billion US dollars
1. Google	4.5	18.3	10.16
2. Bain & Company	4.4	3.6	0.078
3. Nestlé Purina PetCare	4.4	1.98	0.224
4. F5 Networks	4.3	16.89	0.25
5. Boston Consulting Group	4.3	17	0.75
6. Chevron	4.2	-7.38	-16.88
7. In-N-Out Burger	4.2	23.66	0.11
8. McKinsey & Company	4.2	10.67	0.8
9. Mayo Clinic	4.2	3.6	0.34
10. Procter & Gamble	4.2	-1.32	-1.08
11. Brigham and Women's Hospital	4.2	3.6	0.15
12. Facebook	4.1	58.5	4.6
13. Qualcomm	4.1	6.51	1.62
14. Southwest Airlines	4.1	5.14	0.91
15. Slalom Consulting	4.1	18.75	0.09
Average	**4.23**	**11.97**	**0.139**
Total		**191.47**	**2.23**

i.e. representatives of the information industry which products developed at the intersection of disciplines: Google (leader – Larry Page) and social network Facebook (permanent leader Mark Zuckerberg).

Nourishing a “top” leader, the companies showed an average growth of about 19%, which is strikingly 6.81% more than in the case of those representatives focused on developing corporate culture. The same situation can be observed in annual cash-equivalent increase. For example, this annual increase included 90 billion dollars, which is 40 times more the index shown in table 1. Even if we exclude one top-performer in loss and growth, the average increase would still be 2.4 billion dollars which is 76% more comparable to the extra index in table 1 – 1.36 billion dollars.

Generally speaking, growth dynamics of companies with high encouraging values, the willingness to keep working is significantly lower than in the case of the companies with “top” leaders. In the first case, it is relatively unknown companies. Companies with strong energetic leaders are mainly major ones embracing the highly-profitable markets of information

Table 2. Growth indicators of a company with prominent leaders

Company leaders	Appraisal level	Increasing revenues, %	Absolute deviation, billion US dollars
1. Google	97	18.30	10.16
2. NIKE	97	9.84	2.49
3. Facebook	95	58.45	4.6
4. Ultimate Software	95	23.28	0.096
5. Monsanto Company	95	6.73	1
6. Goldman Sachs	95	-1.91	-0.78
7. Northwestern Mutual	95	3.09	0.8
8. Insight Global	94	32.9	0.3
9. Apple	94	27.86	50.92
10. Expedia	94	20.75	0.99
11. LinkedIn	93	45.1	0.69
12. Costco Wholesale	93	7.11	7.48
13. T-Mobile	93	21.06	5.144
14. Edward Jones	93	10.17	0.58
15. Network Capital	92	-1.51	-0.0004
Average	**94.33**	**18.78**	**5.631**
Total		**281.70**	**90.10**

application, telecommunication, financial sector and electronics production. Another factor is the problematic access to the financial data of such companies, excluding information on developed corporate culture. This indicates that there are two sides of this coin: a strong leader is more attractive for the public and investors, but he/she lacks the primacy motivation to increase both the company's financial indexes and improve the corporate culture by developing the values and domestic climate of the company itself.

Directly or indirectly, excluding existing contradictions, corporate culture and leadership are intrinsically interconnected and complement each other. Moreover, most researchers consider leadership the only explicit factor that influences corporate culture. This implies that leadership could be considered as the "polishing" process of corporate culture, developing those elements that would provide and guarantee the effective company performance in implementing its goals and strategies.

Practically, all examples illustrating the leadership influence on corporate culture include the description of several values developed by the company leader and the further value education. For this purpose, the leader should understand the actual motivation level, have allegiance to the existing company activities and know the demands of his/her employees. This, in its turn, would result in the value-based cohesion to further the set goals and tasks despite different knowledge component spheres, which optimizes continuous training, integrated target-setting and awareness of being in a team.

In conclusion, it should be noted that working under conditions of changed corporate culture and developed institute of leadership, being innovative and rare, actually produces results. Annual financial statements of described companies showed that these companies extensively outrun the average market growth index. Primarily, the influence of the leader on the company revenues reflects the role of this or that leader in the formation of corporate culture. However, obtained results could not fully illustrate the exclusive development of leader ambitions and potentials, lack of following corporate culture changes, especially in project teams. In view of this, the community, having shaped an ideal image of a leader, could be the main prosecutor in cases of a collision with formidable challenges in the future.

Integrating leadership "path", as well as, supporting corporate culture, is possible despite the existing changes in the company principles throughout the years. The team and company activities should include shaping common base values and developing leader personality as sustainable growth is only possible under the conditions of supporting human resource values.

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OUR AUTHORS

ANGÉLA VÁRADINÉ SZARKA
PhD, Dr.habil, Associate Professor, Head of Department of electrical and electronic Engineering, University of Debrecen
E-mail: angela.varadi@science.unideb.hu

CARLOS MARCELO
Professor in the Faculty of Sciences of Education at the University of Seville, Spain
E-mail: marcelo@us.es

CARMEN YOT
Research Assistant at the Faculty of Sciences of Education at the University of Seville, Spain
E-mail: carmenyot@us.es

JUAN JESUS PEREZ
Professor, Department of Chemical Engineering, Universitat Politecnica de Catalunya, Spain
E-mail: juan.jesus.perez@upc.edu

JOSÉ CARLOS QUADRADO
PhD, DSc, Habil in Engineering, Full Coordinating Professor, Vice President of Instituto Superior de Engenharia do Porto (ISEP)
E-mail: jcquadrado@gmail.com

LADISLAV MUSÍLEK
Professor, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czech Republic
E-mail: musilek@fjfi.cvut.cz

PHILLIP ALBERT SANGER
PhD, Full professor, School of Engineering Technology, Purdue Polytechnic Institute, Purdue University, USA
E-mail: psanger@purdue.edu

RUTH MARTINEZ-LOPEZ
PhD Candidate, Education Technology, Faculty of Sciences of Education at the University of Seville, Spain, Junior Researcher at Samara National Research University, Russia
E-mail: rm@ssau.ru

SERGEY SOSNOVSKY
Head of the Intelligent e-Learning Technology Lab in the Centre for e-Learning Technology (CeLTech) at the German Center for Artificial Intelligence (DFKI)
E-mail: tandor20@rambler.ru

ABDEEV RINAT GAZIZ'YANOVICH
DSc (Engineering Sciences), Professor, Head of Production Machines and Equipment Department, Bashkir State University
E-mail: bgutmo@mail.ru,
arg@bgutmo.ru

ABDEEV ELDAR RINATOVICH
PhD (Engineering Sciences), Associate Professor, Production Machines and Equipment Department, Bashkir State University
E-mail: bgutmo@mail.ru,
arg@bgutmo.ru

AKULYENOK MARINA VICTOROVNA
DSc (Engineering Sciences), Associate Professor, Department of Quality Control, National Research University of Electronic Technology MIET, Honorary Worker of Higher Professional Education
E-mail: amv@s2q.ru

BAKIEVA ELVIRA VALER'EVNA
PhD (Pedagogy) Associate Professor, Production Machines and Equipment Department, Bashkir State University
E-mail: bgutmo@mail.ru,
bakieva@bgutmo.ru

BARABANOVA SVETLANA VASIL'EVNA
DSc (Law), Associate Professor; Professor of Legal Studies, Kazan National Research Technological University, Honorary Worker of Higher Professional Education
E-mail: sveba@inbox.ru

BOGATOVA LARISA MIKHAILOVNA
DSc (Philosophy), Associate Professor, Professor of General Philosophy Department, Kazan Federal University
E-mail: bolami@inbox.ru

BOGDANOV ANDREY VICTOROVICH
DSc (Engineering Sciences), Professor, Department of Mineral Processing and Environmental Protection, Irkutsk National Research Technical University, Honorary Ecologist of Irkutsk Oblast
E-mail: bogdanov.lab@istu.edu

BOGOUDINOVA ROZA ZAKIROVNA
DSc (Pedagogy), Professor, Department of Engineering Pedagogy and Psychology, Kazan National Research Technological University, Honorary Scientist of the RF, Government Award in Education
E-mail: rozabog@bk.ru

BORONAKHIN ALEXANDER MIKHAILOVICH
DSc (Engineering Sciences), Associate Professor, Dean of Faculty of Information Measurement and Biotechnical Systems, Saint Petersburg Electrotechnical University "LETI"
E-mail: amboronahin@etu.ru

BUGAYEVA OLGA OLEGOVNA
Master-student (Innovations in Higher Education), Department of Management and Technology in Higher Professional Education, Institute of Humanities, Social Sciences & Technologies, engineer of Design and Research Institute, National Research Tomsk Polytechnic University
E-mail: oob1@tpu.ru

BUKALOVA GALINA VASIL'EVNA
PhD (Pedagogy), Associate Professor, Department of Machine Service and maintenance, State University ESPC, Orel
E-mail: 57orleya@gmail.com

VAICHUK MIKHAIL SERGEEVICH
Master-student, Department of Management and Technology in Higher Professional Education, Institute of Humanities, Social Sciences & Technologies, National Research Tomsk Polytechnic University
E-mail: VaychukMS@gmail.com

GALIKHANOV MANSUR FLORIDOVICH

DSc (Engineering Sciences), Professor, Vice-Director, Institute of Additional Professional Education, Kazan National Research Technological University

E-mail: mgalikhanov@yandex.ru

GORODETSKAYA INNA MIKHAILOVNA

PhD (Psychology), Associate Professor, Expert in Academic Affairs, Additional Professional Education Institute, Kazan National Research Technological University

E-mail: innamgor@mail.ru

GRISHIN DMITRY VYACHESLAVOVICH

Senior lecturer, Oil and Gas Well Drilling Department, Gubkin Russian State University of Oil and Gas (National Research University); Head of Service department, Research and Design Center of Oil and Gas Technologies, Professional Engineer of the RF

E-mail: D_Grishin@gasoilcenter.ru

DUBENETSKY VLADISLAV ALEKSEEVICH

PhD (Engineering Sciences), Associate Professor, Department of Information Systems, Saint Petersburg Electrotechnical University "LETI", Honorary Worker of Higher Professional Education of the RF

E-mail: chr12@yandex.ru

DUL'ZON ALFRED ANDREEVICH

DSc (Engineering Sciences), Professor, Department of Engineering Entrepreneurship, Institute of Humanities, Social Sciences & Technologies, National Research Tomsk Polytechnic University, Honorary Scientist of the RF

E-mail: vizepres@tpu.ru

ZHELEZNYAKOVA ANASTASIA VYACHESLAVOVNA

PhD (Engineering Sciences), Associate Professor, Department of Functional Electronics Materials, National Research University of Electronic Technology MIET

E-mail: stushka@bk.ru

ZAKHAROVA ANASTASIA GAVRIL'EVNA

Student, Department of Engineering Entrepreneurship, Institute of Humanities, Social Sciences & Technologies, National Research Tomsk Polytechnic University

E-mail: anastasiya_zakharova@mail.ru

IBRAGIMOV GASANGUSEYN IBRAGIMOVICH

DSc (Pedagogy), Professor, corresponding member of Russian Academy of Education, Professor of Engineering Pedagogy and Psychology Department, Kazan National Research Technological University, Honorary Scientist of the RF, Honorary Scientist of the Republic of Tatarstan, Government Award in Education of the RF (2005), Honorary Worker of Higher Professional Education of the RF, Honorary Worker of Vocational Education of the RF

E-mail:guseinibragimov@yandex.ru

IBRAGIMOVA ELENA MIKHAILOVNA

DSc (Pedagogy), Professor, Head of Theory and Methods of Teaching Law Department, Faculty of Law, Kazan Federal University, Honorary Teacher of the Republic of Tatarstan

E-mail: timop2001@mail.ru

IVANOV VASILY GRIGOR'EVICH

DSc (Pedagogy), Professor, First Vice Rector for Academic Affairs of Kazan National Research Technological University, Director of Additional Professional Education Institute, Head of Engineering Pedagogy and Psychology Department, corresponding member of Russian Academy of Pedagogical and Social Sciences, Honorary Worker of Higher Education of the RF

E-mail: dilanyr@mail.ru

IRISMETOV ALISHER IL'MURATOVICH

PhD (Pedagogy), Associate Professor, Department of Engineering Ecology, Engineering Pedagogy and Psychology Department, Kazan National Research Technological University

E-mail: alisher240381@mail.ru

KARABTSEV VLADIMIR SERGEEVICH

PhD (Engineering Sciences), Deputy Chief Designer for Science and Innovations, KAMAZ

E-mail: Vladimir.Karabtsev@kamaz.ru

KACHOR OLGA LEONIDOVNA

PhD (Engineering Sciences), Associate Professor, Department of Mineral Processing and Environmental Protection, Irkutsk National Research Technical University

E-mail: oll_ka@bk.ru

KIZEEV VENIAMIN MIKHAILOVICH

Senior lecturer, Department of Engineering Entrepreneurship, Institute of Humanities, Social Sciences & Technologies, National Research Tomsk Polytechnic University, director WIN Corp, Tomsk

E-mail: betula@tpu.ru

KONDRAT'EV VLADIMIR VLADIMIROVICH

DSc (Pedagogy), Associate Professor, Head of Professional Retraining and Advanced Training Center for University Professors of the Volga region and Urals, Head of Engineering Activity Methodology Department, Kazan National Research Technological Universityдоктор, RF Government Award in Education, Honorary Scientist of the Republic of Tatarstan

E-mail: vvkondr@mail.ru

KONYUKHOV IGOR NIKOLAEVICH

Methodologist, municipal state funded institution of additional education “Parus”, Ufa, the Republic of Bashkortostan

E-mail: vestnikki@mail.ru

KOSYKH ANATOLY VLADIMIROVICH

DSc (Engineering Sciences), Professor, Rector of Omsk State Technical University

E-mail: avkosykh@omgtu.ru

KUZNETSOV ALEXANDER GRIGOR'EVICH

PhD (Engineering Sciences), Senior Research Fellow, Associate Professor, Department of Information Systems, Saint Petersburg Electrotechnical University "LETI"

E-mail: chr12@yandex.ru

KUZNETSOV IGOR ROSTISLAVOVICH

PhD (Engineering Sciences), Associate Professor, Saint Petersburg Electrotechnical University "LETI"

E-mail: IRKuznetsov@etu.ru

KUTUZOV VLADIMIR MIKHAILOVICH

DSc (Engineering Sciences), Professor, Rector of Saint Petersburg Electrotechnical University "LETI", Honorary Worker of Higher Education of the RF, RF Government Award in Science and Technology, RF Government Award in Education

E-mail: vmkutuzov@eltech.ru

LARIONOVA OLGA ALEXANDROVNA

Post-graduate student, Engineering Pedagogy and Psychology Department, Kazan National Research Technological University

E-mail: larionova2802@rambler.ru

LIKHOLETOV VALERY VLADIMIROVICH

DSc (Pedagogy), PhD (Engineering Sciences), Associate Professor, Professor of Economics and Economic Security Department, South Ural State University (National Research University)

E-mail: likholetov@yandex.ru

LOBANOV MAXIM ALEXANDROVICH

Teaching Assistant, Associate Professor, Production Machines and Equipment Department, Bashkir State University

E-mail: bgutmo@mail.ru, lobanov@bgutmo.ru

LOSCHILOVA MARINA ANDREEVNA

Senior Lecturer, Department of Economics and Automated Control Systems, Urga Technological Institute, National Research Tomsk Polytechnic University

E-mail: marisha20@bk.ru

LYSENKO NIKOLAY VLADIMIROVICH

DSc (Engineering Sciences), Professor, Head of Television and Video Engineering Department, Saint Petersburg Electrotechnical University "LETI"

E-mail: nvlysenko@etu.ru

MAKAROVA IRINA VICTOROVNA

DSc (Engineering Sciences), Professor, Transport Systems Service Department, Kazan Federal University - Naberezhnye Chelny Institute, Honorary Worker of Higher Professional Education of the RF

E-mail: kamIVM@mail.ru

MALYSHEV VIKTOR NUKOLAEVICH

DSc (Engineering Sciences), Professor, Dean of Faculty of Radio Engineering, Saint Petersburg Electrotechnical University "LETI", Honorary Worker of Higher Professional Education of the RF

E-mail: VNMalyshev@etu.ru

MINGAZOVA DILYARA NUROVNA

Assistant Director of Additional Professional Education Institute, Kazan National Research Technological University

E-mail: idpoknitu@mail.ru

MININA ANASTASIA ANDREEVNA

PhD (Engineering Sciences), Associate Professor, Deputy Senior Vice-Rector, Executive Secretary of Admission Committee, Saint Petersburg Electrotechnical University "LETI"

E-mail: aaminina@etu.ru

MIFTAKHUTDINOVA LILIYA TAGIROVNA

PhD (Philology), Associate Professor, Deputy Director of Additional Professional Education Institute, Director of Open (Distance) Learning Center, Kazan National Research Technological University

E-mail: nelufer@yandex.ru, miftakhutdinova@kstu.ru

MIKHEEVA SVETLANA ALEXANDROVNA

Director of Personnel Development Department, KAMAZ

E-mail: miheeva@kamaz.ru

MYSHLYAVTSEV ALEXANDER VLADIMIROVICH

DSc (Engineering Sciences), Professor, Vice-Rector (Education), Omsk State Technical University

E-mail: myshl@omgtu.ru

PAVLOV VLADIMIR NIKOLAEVICH

PhD (Engineering Sciences) Associate Professor, Vice-Rector for Scientific Affairs, Saint Petersburg Electrotechnical University "LETI"

E-mail: pvn1955@etu.ru

PAVLOVA IRINA VICTOROVNA

PhD (Chemistry), Associate Professor, Engineering Pedagogy and Psychology Department, Kazan National Research Technological University

E-mail: ipavlova@list.ru

PEL'MENYEVA ANASTASIA ALEKSEEVNA

PhD (Economics), Associate Professor, Economics of Oil and Gas Industry Department, Gubkin Russian State University of Oil and Gas (National Research University)

E-mail: anastasia_plmn@mail.ru

PETKAU OLEG GERGARDOVICH

PhD (Engineering Sciences), General Director of Scientific Research Institute Vektor, Government Award in Science and Technology of the RF

E-mail: nii@nii-vektor.ru

**PODREZOVA
POLINA ANDREEVNA**

Master student, Institute of Humanities, Social Sciences & Technologies, National Research Tomsk Polytechnic University, project coordinator "WIN business decisions", Tomsk

E-mail: polinapodrezova@gmail.com

**PONOMAREVA
KSENIYA OLEGOVNA**

Student, Department of Engineering Entrepreneurship, Institute of Humanities, Social Sciences & Technologies, National Research Tomsk Polytechnic University

E-mail: ponomareva.k.1995@yandex.ru

**POKHOLKOV
YURY PETROVICH**

DSc (Engineering Sciences), Professor, Head of Management and Technology in Higher Professional Education Department, Institute of Humanities, SocialSciences and Technologies, National Research Tomsk Polytechnic University, President of the Association for Engineering Education of Russia, Government Award in Education, Honorary Worker of Science and Technology

E-mail: pyuori@mail.ru

**PUZANKOV
DMITRY VICTOROVICH**

DSc (Engineering Sciences), Professor, Professor Emeritus of Saint Petersburg Electrotechnical University "LETI", Rector (1998-2009), Honorary Scientist of the RF

E-mail: dvpuzankov@mail.ru

**PYATIBRATOV
PETR VADIMOVICH**

PhD (Engineering Sciences), Associate Professor, Department of Oil Field Development, Gubkin Russian State University of Oil and Gas (National Research University), RF Government Award in Science and Technology for Young Scientists, RF Government Award in Education

E-mail: pyatibratov.p@gmail.com

**REDIN
LEV VADIMOVICH**

PhD (Engineering Sciences), Associate Professor, Engineering Pedagogy and Psychology Department, Kazan National Research Technological University

E-mail: levvr@mail.ru

**REZNICHENKO
MARIA GENNAD'EVNA**

DSc (Pedagogy), Professor, Department of Social Systems and Law, Samara State University

E-mail: rezmary@mail.ru

**SEMYENOV
VICTOR PAVLOVICH**

DSc (Economics), Professor, Head of Management and Quality Systems Department, Saint Petersburg Electrotechnical University "LETI"

E-mail: vps@etu.ru

**SIRAZITDINOVA
YULIYA SHAMIL'EVNA**

Deputy Director of RASA Center, Tomsk; Senior lecturer, Department of Engineering Entrepreneurship, Institute of Humanities, Social Sciences & Technologies, National Research Tomsk Polytechnic University

E-mail: sirazitdinova@tpu.ru

**STARSHINOVA
TATYANA ALEXANDROVNA**

PhD (Pedagogy), Associate Professor, Engineering Pedagogy and Psychology Department, Kazan National Research Technological University

E-mail: tstar@any.com

**STYCHKOVA
VERONIKA IGOREVNA**

Senior Lecturer, Department of Foreign Languages and Russian as Secondary Language, Samara State University

E-mail: veronika_stychkova@mail.ru

**TARAKANOV
ALEXANDER YUR'EVICH**

Head of Research and Specialist Training Center, Scientific Research Institute Vektor

E-mail: atarakanov@list.ru

**TARASOVA
EKATERINA NIKOLAEVNA**

PhD (Pedagogy), Associate Professor, Urga Technological Institute, National Research Tomsk Polytechnic University

E-mail: artemm2005@ya.ru

**TIMOFEEV
OLEG NIKOLAEVICH**

PhD (Engineering Sciences), Associate Professor, Engineering Pedagogy and Psychology Department, Kazan National Research Technological University

E-mail: Timofeev_ON@mail.ru

**TOLKACHEVA
KSENIA KONSTANTINOVNA**

Specialist, Department of Management and Technology in Higher Professional Education, Institute of Humanities, Social Sciences and Technologies, National Research Tomsk Polytechnic University, Manager, Russian Association of Engineering Education (AEER)

e-mail: tolkacheva@tpu.ru

**USHENIN
ALEXANDER MIKHAILOVICH**

Chief Human Resources and Development Officer, KAMAZ

E-mail: ushenin@kamaz.org

**KHABIBULLIN
RIFAT GABDULKHANOVICH**

DSc (Engineering Sciences), Professor, Head of Transport Systems Service Department, Kazan Federal University - Naberezhnye Chelny Institute, Honorary Worker of Higher Professional Education of the RF

E-mail: hrg_kampi@mail.ru

**KHATSRINOVA
OLGA YUR'EVNA**

PhD (Engineering Sciences), Associate Professor, Engineering Pedagogy and Psychology Department, Kazan National Research Technological University

E-mail: khatsrinovao@mail.ru

**KHOKHLOVA
MARIA SERGEEVNA**

PhD (Geology and Mineralogy), Associate Professor, Department of Geophysical Information Systems, Gubkin Russian State University of Oil and Gas (National Research University), RF Government Award in Science and Technology for Young Scientists

E-mail: khokhlova.ms@gubkin.ru

TSEKHANOVSKY VLADISLAV VLADIMIROVICH

PhD (Engineering Sciences), Associate Professor, Head of Information Systems Department, Saint Petersburg Electrotechnical University, Honorary Worker of Higher Professional Education of the RF

E-mail: chr12@yandex.ru

SHAGEEVA FARIDA TAGIROVNA

DSc (Pedagogy), Associate Professor, Dean of Additional Professional Education Institute, Professor of Engineering Pedagogy and Psychology Department, Kazan National Research Technological Universityдоктор, Honorary Worker of Higher Professional Education of the RF

E-mail: faridash@bk.ru

SHALAY VICTOR VLADIMIROVICH

DSc (Engineering Sciences), Professor, President of Omsk State Technical University, Honorary Worker of Higher Education of the RF

E-mail: shalay@omgtu.ru

SHALYMOV ROMAN VADIMOVICH

PhD (Engineering Sciences), Deputy Dean for Enrollment and Occupational Guidance, Faculty of Information Measurement and Biotechnical Systems, Saint Petersburg Electrotechnical University "LETI"

E-mail: rvshalymov@etu.ru

SHAPOSHNIKOV SERGEY OLEGOVICH

PhD (Engineering Sciences), Associate Professor, Executive Director of Information Expertise Center in Engineering Education Development, Saint Petersburg Electrotechnical University "LETI", Honorary Worker of Higher Education of the RF

E-mail: soshaposhnikov@gmail.com

SHATROVA ANASTASIA SERGEEVNA

Post-graduate student, Department of Mineral Processing and Environmental Protection, Irkutsk National Research Technical University

E-mail: unicorn1990@rambler.ru

SHVETSOV VLADIMIR IVANOVICH

DSc (Engineering Sciences), Professor, Department of Mathematical Support and Supercomputer Technologies, Institute of Information Technology, Mathematics and Mechanics, Lobachevsky State University of Nizhni Novgorod (UNN), Government Award in Education of the RF

E-mail: shvetsov@unn.ru

SHEVCHENKO MAIYA EVGEN'EVNA

PhD (Engineering Sciences), Associate Professor, Saint Petersburg Electrotechnical University "LETI"

E-mail: m_e_shevchenko@mail.ru

SHEINBAUM VICTOR SOLOMONOVICH

PhD (Engineering Sciences), Associate Professor, Rector Advisor, Professor of Department of Machines and Equipment for Oil and Gas Industry, Gubkin Russian State University of Oil and Gas (National Research University), RF Government Award in Education, Honorary Worker of Higher Education, Honorary Worker of the Ministry of Fuel and Energy, Honorary Worker of Higher Professional Education of the RF, Honorary Petroleum Engineer, Honorary Worker of Petroleum Industry

E-mail: shvs@gubkin.ru

SHMAKOV BORIS VASIL'EVICH

PhD (Economics), Associate Professor, Department of Entrepreneurship and management, South Ural State University (National Research University)

E-mail: shboris17a@mail.ru

SHTRIPLING LEV OTTOVICH

DSc (Engineering Sciences), Professor, Vice-Rector for Academic Affairs, Omsk State Technical University, Honorary Worker of Higher Education of the RF

E-mail: los@omgtu.ru

Summary

ENGINEERING STAFF DEVELOPMENT IN RESEARCH UNIVERSITY: SYNERGY OF TRADITIONS AND INNOVATIONS

V.G. Ivanov, S.V. Barabanova,
M.F. Galikhanov, L.T. Miftakhutdinova
Kazan National Research Technological University

The paper deals with innovative processes in additional professional education for engineers. These processes are based on the modern state educational policy, new educational technologies, and multidisciplinary approach. The experience of KNRTU in designing continuing professional development programmes in cooperation with business partners is suggested as a positive model.

GLOBAL INTERDISCIPLINARY TEAMS IN ENGINEERING EDUCATION

J.C. Quadrado
Instituto Superior de Engenharia do Porto (ISEP)
K.K. Tolkacheva
National Research Tomsk Polytechnic University
Association for Engineering Education of Russia

Multiple disciplines approach, which includes global enhanced interdisciplinarity, has been discussed in the engineering education context from the early 21st Century. There is very little disagreement about its importance for the engineers, the key question has been how to implement theory into practice both in the curriculum and in the actual learning enhancement phase. Both Problem-based learning and CDIO framework are constructivist learning approaches that emphasize these issues. In this paper, we discuss how to mitigate the social distance in these global education teams and therefore how it becomes the primary management challenge for the global interdisciplinary team leader. The management of the social distance is then paramount to identify and successfully improve the social distance. This approach reflects several components, namely, the structure, the process, the language, the identity, and the technology used. A successful interdisciplinary and multidisciplinary teacher/learning depends on the general team dynamics. Several strategies to enhance interdisciplinary teams in engineering education are presented.

ENGINEERS FOR INTERDISCIPLINARY TEAMS AND PROJECTS: MANAGEMENT OF TRAINING PROCESS

Yu.P. Pokholkov
National Research Tomsk Polytechnic University
Association for Engineering Education of Russia

The paper deals with the management issues of training specialists in the field of engineering and technology ready to work in interdisciplinary teams and projects. Interdisciplinarity in the engineering education is considered as a basis for critically new competitive engineering solutions. The indicators proving the presence of interdisciplinary management system at university are outlined. Based on the elaborated principles of interdisciplinary activities a set of required tools and elements to manage interdisciplinary training of engineers is presented.

INTERDISCIPLINARY APPROACH IN ENGINEERING EDUCATION IN TERMS OF INTERNATIONAL FRAMEWORKS AND METHODOLOGY

V.M. Kutuzov, V.N. Pavlov,
D.V. Puzankov, S.O. Shaposhnikov
Saint Petersburg Electrotechnical University "LETI"

The article analyzes the standards and guidelines of international educational frameworks and initiatives in terms of interdisciplinarity of degree programmes in Engineering and Technology.

POSSIBLE ALTERNATIVE OF INTERDISCIPLINARY LEARNING IN RUSSIAN ENGINEERING TRAINING SYSTEM

I.N. Konyukhov
Municipal state funded institution of additional education "Parus", Ufa city

At present the Russian system of supplementary education for schoolchildren does not imply interdisciplinary learning. One of the alternatives of such learning is to develop supplementary education programmes for school age children that would involve diverse scientific and activity areas. Another challenge is to train instructors who would be able to implement such programs.

THE ENGAGEMENT OF EDUCATIONAL PROCESS INTO THE PRACTICAL ACTIVITIES AS A MAIN ROUTE FOR DEVELOPMENT OF MODERN ENGINEERING EDUCATION

V.V. Shalay, A.V. Kosykh,
A.V. Myshlyavtsev, L.O. Shtripling
Omsk State Technical University

The best practices and perspectives of practice-oriented education development are disclosed in the article.

INTERDISCIPLINARY APPROACH IN INTERACTIVE SELF-LEARNING

R.Z. Bogoudinova, I.M. Gorordetskaya
Kazan National Research Technological University

The paper considers theoretical and methodological bases for interdisciplinary approach to interactive self-learning and principles of academic process organization via interactive learning techniques.

INTERDISCIPLINARY INTERACTION IN ISO 9001-2015 STANDARDS

M.V. Akulenok
National Research University of Electronic Technology MIET

The article is devoted to the analysis of quality management system of interdisciplinary interaction and trends in university QMS improvement in accordance with the requirements of the new implemented edition of International ISO 9000 standards, in particular, the requirement for risk management.

TECHNOLOGY IN THE LEARNING DESIGN BY UNIVERSITY TEACHERS IN THE RUSSIAN CONTEXT

R. Martínez-López, M. Reznichenko
Samara National Research University (Russia)
C. Yot, C. Marcelo
University of Seville (Spain)

This research describes the type of the learning activities technology used by the teachers at the Russian Universities. Results offer evidence to the strong influence of confidence as a predictor of teachers' technology use and transfer. An instrument is adapted in Russian context for future research.

COMPUTER APPLICATIONS IN ENGINEERING EDUCATION: NEW OPPORTUNITIES IN TRAINING ENGINEERS FOR CREATIVE ECONOMY

I.V. Makarova, R.G. Khabibullin
Kazan Federal University
A.M. Ushenin, S.A. Mikheeva, V.S. Karabtsev
PTC "KAMAZ"

The article addresses the issue of ensuring qualitative training of specialists for mechanical engineering and road-and-transportation complex. To increase the competitiveness of the personnel, a new education pattern is proposed. It has been revealed that introduction of system approach in engineering training makes it possible to handle the problems in training engineers able to design, manufacture, and maintain complex machines and equipment.

A SYSTEM OF INTEGRATED FIELD-ORIENTED TRAINING OF SPECIALISTS BASED ON INNOVATIVE RESEARCH AND DEVELOPMENTS

I.R. Kuznetsov, V.N. Malyshev, M.E. Shevchenko
Saint Petersburg Electrotechnical University "LETI"
O.G. Petkau, A.Yu. Tarakanov
Scientific Research Institute Vektor

The article presents innovative university strategy for solving scientific and practical problems and training of field-oriented specialists for science and industry focused on the development of an advanced interdisciplinary training of specialists and modernization of educational environment in the field of advanced radioelectronic measures, as well as on an efficient commercialization of scientific research and developments.

SYNERGY OF EDUCATIONAL CLUSTER DEVELOPMENT IN THE FRAMEWORK OF UNIVERSITY SUPPLEMENTARY PROFESSIONAL EDUCATION

A.G. Zakharova, K.O. Ponomareva
National Research Tomsk Polytechnic University

The article deals with advantages of cluster additional vocational education. Synergetic effect is considered in the development of programme cluster in the framework of additional vocational education in a university. A strategy in programme cluster development is suggested using scenario development based on "neosystem approach".

FOSTERING PROFESSIONAL COMPETENCES WITHIN INTEGRATED ENGINEERING EDUCATION PROGRAMS

V.M. Kutuzov, N.V. Lysenko
Saint Petersburg Electrotechnical University "LETI"

The article discloses special aspects of specialists' cycle education. The requirements of employers towards HEI graduates' competences are presented. Types of Centers for Competences executing integrated educational programmes are described.

INTERDISCIPLINARITY IN EDUCATION: EDUCATION PROGRAMMME DESIGN

L.V. Redin, V.G. Ivanov
Kazan National Research Technological University

The significance of interdisciplinarity in education under the condition of sharp growth in patent activity in developed countries and the increased role of intellectual property items in modern economy are shown. Inderdisciplinarity is based on the network relations among the studied disciplines. Goal, content, and trends in interdisciplinarity are presented in the system of re-training, staff development, and Bachelor's training.

DEVELOPMENT OF SPECIALISTS' TRAINING ENVIRONMENT FOR INTERDISCIPLINARY RESEARCH PROJECTS USING RASA CENTER IN TOMSK AS AN EXAMPLE

Yu.Sh. Sirazitdinova, O.O. Bugaeva
National Research Tomsk Polytechnic University

At present, the Russian system of higher professional education stands at a pivotal moment. Challenges of globalization and international competition for talented specialists pose new problems for the Russian universities. The article considers experience of Tomsk Polytechnic University in development of environment for training students in interdisciplinary research projects in collaboration with leading scientists and research-educational centers.

ENGINEERING TEACHER TRAINING ON THE BASIS OF INTERDISCIPLINARY APPROACH

V.V. Kondrat'ev
Kazan National Research Technological University

The paper deals with one of the topical issues of today's engineering education, i.e. integrated interdisciplinary knowledge acquired by an engineer. Considering engineering teacher training based on interdisciplinary approach, the authors analyze such notions as "interdisciplinarity" and "interdisciplinary approach". These notions are connected with changes in the system of university teacher training and continuous professional development, which are specified in the paper. The most important methodological principle to ensure the efficiency of teacher training system has been identified – the education system should be sensitive to the changes in science, technics and technologies, which, in turn, results in changes in engineer's and teacher's professional activities.

EDUCATIONAL STANDARDS AS A BASIS FOR INTERDISCIPLINARY INTEGRATIVE MODULE

G.V. Bukalova
Orel State University n.a. I.S. Turgenev

The author proves axiological function of the integrative approach which is implemented for the new educational standards to be applied for engineering education. The conditions to enhance discipline integration process are determined in terms of systemology fundamentals. The author describes the stages of the integrative module design. The experience in the design of interdisciplinary integrative educational module (automotive transport) is shared and discussed.

TEAM WORK FOR COMPREHENSIVE ENGINEERINGY

O.N. Timofeev
Kazan National Research Technological University

The paper considers the ways to ensure education quality. The principles of creative self-development are described to demonstrate that the psychological function of education, i.e. goal-oriented activity and intentionality, plays an important role in transition from development to self-development. The personality self-development is controlled by the mechanism of emotion regulation and determined by the level of emotional intelligence. The author analyses the assessment criteria for the quality of engineering education provided in higher education institutions in the signatory countries of Washington Accord. The major requirement for engineering student training, which ensures the high quality of education, is to develop the abilities and skills of comprehensive engineering. The authors suggest that leadership skills are the key engineer's competencies to be developed in Russia. The interconnection between comprehensive engineering and leadership skills has

been revealed. Also, it has been established that the four abilities and relevant skills included in emotional intelligence (EQ) are essential professional qualities of the leader. The levels of PDLS development have been identified.

PARTICULARITIES OF SELF-STUDY WITHIN "ELECTRONICS AND NANO-ELECTRONICS" EDUCATION PROGRAMMES

M.V. Akulenok, A.V. Zheleznyakova
National Research University of Electronic Technology MIET

The paper considers the ways to organize student self study within Electronics and Nano-Electronics education programs. The case-study is analyzed in terms of process approach to education and programme interdisciplinarity.

MODERN APPROACHES TO THE ASSESSMENT OF SOFT SKILLS AND PROFESSIONAL COMPETENCES: THE INTERDISCIPLINARY ASPECT

G.I. Ibragimov
Kazan National Research Technological University
E.M. Ibragimova
Kazan Federal University

This article discloses three approaches to understanding the structure of competences as an object of assessment. The key problems faced by teaching staff, when assessing competences, are underlined. The role and place of various means for diagnostics and assessment of competences are presented. The key development trends of different form, methods and means for competences assessment are determined in line with the interdisciplinary approach.

ADAPTATION OF BACHELOR AND MASTER DEGREE PROGRAMMES TO MEET MODERN STANDARDS (INFORMATION SYSTEMS AND TECHNOLOGIES)

V.A. Dubenetsky, A.G. Kuznetsov, V.V. Tsekhanovsky
Saint Petersburg Electrotechnical University "LETI"

The paper considers different approaches to the use of models, which are applied in the sphere of information technologies and specified in modern standards and guidelines, for the development of bachelor and master degree programs, the specialty of Information Systems and Technologies. The authors give examples of educational process management based on Unified Modeling Language (UML).

DEVELOPMENT OF GLOBAL PROFESSION-RELATED FOREIGN LANGUAGE COMPETENCY ON THE BASIS OF INTEGRATIVE APPROACH AS AN IMPORTANT ASPECT IN INTERDISCIPLINARY TEAM WORK TRAINING FOR PETROLEUM WORKERS

T.A. Starshinova, V.G. Ivanov, O.A. Larionova
Kazan National Research Technological University

Interdisciplinary tasks of petroleum industry boost intensive international collaboration and intercultural cooperation. This necessitates development of global profession-related foreign language competency required for both engineers and middle-ranking staff since it is a crucial factor in interdisciplinary and international team work training for the next generation of petroleum workers. The authors of the present paper suggest educational process design based on integrative approach and relevant principles.

ECONOMIC, SCIENTIFIC AND TECHNICAL FACTORS IN QUALITY MANAGEMENT

V.P. Semenov
Saint Petersburg Electrotechnical University "LETI"

The article examines interaction of economic, scientific and technical factors in quality management training including not only development of new approaches, but also design of integrated systems based on the principles of total quality management. In order to estimate efficiency of interdisciplinary projects, multi-criteria and multi-model approaches are considered essential.

INTERDISCIPLINARITY IN PRACTICE-ORIENTED TRAINING OF BACHELORS IN LINE WITH THE CDIO INITIATIVE

A.M. Boronakhin, A.A. Minina, R.V. Shalymov
Saint Petersburg Electrotechnical University "LETI"

In the context of modern constantly changing realm the successfulness of technical HEIs' graduates is determined not only by their current knowledge, but also by their ability to adapt to these changes. This article is devoted to the efforts of the Saint Petersburg Electrotechnical University "LETI" and namely the Faculty of Information Measurement and Biotechnical Systems (FIMBS) on implementing the CDIO Initiative approaches for development of the required students' competences.

PROMOTION OF COOPERATION IN RESEARCH AND DEVELOPMENT BETWEEN UNIVERSITIES AND INDUSTRY IN THE CZECH REPUBLIC

L. Musílek
Czech Technical University in Prague

Universities must react to the situation in industry, increasingly oriented towards sophisticated technologies. Grant applications submitted together with industrial companies, direct support of applied research by industry, integrating students into applied research, project-oriented education, all these ways help to bring universities closer to the needs of industry. Supporting collaboration between universities and industry in the Czech Republic is briefly reviewed in the paper.

THE VITAL COLLABORATION OF INDUSTRY AND ACADEMIA FOR THE CREATION OF INTERDISCIPLINARY REAL WORLD STUDENT PROJECTS

P.A. Sanger
Purdue University, USA

The global economy in which engineers live is in constant change and evolution. The requirements for engineers today includes not only solid technical knowledge but also require they know how to apply that knowledge to real world problems. For these reasons, engineering education must reach beyond the academic world and draw in industry. The real world experiences that engineering students must have to be effective come from industry and not the more research oriented university environment. This paper reviews what avenues are available to enrich and grow the university/industry relationship and in particular, this paper describes an approach successfully implemented in the U.S. of industry sponsored and driven, final year, interdisciplinary, year long, capstone projects.

PROFESSIONAL ACTIVITIES IN VIRTUAL LEARNING ENVIRONMENT: INTERDISCIPLINARY TRAINING CASE STUDY

V.S. Sheinbaum, P.V. Pyatibratov, M.S. Khokhlova, D.V. Grishin, A.A. Pel'menyeva
Gubkin Russian State University of Oil and Gas (National Research University)

The technology of performing professional activities in virtual learning environment has been developed and is being successfully implemented at Gubkin Russian State University of Oil and Gas.

The education is provided in the form of trainings for interdisciplinary groups of students, which simulate real world project and production activities. The paper describes one of the training case studies.

POWERFUL INTERDISCIPLINARY ADULT EDUCATION FOR INDUSTRY: "COMBINING ANDRAGOGY AND PROJECT BASED LEARNING"

I.V. Pavlova, V.G. Ivanov
Kazan National Research Technological University
P.A. Sanger
Purdue University, USA

In this rapidly changing world of technology and economic conditions, it is essential that practicing professionals continue to grow in their skills and knowledge in order to stay competitive and relevant in the industrial workplace. This paper describes an approach to adult education that combines the best techniques of andragogy with project-based learning taking advantage of the experience, maturity and wisdom of the adult learner. Well-known project based learning (PBL) exercises such as the Skyscraper Project [1] and the "Deep Dive" video [2] have been adapted and expanded to include andragogic approaches and capitalize on the knowledge and depth of maturity in these mature learners.

INTERDISCIPLINARY PROJECT MANAGEMENT IN NETWORKING COOPERATION: TRAINING STUDENTS OF BACHELOR'S DEGREE PROGRAMME (MACHINERY ENGINEERING)

M.A. Loschilova, M.S. Vaichuk
Urga Technological Institute, National Research Tomsk Polytechnic University

The paper reveals the necessity for new open system of professional education to eliminate the gap between labor market demand and education services supplied. The authors suggest the ways for networking cooperation in training students of bachelor's degree in machinery engineering programme, which is based on the principles of openness and continuation.

ENGINEERING TEACHER TRAINING ON THE BASIS OF INTERDISCIPLINARY APPROACH

V.V. Kondrat'ev, V.G. Ivanov
Kazan National Research Technological University

The paper deals with one of the topical issues of today's engineering education, i.e. integrated interdisciplinary knowledge acquired by an engineer. Considering teachers of engineering training based on interdisciplinary approach, the authors analyze such notions as "interdisciplinarity" and "interdisciplinary approach". These notions are connected with changes in the system of university teachers training and continuing professional development, which are specified in the paper. The most important methodological principle to ensure the efficiency of teachers training system has been identified – the education system should be sensitive to the changes in science, technics and technologies, which, in turn, result in changes in engineer's and teacher's professional activities.

IMPROVED TEACHING OF MATHEMATICS AS AN IMPORTANT COMPONENT OF INTERDISCIPLINARY ENGINEERING EDUCATION

V.I. Shvetsov
Lobachevsky State University of Nizhni Novgorod
S. Sosnovsky
German Center for Artificial Intelligence (DFKI)

The paper considers the outcomes of the project "Modern Educational Technologies for Math Curricula in Engineering Education of Russia" (Tempus), implemented by the consortium of European and Russian higher educations institutions. Having analyzed the national and international experience in teaching mathematics, the authors suggest a new method to enhance math teaching thus improving the quality of engineering education. The method implies using the intelligent system of e-learning.

INTERDISCIPLINARY-BASED ADDITIONAL PROFESSIONAL EDUCATION FOR STUDENTS OF TECHNOLOGICAL UNIVERSITY

F.T. Shageeva, V.G. Ivanov
Kazan National Research Technological University

The article describes the project of National Research University. It has been revealed that additional professional education based on the interdisciplinary approach enhances interdisciplinary competency of students, thus, increasing their competitiveness. Such a training requires not only application of universal education technologies, but also search for numerous alternative solutions.

IMPROVING YOUNG EMPLOYEES TRAINING AT ENGINEERING, REPAIR AND INSTALLATION ENTERPRISES

R.G. Abdeev, E.R. Abdeev,
E.V. Bakieva, M.A. Lobanov
Bashkir State University

The article considers the implementation of network as a form of training in the higher school. It highlights the necessity of implementing this form of training students for engineering enterprises involved in repair and installation of equipment. The authors offer a model of interaction between engineering enterprises in the framework of network industry educational programs.

CROSS-CULTURAL INTERDISCIPLINARY STUDY OF LEARNING MOTIVATION OF ENGINEERING STUDENTS IN RUSSIA AND THE USA

P.A. Sanger
Purdue University, USA
I.M. Gorodetskaya, V.G. Ivanov
Kazan National Research Technological University

The paper addresses cross-cultural analysis of the learning motivation of Russian and US students majoring in engineering. The study is carried out with the use of psychological and pedagogical methodology. Empiric analysis has not revealed significant differences between the Russian and US groups, however some peculiarities in the hierarchy and structure of motivational sphere were found and should be taken into consideration in organizing international mobility programs.

INTERDISCIPLINARY FCA- AND TRIZ-BASED PROJECTS: EXPERIENCE AND PROSPECTS IN TRAINING TEACHERS

V.V. Likholetov, B.V. Shmakov
South Ural State University
(National Research University)

The paper analyzes the ways to improve the quality of engineering training in Russia. It proves the importance of using Russian experience in problem-solving and project-based learning, as well as, it necessitates introduction of training course for teachers to be involved in interdisciplinary FCA- and TRIZ-based projects.

STUDENT SATISFACTION WITH EDUCATION QUALITY AS A SYNERGY FACTOR

R.Z. Bogoudinova, V.G. Ivanov,
D.N. Mingazova, O.Yu. Khatsrinova
Kazan National Research Technological University

The article provides a method to evaluate the quality of educational process. The authors suggest evaluating the quality of education in terms of consumer satisfaction, taking into consideration the weight-of- coefficient for each quality indicator. The analysis has revealed the dependence between positive tendencies in classroom management and satisfaction level of students.

PROFESSIONAL IDENTITY AS A FACTOR OF PROFESSIONAL MOBILITY

M.G. Reznichenko, V.I. Stychkova
Samara National Research University

Professional mobility is an important factor of engineer's career development. The authors emphasize that developed status of professional identity is a precondition for the professional mobility. The article provides the results of tests that revealed a negative trend of professional identity development. Contextual education approach is proposed as a solution to the existing problem.

SYNERGY OF INTERDISCIPLINARY TEACHING IN HUMANITIES

L.M. Bogatova
Kazan National Research Technological University

The paper deals with synergy effect resulted from interdisciplinary teaching of humanities. The author identifies homogeneous and heterogeneous synergies and pays particular attention to interdisciplinary aspect of the humanities. The analysis of interaction between moral and legal components of the education process in high school reveals that the synergy effect has a profound social and cultural context connected with the development of personality of a certain type.

MORAL EDUCATION OF STUDENTS IN THE FRAMEWORK OF HUMANITIES PROVIDED BY HIGH ENGINEERING SCHOOL

E.N. Tarasova
Kazan National Research Technological University

The paper discusses the results of the study devoted to moral education of students in the framework of humanities provided by high engineering school. The aim and content of humanities in terms of moral education has been identified. The issues specific to interdisciplinary relationships in the framework of humanities provided for engineering students are studied. Educational potential of humanities for development of student moral qualities is defined. The paper also provides a brief review of the theoretical model of moral education of engineering students, which incorporate teaching of humanities in higher technical school.

EFFECTS OF INTERDISCIPLINARY EDUCATION TO THE COMPETITIVENESS OF ENGINEERS

A.V. Szarka
University of Debrecen

Interdisciplinarity is discussed as one of the effective tools increasing young generation's enthusiasm for engineering; increasing motivation of engineering students; increasing collaboration efficiency between professionals of different fields. Paper includes history and new systems of interdisciplinarity in engineering education, dual education system preparing new graduates for real industrial environment of inter- and multidisciplinary activities.

AN INTERDISCIPLINARY APPROACH FOR ACQUIRING COMPETENCE FOR SOCIAL RESPONSIBILITY

J.J. Perez
Universitat Politecnica de Catalunya

Graduate students should exhibit hard competences – specific knowledge – in their field of study and, also soft or transversal competences that provide complementary abilities to use the former in any specific environment. Social responsibility is among the list of transversal competences. This competence provides graduates a guidance to develop their activities as professionals within a framework of sustainable development, in such a way that projects include considerations concerning environmental, social and economic dimensions. In the present work we revise the concept of social responsibility and propose a quality assurance procedure to assess and improve the level of competence achieved by graduates.

DEVELOPMENT OF ECO-FRIENDLY TECHNOLOGY OF COLLOIDAL DEPOSIT UTILIZATION IN PULP AND PAPER INDUSTRY

A.V. Bogdanov, A.S. Shatrova, O.L. Kachor
Irkutsk National Research Technical University

Development of eco-friendly technology for intensive processing of sludge-lignin deposits, which is based on the best available utilization methods, is one of the urgent task to be addressed. The proposed technology to recover deposits in the storage pits of Baikalsk Pulp and Paper Mill on the basis of natural freezing allows reducing the costs and enhancing environmental safety of the project.

FORMATION OF PROFESSIONAL COMPETENCES FOR FUTURE ENVIRONMENTAL ENGINEERS BASED ON THE INTERDISCIPLINARY APPROACH

A.E. Irismetov
Kazan National Research Technological University

The article discloses new requirements towards future environmental engineers, who will be conducting environmental protection under new socio-economic conditions. The definition of professional competency of an environmental engineer is determined.

PROJECT MANAGERS: WHAT SHOULD THEY BE LIKE?

A.A. Dul'zon
National Research Tomsk Polytechnic University

The article discusses working conditions and basic duties of project managers in comparison with those of line managers. It provides the main duties of project managers and basic requirements for their professional, communicative and personal characteristics and competencies. It also discusses the issue of project manager salary.

DEPENDENCE OF INTERDISCIPLINARY PROJECT MANAGEMENT ON DIFFERENCE BETWEEN CORPORATE CULTURES

P.A. Podrezova, V.M. Kizeev
National Research Tomsk Polytechnic University

The article discusses the influence of corporate culture on a large interdisciplinary project organization. In particular, in the case where large organizations involved in a project, have a vertical linear structure and unique corporate culture. The article describes the project «The Opening of the research and educational center «Modern manufacturing technologies» as an example.

LEADERSHIP AND CORPORATE CULTURE, THEIR IMPACT ON COMPANY GROWTH

M.S. Vaichuk
National Research Tomsk Polytechnic University

The term "values" is no longer used only in a political context. The intangible factors become the key of stability and a driver of development. In this regard, the article provides the correlation of corporate culture development and the presence of a strong leader in a company with dynamics of companies' profitability ratios.

Professional-Public Accreditation of Educational Programmes (Results)

Over the past 20 years, Russian Association of Engineering Education (AEER) has been developing the system ofprofessional and social accountability accreditation of engineering and technology programmes in Russia.

AEER is a member of the most authoritative international organizations involved in engineering programme accreditation: International Engineering Alliance, Washington Accord, European Network for Accreditation of Engineering Education (ENAEE). AEER is the only national organization entitled to assign the international certification label (EUR -ACE label) for accredited programmes.

The system of professional and social accountability accreditation of engineering programmes developed and implemented by AEER is now international and accepted in the majority of developed countries.

By June 01, 2016, AEER has accredited 424 education programmes (first and second cycles) provided by 67 leading universities of Russia, Kazakhstan, Kirgizstan, Tajikistan, and Uzbekistan. The European certification label EUR-ACE has been awarded to 343 programmes. Also, three secondary vocational education programmes provided by Russian vocational training colleges have been accredited. The lists of education programmes accredited by AEER are regularly submitted to Federal Education and Science Supervision Service and reported to the signatories of Washington Accord and ENAEE.

International accreditation of the education programmes improves the image of Russian education on the global market, and makes national universities more attractive both for Russian and foreign students. It intensifies academic mobility and development of international cooperative education programmes. Graduating from an accredited institution allows young professionals to be recognized by APEC and FEANI engineer registers.

The following Register shows the education programmes accredited by AEER.

List of Accredited Programmes, Russian Federation (as of 01.06.2016)

	Programme Code	Qualification	Programme 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
5.	151900 (15.03.05)	FCD	Design Engineering Solutions for Mechanical Engineering Industries	AEER EUR-ACE®	2015-2020
	Belgorod State National Research University				
1.	210400	FCD	Telecommunications	AEER EUR-ACE®	2012-2017
2.	210406	INT	Communication Networks and Switching Systems	AEER EUR-ACE® WA	2012-2017
3.	210602	INT	Nanomaterials	AEER EUR-ACE® WA	2012-2017
4.	120700	FCD	Land Management and Cadastre	AEER EUR-ACE®	2014-2019
5.	120700	SCD	Cadastre and Land Monitoring	AEER EUR-ACE®	2014-2019
6.	130101	INT	Exploration and Prospecting of Underground Waters and Engineering Geological Survey	AEER EUR-ACE® WA	2014-2019
7.	210700	FCD	Communication Networks and Commutation Systems	AEER EUR-ACE®	2014-2019
8.	150100	SCD	Materials Science and Technology	AEER EUR-ACE®	2015-2020
	Belgorod State Technological University named after V.G. Shukhov				
1.	08.04.01 (270800.68)	SCD	Nanosystems in Building Materials Science	AEER EUR-ACE®	2015-2020
	Dagestan State University				
1.	210104	INT	Microelectronics and Solid State Electronics	AEER EUR-ACE® WA	2013-2018
2.	280201	INT	Environmental Protection and Rational Use of National Resources	AEER EUR-ACE® WA	2013-2018
	National Research University Higher School of Economics				
1.	11.04.04	SCD	Electronic Engineering	AEER EUR-ACE®	2015-2020
2.	11.04.04	SCD	Measurement Technologies of Nanoindustry	AEER EUR-ACE®	2015-2020
3.	09.03.01	FCD	Information Science and Computation Technology	AEER EUR-ACE®	2016-2021
4.	09.04.01	SCD	Computer Systems and Networks	AEER EUR-ACE®	2016-2021
5.	01.03.04	FCD	Applied Mathematics	AEER EUR-ACE®	2016-2021
6.	01.04.04	SCD	Management Systems and Information Processing in Engineering	AEER EUR-ACE®	2016-2021
	Ivanovo State Power University				
1.	140404	INT	Nuclear Power Plants and Installations	AEER EUR-ACE® WA	2009-2014
2.	210106	INT	Industrial Electronics	AEER EUR-ACE® WA	2009-2014

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Irkutsk National Research Technical University				
1.	130100	INT	Aircraft and Helicopter Construction	AEER	2004-2009
2.	250400	INT	Chemical Engineering of Natural Power Supplies and Carbon-base Materials	AEER	2004-2009
3.	140400	SCD	Optimization of Developing Power-supply Systems	AEER EUR-ACE®	2014-2019
4.	140400	SCD	Energy Efficiency, Energy Audit and Energy Department Management	AEER EUR-ACE®	2014-2019
5.	190700	SCD	Logistic Management and Traffic Control	AEER EUR-ACE®	2014-2019
6.	280700	SCD	Ecological Safety	AEER EUR-ACE®	2014-2019
7.	280700	SCD	Waste Management	AEER EUR-ACE®	2014-2019
8.	15.04.01	SCD	Technology, Equipment and Quality System for Welding	AEER EUR-ACE®	2015-2020
9.	20.04.01	SCD	Fire Protection	AEER EUR-ACE®	2015-2020
10.	15.04.02	SCD	Food Engineering	AEER EUR-ACE®	2015-2020
11.	20.04.01	SCD	Population Saving, Occupational, Environmental and Disaster Risk Management	AEER EUR-ACE®	2015-2020
	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
3.	28.04.02	SCD	Nanostructured Natural and Synthetic Materials	AEER EUR-ACE®	2015-2020
	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
	Kuban State Technological University				
1.	260100	FCD	Technology of Fermentation Manufacture and Winemaking	AEER EUR-ACE®	2014-2019
2.	260100	FCD	Technology of Bread Products	AEER EUR-ACE®	2014-2019
3.	260100	FCD	Technology of Fats, Essential Oils, Perfume and Cosmetic Products	AEER EUR-ACE®	2014-2019
	«MATI» – Russian State Technological University				
1.	190300	INT	Aircraft instruments, Measuring and Computing complexes	AEER	1996-2001
2.	110400	INT	Foundry of Ferrous and Non-ferrous Metals	AEER	1996-2001

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
3.	110500	INT	Metal Science and Thermal Treatment of Metals	AEER	1996-2001
4.	110700	INT	Welding Metallurgy	AEER	1996-2001
	Moscow State Mining University				
1.	090400	INT	Mine and Underground Construction	AEER	1996-2001
2.	090500	INT	Open-pit Mining	AEER	1996-2001
3.	130408	INT	Mine and Underground Construction	AEER EUR-ACE® WA	2010-2015
	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
5.	210300	INT	Robots and Robotic Systems	AEER	1993-1998
6.	220300	INT	Automated Production Systems	AEER	1993-1998
	Moscow State University of Applied Biotechnology				
1.	070200	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® WA	2008-2013
9.	210104	INT	Microelectronics and Solid State Electronics	AEER EUR-ACE® WA	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
	National Research University of Electronic Technology (MIET)				
1.	210100	FCD	Electronics and Microelectronics	AEER	2003-2008
2.	230100	FCD	Computer Science	AEER	2003-2008
	National Research University (MPEI)				
1.	140600	FCD	Electrical Engineering, Electromechanics and Electrical Technology	AEER	2005-2010
2.	140602	INT	Electrical and Electronic Machines	AEER EUR-ACE®	2007-2012

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
3.	140604	INT	Electrical Drives and Automated Industrial Sets and Engineering Systems	AEER EUR-ACE® WA	2007-2012
4.	140609	INT	Electrical Equipment for Aircraft	AEER EUR-ACE® WA	2007-2012
5.	140611	INT	Insulators, Cables and Capacitors	AEER EUR-ACE® WA	2007-2012
6.	140403	INT	Technical Physics of Thermonuclear Reactors and Plasma Installations	AEER EUR-ACE® WA	2010-2015
	National Research Tomsk Polytechnic University				
1.	071600	INT	High Voltage Engineering and Physics	AEER	1996-2001
2.	080200	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.	070500	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.	020804	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® WA	2007-2012
20.	200203	INT	Opto-Electronic Equipment and Systems	AEER EUR-ACE® WA	2007-2012
21.	240304	INT	Chemical Engineering of Refractory Non-Metal and Silicate Materials	AEER EUR-ACE® WA	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® WA	2011-2016

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
31.	210100	SCD	Physical Electronics	AEER EUR-ACE®	2011-2016
32.	140200	SCD	Mode Control of Electric Power Systems	AEER EUR-ACE®	2011-2016
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® WA	2012-2017
38.	240501	INT	Chemical Technology of Modern Power Engineering Materials	AEER EUR-ACE® WA	2012-2017
39.	140404	INT	Nuclear Power Plants and Installations	AEER EUR-ACE® WA	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 Supplies 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.	022000	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 Mechanical Engineering	AEER EUR-ACE®	2014-2019
60.	150100	SCD	Nanostructured Materials Tool Production	AEER EUR-ACE®	2014-2019
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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
63.	12.04.02	SCD	Lighting Technology and Light Sources	AEER EUR-ACE®	2014-2019
64.	12.04.02	SCD	Photonic Technologies and Materials	AEER EUR-ACE®	2014-2019
65.	15.04.01	SCD	High-technology Physics in Mechanical Engineering	AEER EUR-ACE®	2014-2019
66.	19.03.01	FCD	Biotechnology	AEER EUR-ACE®	2014-2019
67.	12.04.04	SCD	Medical and Biological Devices, Systems and Complexes	AEER EUR-ACE®	2014-2019
68.	15.03.01	FCD	Automation of Manufacturing Processes and Production in Mechanical Engineering	AEER EUR-ACE®	2014-2019
69.	21.05.03	INT	Geology and Exploration of Minerals	AEER EUR-ACE® WA	2014-2019
70.	21.05.03	INT	Geophysical Methods of Well Logging	AEER EUR-ACE® WA	2014-2019
71.	11.04.04	SCD	Electronics and Nanoelectronics	AEER EUR-ACE®	2015-2020
72.	27.04.01	SCD	Standardization and Metrology	AEER EUR-ACE®	2015-2020
	National Research Tomsk State University				
1.	12.04.03	SCD	Appliances and Devices in Nanophotonics	AEER EUR-ACE®	2015-2020
	National Research University «Lobachevsky State University of Nizhni Novgorod»				
1.	010300	FCD	Software Engineering	AEER EUR-ACE®	2014-2019
2.	010300	FCD	Fundamental Computer Science and Information Technologies (in English)	AEER EUR-ACE®	2014-2019
3.	010300	SCD	Software Engineering	AEER EUR-ACE®	2014-2019
	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.	011200	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.	011200	SCD	Physics of Condensed Matter	AEER EUR-ACE®	2014-2019

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
19.	011200	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
	North-Caucasus Federal University				
1.	140400	FCD	Electrical Power Systems and Networks	AEER EUR-ACE®	2015-2020
2.	240100	FCD	Process Chemistry of Natural Energy Carriers and Carbon Materials	AEER EUR-ACE®	2015-2020
3.	090900	FCD	Organization and Technology of Information Security	AEER EUR-ACE®	2015-2020
4.	090303	INT	Information Security of Automated Systems	AEER EUR-ACE® WA	2015-2020
5.	131000	SCD	Oil Field Reservoir Management	AEER EUR-ACE®	2015-2020
6.	140400	SCD	Monitoring and Control of Electrical Networks Based on Intelligent Information-Measuring Systems and Technologies	AEER EUR-ACE®	2015-2020
7.	21.05.02	INT	Geology of Oil and Gas	AEER EUR-ACE® WA	2015-2020
8.	21.05.03	INT	Geophysical Methods for Well Exploration	AEER EUR-ACE® WA	2015-2020
9.	23.04.03	SCD	Technical Exploitation of Automobiles	AEER EUR-ACE®	2015-2020
10.	23.03.03	FCD	Automobiles and Vehicle Fleet	AEER EUR-ACE®	2015-2020
11.	09.04.03	SCD	Knowledge Management	AEER EUR-ACE®	2015-2020
12.	10.04.01	SCD	Comprehensive Protection for Computerization Facilities	AEER EUR-ACE®	2015-2020
13.	11.03.02	FCD	Communication network and Switching Systems	AEER EUR-ACE®	2015-2020
	Institute of Service, Tourism and Design (Branch of North-Caucasus Federal University in Pyatigorsk)				
1.	27.03.04	FCD	Management and Computer Science in Technical Systems	AEER EUR-ACE®	2015-2020
2.	23.03.03	FCD	Automobile Service	AEER EUR-ACE®	2015-2020
	Nosov Magnitogorsk State Technical University				
1.	150400	FCD	Forming of Metals and Alloys (Rolling)	AEER EUR-ACE®	2014-2019
2.	150400	SCD	Rolling Production Technology	AEER EUR-ACE®	2014-2019
3.	27.04.01	SCD	Testing and certification	AEER EUR-ACE®	2015-2020
4.	22.04.02	SCD	Hardware Production Technology	AEER EUR-ACE®	2015-2020
5.	11.04.04	SCD	Industrial Electronics and Automation of Electrical Systems	AEER EUR-ACE®	2015-2020
6.	03.04.02	SCD	Solid State Physics	AEER EUR-ACE®	2015-2020
	Novosibirsk State Technical University				
1.	150501	INT	Materials Science in Mechanical Engineering	AEER EUR-ACE® WA	2012-2017
2.	16.04.01	SCD	Laser Science and Technology	AEER EUR-ACE®	2015-2020
3.	22.04.01	SCD	Material Science, Technology and Processing of Materials with Specific Properties	AEER EUR-ACE®	2015-2020
4.	28.04.01	SCD	Micro- and Nanosystem Engineering Materials	AEER EUR-ACE®	2015-2020

	Programme Code	Qualifi-cation	Programme 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
3.	11.04.04	SCD	Electronics and Nanoelectronics	AEER EUR-ACE®	2015-2020
	Penza State University				
1.	11.04.04	SCD	Electronics and Nanoelectronics	AEER EUR-ACE®	2015-2020
2.	27.04.01	SCD	Standardization and Metrology	AEER EUR-ACE®	2015-2020
	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
6.	151900	SCD	Automated Engineering Technology	AEER EUR-ACE®	2015-2020
7.	220400	SCD	Intellectualization and Optimization of Control Processes	AEER EUR-ACE®	2015-2020
	Perm National Research Polytechnic University				
1.	150700	SCD	Beam Technologies in Welding	AEER EUR-ACE®	2014-2019
2.	270800	SCD	Underground and Urban Construction	AEER EUR-ACE®	2014-2019
3.	27.04.04 (220400.68)	SCD	Distributed Computing Information and Control Systems	AEER EUR-ACE®	2015-2020
	Petrozavodsk State University				
1.	210100	SCD	Electronics and Nanoelectronics	AEER EUR-ACE®	2015-2020
	Samara State Aerospace University (National Research University)				
1.	160301	INT	Aircraft Engines and Power Plants	AEER EUR-ACE® WA	2008-2013
2.	160802	INT	Spasecraft and Rocket Boosters	AEER EUR-ACE® WA	2008-2013
3.	24.05.01	INT	Design, Production and Maintenance of Rockets and Space Complexes	AEER EUR-ACE® WA	2015-2020
4.	24.05.07	INT	Airplane and Helicopter Designing	AEER EUR-ACE® WA	2015-2020
5.	12.04.04	SCD	Biotechnical Systems and Technologies	AEER EUR-ACE®	2015-2020
6.	01.04.02	SCD	Supercomputing, Information Technologies and Geoinformatics	AEER EUR-ACE®	2015-2020
	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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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	FCD	Laser Measurement and Navigation Systems	AEER EUR-ACE®	2014-2019
11.	200100	FCD	Devices and Methods of Monitoring of Quality and Diagnostics	AEER EUR-ACE®	2014-2019
12.	231000	SCD	Development of Distributed Software Systems	AEER EUR-ACE®	2014-2019
13.	010400	SCD	Mathematical Provisions and Software of Computers	AEER EUR-ACE®	2014-2019
14.	220451	SCD	Automation and Control of Industrial Complexes and Mobile Objects	AEER EUR-ACE®	2014-2019
15.	220452	SCD	Automated Control Systems for Sea Vehicles	AEER EUR-ACE®	2014-2019
16.	220453	SCD	Shipborne Information and Control Systems	AEER EUR-ACE®	2014-2019
17.	140452	SCD	Automated Electromechanical Complexes and Systems	AEER EUR-ACE®	2014-2019
18.	230161	SCD	Microsystem Computer Technologies: Systems on Chip	AEER EUR-ACE®	2014-2019
19.	230162	SCD	Distributed Intelligent Systems and Technology	AEER EUR-ACE®	2014-2019
20.	230151	SCD	Computer Technologies in Engineering	AEER EUR-ACE®	2014-2019
21.	201051	SCD	Biotechnical Systems and Technologies of Rehabilitation and Prosthetics	AEER EUR-ACE®	2014-2019
22.	201053	SCD	Information Systems and Technologies in Patient Care Institutions	AEER EUR-ACE®	2014-2019
23.	210153	SCD	Electronic Devices and Equipment	AEER EUR-ACE®	2014-2019
24.	210176	SCD	Physical Electronics	AEER EUR-ACE®	2014-2019
25.	210152	SCD	Microwave and Telecommunication Electronics	AEER EUR-ACE®	2014-2019
26.	211006	FCD	Information Technologies for Radio Electronic Engineering	AEER EUR-ACE®	2014-2019
27.	211008	FCD	Information Technologies in Microwave Electronic Engineering	AEER EUR-ACE®	2014-2019
28.	11.04.04	SCD	Nanoelectronics and photonics	AEER EUR-ACE®	2015-2020
29.	11.04.01	SCD	Radiolocation of Objects and Environments	AEER EUR-ACE®	2015-2020
30.	11.04.01	SCD	Microwave, Optical, and Digital Telecommunications Hardware	AEER EUR-ACE®	2015-2020
31.	11.04.01	SCD	Infocommunication Technology in Space Patterns Analysis and Processing	AEER EUR-ACE®	2015-2020
32.	13.04.02	SCD	Electrotechnologies	AEER EUR-ACE®	2015-2020
33.	12.04.01	SCD	Devices and Methods of Quality Control and Diagnostics	AEER EUR-ACE®	2015-2020
34.	12.04.01	SCD	Lazer Measurement Technologies	AEER EUR-ACE®	2015-2020
35.	12.04.01	SCD	Adaptive Measuring Systems	AEER EUR-ACE®	2015-2020
36.	27.04.02	SCD	Integrated Quality Management Systems	AEER EUR-ACE®	2015-2020
37.	11.04.04	SCD	Heterostructure Solar Photovoltaics	AEER EUR-ACE®	2015-2020
38.	28.04.01	SCD	Nano- and Microsystem Engineering	AEER EUR-ACE®	2015-2020
39.	09.04.02	SCD	Distributed Computing Systems of Real-Time	AEER EUR-ACE®	2015-2020
40.	27.04.04	SCD	Control and Information Technologies in Technical Systems	AEER EUR-ACE®	2015-2020

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Saint Petersburg National Research University of Information Technologies, Mechanics and Optics				
1.	27.04.03	SCD	Intelligent Control Systems of Technological Processes	AEER EUR-ACE®	2014-2019
2.	09.04.01	SCD	Embedded Computer Systems Design	AEER EUR-ACE®	2014-2019
3.	09.04.02	SCD	Automation and Control in Educational Systems	AEER EUR-ACE®	2014-2019
4.	09.04.03	SCD	Overall Automation of Enterprise	AEER EUR-ACE®	2014-2019
5.	24.04.01	SCD	Quality Control of Products of Space Rocket Complexes	AEER EUR-ACE®	2014-2019
6.	12.04.02	SCD	Applied Optics	AEER EUR-ACE®	2014-2019
7.	16.04.01	SCD	Integrated Analyzer Systems and Information Technologies of Fuel and Energy Complex Enterprises	AEER EUR-ACE®	2014-2019
8.	19.04.03	SCD	Biotechnology of Therapeutic, Special and Prophylactic Nutrition Products	AEER EUR-ACE®	2014-2019
9.	12.04.01	SCD	Methods of Diagnosis and Analysis in Bionanotechnology	AEER EUR-ACE®	2015-2020
10.	12.04.01	SCD	Devices for Research and Modification of Materials at the Micro- and Nanoscale Level	AEER EUR-ACE®	2015-2020
11.	12.04.03	SCD	Metamaterials	AEER EUR-ACE®	2015-2020
12.	12.04.03	SCD	Nanomaterials and Nanotechnologies for Photonics and Optoinformatics	AEER EUR-ACE®	2015-2020
13.	12.04.03	SCD	Optics of Nanostructures	AEER EUR-ACE®	2015-2020
	Saint-Petersburg State Polytechnic University				
1.	010800	SCD	Mechanics of Deformable Solid Body	AEER EUR-ACE®	2014-2019
2.	210700	SCD	Protected Telecommunication Systems	AEER EUR-ACE®	2014-2019
3.	210100	SCD	Micro- and Nanoelectronics	AEER EUR-ACE®	2014-2019
4.	223200	SCD	Physics of Low-dimensional Structures	AEER EUR-ACE®	2014-2019
5.	151900	SCD	Machine-building Technology	AEER EUR-ACE®	2014-2019
6.	140100	SCD	Technology of Production of Electric Power and Heat	AEER EUR-ACE®	2014-2019
7.	220100	SCD	System Analysis and Control	AEER EUR-ACE®	2014-2019
8.	270800	SCD	Engineering Systems of Buildings and Constructions	AEER EUR-ACE®	2014-2019
9.	270800	SCD	Construction Management of Investment Projects	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
3.	11.04.04	SCD	Electronic Devices and Facilities	AEER EUR-ACE®	2015-2020
4.	11.04.02	SCD	Telecommunication Networks and Communication Devices	AEER EUR-ACE®	2015-2020
5.	11.04.02	SCD	Satellite Communication Systems	AEER EUR-ACE®	2015-2020
	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
3.	09.03.02	FCD	Information Systems and Technologies	AEER EUR-ACE®	2015-2020

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
4.	09.03.04	FCD	Software Engineering	AEER EUR-ACE®	2015-2020
5.	15.03.04	FCD	Automation of Technological Processes and Productions	AEER EUR-ACE®	2015-2020
	Siberian Federal University Sayano-Shushensky Branch				
1.	08.03.01	FCD	Hydrotechnical Construction	AEER EUR-ACE®	2016-2021
	Southwest State University				
1.	28.04.01	SCD	Nanotechnology	AEER EUR-ACE®	2015-2020
	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® WA	2009-2014
2.	150202	INT	Industrial Welding Technology and Equipment	AEER EUR-ACE® WA	2009-2014
3.	151002	INT	Mechanical Engineering Technology	AEER EUR-ACE® WA	2009-2014
4.	22.04.01	SCD	Welding and Soldering of Advanced Metal and Non-Metal Inorganic Materials	AEER EUR-ACE®	2016-2021
5.	22.04.01	SCD	Material Science and Technologies of Nanomaterials and Coatings	AEER EUR-ACE®	2016-2021
6.	20.04.01	SCD	Productional, Industrial and Environmental Safety Management Systems	AEER EUR-ACE®	2016-2021
7.	15.04.05	SCD	Computer-Aided Engineering Technology	AEER EUR-ACE®	2016-2021
8.	13.04.02	SCD	Operating Modes of Electric Power Supplies, Substations, Circuits and Systems	AEER EUR-ACE®	2016-2021
	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
	Transbaikal State University				
1.	21.05.04 (130400.65)	INT	Open Mining	AEER EUR-ACE® WA	2015-2020
2.	08.05.01 (271101.65)	INT	Construction of High-Rise and Long-Span Buildings and Structures	AEER EUR-ACE® WA	2015-2020

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	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 WA	2007-2012
5.	190603	INT	Transport and technological machinery and equipment service (oil and gas production)	AEER WA	2007-2012
6.	190701	INT	Transportation organization and transport management (automobile transport)	AEER WA	2007-2012
7.	130602	INT	Oil and Gas Fields Machinery and Equipment	AEER EUR-ACE® WA	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® WA	2008-2013
10.	240401	INT	Chemical Technology of Organic Substances	AEER EUR-ACE® WA	2009-2014
11.	240403	INT	Chemical Engineering of Natural Power Supplies and Carbon-base Materials	AEER EUR-ACE® WA	2009-2014
12.	240801	INT	Machines and Apparatus of Chemical Production	AEER EUR-ACE® WA	2009-2014
13.	280201	INT	Environmental Control and Rational Use of Natural Resources	AEER EUR-ACE® WA	2010-2015
14.	280102	INT	Safety of Technological Processes and Productions	AEER EUR-ACE® WA	2010-2015
15.	120302	INT	Land Cadastre	AEER EUR-ACE® WA	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 named after the first President of Russia B.N. Yeltsin				
1.	240302	INT	Technology of Electrochemical Productions	AEER EUR-ACE®	2008-2013
2.	210100	SCD	Electronics and Nanoelectronics	AEER EUR-ACE®	2015-2020
3.	221700	SCD	Standardization and Metrology	AEER EUR-ACE®	2015-2020
4.	22.04.01	SCD	Material Science, Technology Acquisition and Processing of Metal Materials with Special Properties	AEER EUR-ACE®	2015-2020
5.	22.04.01	SCD	Materials Science, Production Technology and Processing of Non-Ferrous Alloys	AEER EUR-ACE®	2015-2020
6.	22.04.01	SCD	Material Science and Materials Technology in the Nuclear Energy Industry	AEER EUR-ACE®	2015-2020

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	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® WA	2007-2012
2.	130603	INT	Oil and Gas Processing Equipment	AEER EUR-ACE® WA	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® WA	2008-2013
6.	130602	INT	Oil and Gas Fields Machinery and Equipment	AEER EUR-ACE® WA	2008-2013
7.	130501	INT	Design, Construction and Operation of Gas and Oil Pipelines and Storage Facilities	AEER EUR-ACE® WA	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
15.	241000	FCD	Environmental Protection and Rational Use of National Resources	AEER EUR-ACE®	2015-2020
16.	240100	FCD	Process Chemistry of Natural Energy Carriers and Carbon Materials	AEER EUR-ACE®	2015-2020
17.	140400	FCD	Electrical Equipment and Electrical Facilities of Companies, Organizations and Institutions	AEER EUR-ACE®	2015-2020
18.	18.03.01	FCD	Chemical Technology of Natural Energy Carriers and Carbon Materials	AEER EUR-ACE®	2015-2020
19.	18.04.01	SCD	Chemistry and Technology of Basic Organic and Petrochemical Synthesis Products	AEER EUR-ACE®	2015-2020
20.	19.04.01	SCD	Industrial Biotechnology and Bioengineering	AEER EUR-ACE®	2015-2020
	Vladimir State University named after Alexander and Nikolay Stoletovs				
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
3.	200400	SCD	Laser Devices and Systems	AEER EUR-ACE®	2015-2020
	Volga State University of Technology				
1.	15.03.01 (150700)	FCD	Machine Building	AEER EUR-ACE®	2015-2020
2.	11.03.02 (210700)	FCD	Information and Communication Technologies and Telecommunication Systems	AEER EUR-ACE®	2015-2020

LIST OF AEER ACCREDITED PROGRAMMES

List of Accredited Programs, Republic of Kazakhstan (as of 01.06.2016)

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	D. Serikbayev East Kazakhstan State Technical University				
1.	050703	FCD	Information Systems	AEER EUR-ACE®	2011-2016
2.	050713	FCD	Transport, Transport Facilities and Technology	AEER EUR-ACE®	2011-2016
	L.N. Gumilyov Eurasian National University				
1.	050702	FCD	Automation and Control	AEER EUR-ACE®	2011-2016
2.	050732	FCD	Standardization, Metrology and Certification	AEER EUR-ACE®	2011-2016
3.	050901	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				
1.	050701	FCD	Biotechnology	AEER EUR-ACE®	2010-2015
2.	050718	FCD	Electrical Power Engineering	AEER EUR-ACE®	2010-2015
	Kazakh National Technical University named after K.I. Satpaev				
1.	050704	FCD	Computer Science and Software	AEER EUR-ACE®	2010-2015
2.	050711	FCD	Geodesy and Cartography	AEER EUR-ACE®	2010-2015
3.	050712	FCD	Mechanical Engineering	AEER EUR-ACE®	2010-2015
4.	050718	FCD	Electrical Power Engineering	AEER EUR-ACE®	2010-2015
5.	050723	FCD	Technical Physics	AEER EUR-ACE®	2010-2013
6.	050713	FCD	Transport, Transport Facilities and Technology	AEER EUR-ACE®	2011-2016
7.	050716	FCD	Instrumentation Engineering	AEER EUR-ACE®	2011-2016
8.	050719	FCD	Radio Engineering, Electronics and Telecommunications	AEER EUR-ACE®	2011-2016
9.	050720	FCD	Chemical Technology of Inorganic Substances	AEER EUR-ACE®	2011-2016
10.	050721	FCD	Chemical Technology of Organic Substances	AEER EUR-ACE®	2011-2016
11.	050722	FCD	Printing	AEER EUR-ACE®	2011-2016
12.	050724	FCD	Processing Machinery and Equipment	AEER EUR-ACE®	2011-2016
13.	050729	FCD	Construction	AEER EUR-ACE®	2011-2016
14.	050731	FCD	Life Safety and Environmental Protection	AEER EUR-ACE®	2011-2016
15.	050732	FCD	Standardization, Metrology and Certification	AEER EUR-ACE®	2011-2016
	Karaganda State Technical University				
1.	050702	FCD	Automation and Control	AEER EUR-ACE®	2010-2015
2.	050707	FCD	Mining Engineering	AEER EUR-ACE®	2010-2015
3.	050709	FCD	Metallurgy	AEER EUR-ACE®	2010-2015

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
4.	050712	FCD	Mechanical Engineering	AEER EUR-ACE®	2010-2015
5.	050713	FCD	Transport, Transport Facilities and Technology	AEER EUR-ACE®	2010-2015
	Kostanay Engineering and Pedagogical University				
1.	050713	FCD	Transport, Transport Equipment and Technology	AEER EUR-ACE®	2011-2016
2.	050732	FCD	Standardization, Metrology and Certification	AEER EUR-ACE®	2011-2016
	Semey State University named after Shakarim				
1.	050727	FCD	Food Technology	AEER EUR-ACE®	2010-2015
2.	050724	FCD	Processing Machinery and Equipment	AEER EUR-ACE®	2010-2015

List of Accredited Programs, Kyrgyzstan (as of 01.06.2016)

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Kyrgyz State Technical University named after I. Razzakov				
1.	690300	FCD	Communication Networks and Switching Systems	AEER EUR-ACE®	2015-2020
	Kyrgyz State University of Construction, Transport and Architecture named after N. Isanov				
1.	750500	FCD	Industrial and Civil Engineering	AEER EUR-ACE®	2015-2020

List of Accredited Programs, Tajikistan (as of 01.06.2016)

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Tajik Technical University named after Academician M.S. Osimi				
1.	700201	FCD	Design of Buildings and Constructions	AEER EUR-ACE®	2015-2020
2.	430101	SCD	Electrical Stations	AEER EUR-ACE®	2015-2020

List of Accredited Programs, Uzbekistan (as of 01.06.2016)

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Tashkent State Technical University named after Abu Raykhan Beruniy				
1.	5310800	FCD	Electronics and Instrumentation	AEER EUR-ACE®	2015-2020

List of Accredited Secondary Professional Education Programmes
(as of 01.06.2016)

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	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

AEER re-authorization to award the «EUR-ACE® Label»

Meeting of the Administrative Council of ENAEE (European Network for Accreditation of Engineering Education) was held in Istanbul on June 23, 2015. During this meeting the Association of Engineering Education of Russia was authorized to award European quality label «EUR-ACE Bachelor Label» to accredited engineering programmes at first cycle level (bachelor) and «EUR-ACE Master Label» to accredited engineering programmes at second cycle level (diploma specialist, master) until **31st of December (http://www.enaee.eu/wp-content/uploads/2012/01/overview-WEB-of-all-authorizations-granted4.pdf)**

Following 13 national agencies are authorised to award the EUR-ACE® label to their accredited programmes:

1. **GERMANY** – ASIIN – Fachakkreditierungsagentur fьr Studiengдnge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften, und der Mathematik e.V. – www.asiin.de
2. **FRANCE** – CTI – Commission des Titres d'Ingйnieur – www.cti-commission.fr
3. **UK** – Engineering Council – www.engc.org.uk
4. **IRELAND** – Engineers Ireland – www.engineersireland.ie
5. **PORTUGAL** – Ordem dos Engenheiros – www.ordemengenheiros.pt
6. **RUSSIA** – AEER – Association for Engineering Education of Russia – www.aeer.ru
7. **TURKEY** – MьDEK – Association for Evaluation and Accreditation of Engineering Programmes – www.mudek.org.tr
8. **ROMANIA** – ARACIS – The Romanian Agency for Quality Assurance in Higher Education – www.aracis.ro
9. **ITALY** – QUACING – Agenzia per la Certificazione di Qualita e l'Accreditamen to EUR-ACE dei Corsi di Studio in Ingegneria – www.quacing.it
10. **POLAND** – KAUT – Komisja Akredytacyjna Uczelni Technicznych – www.kaut.agh.edu.pl
11. **SWITZERLAND** – AAQ - Schweizerische Agentur fьr Akkreditierung und Qualitдtssicherung – www.aaq.ch
12. **SPAIN** – ANECA – National Agency for Quality Assessment and Accreditation of Spain – www.aneca.es (in conjunction with IIE – Instituto de la Ingenierнa de Espaсa – www.iies.es)
13. **FINLAND** – FINEEC – Korkeakoulujen arviointineuvosto KKA – http://karvi.fi/en/

European Network for Accreditation of Engineering Education

ENAEE

European Accreditation of Engineering Programmes EUR-ACE®

AEER

Association for Engineering Education of Russia

is re-authorized

from 31 June 2015
to 31 December 2019

to award the EUR-ACE® Label to accredited
Bachelor and Master level engineering programmes

Brussels, 23 June 2015

EUR-ACE label awards: Authorization Period

Status: 23 June 2015

Country	Agency	First Cycle	From	Until	Second Cycle	From	Until
DE	ASIIN	X	Nov 2008	**31 Dec 2019**	X	Nov 2008	**31 Dec 2019**
FR	CTI				X	Nov 2008	**31 Dec 2019**
IE	EI	X	Nov 2008	**31 Dec 2018**	X **Honors Bachelor**	Nov 2010	**31 Dec 2018**
					X **Master SC**	Sept 2012	**31 Dec 2018**
PT	OE	X	Sept 2013	**31 Dec 2018**	X	Jan 2009	**31 Dec 2018**
RU	AEER	X	Nov 2008	**31 Dec 2019**	X	Nov 2008	**31 Dec 2019**
TR	MÜDEK	X	Jan 2009	**31 Dec 2018**			
UK	EngC	X	Nov 2008	**31 Dec 2016**	X	Nov 2008	**31 Dec 2016**
RO	ARACIS	X	Sept 2012	**31 Dec 2017**			
IT	QUACING	X	Sept 2012	**31 Dec 2015**	X	Sept 2012	**31 Dec 2015**
PL	KAUT	X	Sept 2013	**31 Dec 2018**	X	Sept 2015	**31 Dec 2018**
ES	ANECA (w/IIE)	X	June 2014	**31 Dec 2018**	X	June 2014	**31 Dec 2018**
FI	FINEEC	**4Y Bachelor**	June 2014	**31 Dec 2018**			
CH	OAQ	X	June 2014	**31 Dec 2018**	X	June 2014	**31 Dec 2018**

ENGINEERING EDUCATION

Responsible 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