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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

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 programs 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 programs for engineers are an effective model of cooperation between the state and private enterprises. Being an educational phenomenon, these programs 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 Program of engineering staff training for 2012-2014 (hereinafter Program P) [2], which was primarily focused on industrial enterprises staff.

Since 2013, many Russian industrial enterprises have chosen continuing professional development programs within the framework of Program 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 Program for 2013-2016 (Program 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 programs of governmental support, this system is being currently developed, which provides new material for research. The present paper deals with the programs 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.

Program 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 program costs were funded from the federal budget. 30% of the program costs (or 50% of budget costs) were funded by the enterprises including the costs for business trips to the place of education. The program 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 program status changed and it got under the supervision of the Ministry of Education and Science of the


V.G. Ivanov


S.V. Barabanova


M.F. Galikhanov


L.T. Miftakhutdinova

RF (hereinafter Program V) [7]. However, the program 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 program implementation is funded by the federal budget and business sector in equal shares.

As for the program 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 program as well. The academic staff providing the program 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 programs (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 program implementation.

The university has participated in Program P since 2013. Over two years, there have been 7 continuing professional development programs implemented within the Program framework. This allowed Program 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 program implementation stipulated the development of new teaching approach since the program 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 programs in terms of professional competencies development and qualification acquisition. All the programs 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 program 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 program participated in the practical trainings that were organized for the program trainees in Russia and abroad. At first, these trainings for academic staff were funded by the university.

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

The conducted research indicated the necessity for Programs 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 programs 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 program being partly funded by the corporate customers leads to contractual relationships, which will allow the program implementation even without government financial support. This positive experience boosted establishment of private-public partnerships in different Subjects of the RF.

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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, Program 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 program is peculiar since there is an opportunity to provide not only continuing professional development programs, but also the programs of professional retraining for the enterprises within the cluster.

The foundation of Program K rests on the educational courses of Programs P and V: Program 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 program 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 programs for more than 200 professionals of KIC enterprises, with 2 of the programs provided several times. One of the most in-demand programs 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 program "Modern polymer nanocomposites" was recognized as one of the best Russian education programs in the course of Program P implementation. Moreover, the program is provided annually, which allows comparing program outcomes and monitoring the number of trainees after program 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 program 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 programs provided within the cluster were integrated since they were developed in compliance with the algorithm of additional education program 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 programs for KIC enterprises staff were amended to be focused on innovation-related activities. We suppose that such programs 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 programs 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 program 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 (Program G).

Over the period December, 2015 – April, 2016, a number of professional development programs were designed: "Industrial Process Automation", "Corrosion and Pipeline Protection", "Metrology Support for Automation Equipment", "Compression Plant: Equipment Service and Maintenance". All programs 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 programs 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 programs 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 Program V implemented in 2015. Regardless of economic downturn in 2016, the university got many orders for co-funded professional development programs (Programs K and G). The reason is not only the policy of import phase-out, but also the fact that the programs are top ranked by the former trainees. The above-described programs are unique since they are designed to meet the interests and opportunities of all stakeholders – the programs 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

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

J.C. Quadrado

K.K. Tolkacheva