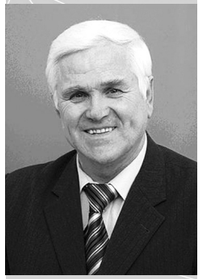
UDC 094:621

Modular Training of Specialists on Innovative Design in Mechanical Engineering

Ufa State Aviation Technical University
N.K. Krioni, M.B. Guzairov, S.G. Selivanov, S.N. Poezjalova

N.K. Krioni

M.B. Guzairov



S.G. Selivanov

S.N. Poezjalova

The basic concepts of modular training of specialists on innovative design in mechanical engineering are presented in the article. The concept of continuous innovative training of specialists on the example of the "Innovatics" module is illustrated. The description of educational and methodical teaching materials for "Innovatics" module is provided as an option for realization of electronic and distant teaching and learning methods.

Key words: innovative activity, innovatics, educational technologies, module, continuous innovative training, educational and methodical teaching materials.

INTRODUCTION

Topicality, aims, objectives and priorities of innovative activity in Russia are set by the requirements of:

- Russian Federation Federal Laws (Federal Law On Science and Governmental Policy on Science and Technology No. 127 – FZ; Federal Law on Education in Russian Federation No. 273-FZ of 29 December 2012; Federal Law On Industrial Policy in Russian Federation No. 488 – FZ of 31December 2014);
- Russian Federation Government Decrees («On Strategy of Innovative Development of the Russian Federation until 2020» of 8 December 2011 No. 2227-p; «On State Support of Innovative Infrastructure Development in Federal Educational Institutions of Higher Professional Education» of 9 April 2010 No. 219);
- Federal Targeted Programmes (Russian Federation Government Resolution No. 97 of 23 May 2015 on Education Development Federal Targeted Programme for 2016 – 2020).

Proposition of the legislative acts mentioned above is triggered by the fact that in the context of a global trend of economic development of developed countries the development tendencies are focused on the technological shifts by means of innovative activity [1, pp. 85-91]:

- the significance of the technological progress among the factors influencing the increase of the USA's GDP had been around 28% (research from 1929 to 1982, [Campbell]);
- the research conducted in the USA after the World War II indicated that 43% of GDP's growth is triggered by inventiveness, technological progress, education and other drivers [Samuelson];
- at the end of the XXth century a Nobel Prize laureate R. Solow had identified that the value of technological shifts (87,5 %) for the economic development of the USA is significantly higher than capital and labor (12,5%) [Solow, Sakhal].

In order to bring to action the requirements towards engineering education and specialists' training stated-above higher education schools have to gain a wide expertize in innovative training of bachelors, masters and qualified specialists based on the use of topnotch achievements of science and technology [2, pp. 29-42]. This issue is discussed further.

1. INNOVATICS – A NEW COURSE FOR ENGINEERING EDUCATION

Leading universities of the world have formulated modules of innovative study programmes as following:

- Innovations (600 h, Stanford University, USA);
- Innovations and Entrepreneurship (480 h, Harvard University, USA);
- Innovations (200 h, Aston University, Birmingham, Great Britain) and others.

The aims and core contents of the "Innovations" module (developed by Dr. Mike Kennard, Aston University, Birmingham, Great Britain) are defined as follows:

1. Acquisition of key theoretical ideas on innovations and innovative activity in industry for assuring competitiveness and prosperity of enterprises.
2. Comparison of scientific research and innovative theories for management of enterprises on practice.
3. Efficiency assessment of innovative strategies for various organizations.
4. Management of innovations.

The contents of this module reflect ideas of strategic management of innovations: processes from creation, development, introduction of new ideas, technologies, products and services to commercialization of new high and critical (key, creative) technologies. "Innovatics" module and theoretical approach to innovations are connected with practice and focus on approaches for development and transformation of innovations for commercial market. Ideas and structure applied for this module of disciplines are completed with topical research on innovations introduced in British enterprises and foreign organizations of international scale. Vital components of innovative training modules at leading foreign universities are the following additions to the typical forms of modules (that use ordinary lectures, practical and laboratory classes, tests, self-training and course project work):

1. Distant learning;
2. Decomposition of modules of innovation-focused disciplines;
3. On-line lectures;
4. Venture programmes for incubation;
5. Group presentations;
6. Investment games.

Similar developments have been introduced at Russian higher education schools [2, pp. 15-28]. The concept of development and realization of innovative educational programmes at Ufa State Aviation Technical University (among 7 leading universities of Russia since 2014) is based on a systemic technical combination of the original innovative technologies mentioned above:

1. Implementation of innovative pedagogy focused on employers;
2. Driver for development of innovative technics, technology and economy of a region;
3. System integrator of best components of innovative pedagogy and innovative activity of leading universities in the interest of innovatively active enterprises.

2. SINERGY EFFECT OF SPECIALISTS' CONTINUOUS INNOVATIVE TRAINING

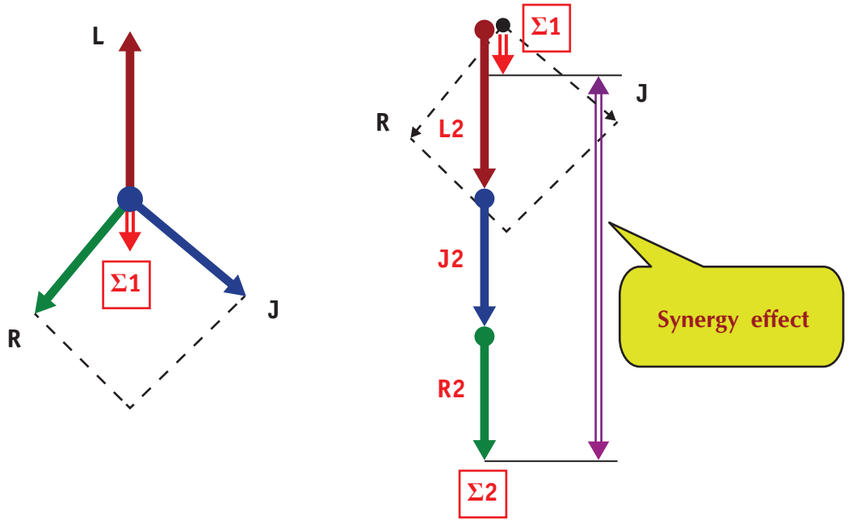
Introduction of programmes for continuous innovative training of specialists, bachelors, and masters, which is carried out at Ufa State Aviation Technical University, ensures synergy effect (synergy, synergism – from Greek "Synergism" – working together). The law of synergy is worded as follow: "A sum of the qualities of a whole is greater than an arithmetic sum of the qualities of its parts".

Synergy effect appears in different organizational systems, including realization of continuous innovative training of specialists (fig. 1, table 1) in connection with problem-oriented educational programmes of scientific courses focused on innovative activity in training engineering workforce [3, pp. 40-63].

The reported example of Ufa State Aviation Technical University allows taking engineers' innovative training to Stanford and Harvard levels (table 1).

Synergy effect of the continuous innovative programme for training specialists appears not so much due to the increase of course hours on "Innovatics" course (it is rather short and lasts for only 72 hours of theoretical training; table 1), but rather due to the introduction of innovation-oriented courses (table 1) and specific units of other disciplines that assure a high-level scientific and technical innovative design.

Fig. 1. Scheme of synergy effect from goal orientation and project organization of staff (enterprises, institutions)



Version I

For instance, specific innovative units of disciplines on natural sciences may include learning the following issues:

Higher Mathematics:

1. Analysis of sigmoidal patterns and relationships, including Fermi equations.
2. Analysis of logistic and bylogistic laws.
3. Analysis of mathematical models of Fisher-Pry, Gompertz, Morris, Sakhal, Kamenev, Pearl.
4. Analysis of Parzen's cross-covariance functions.
5. Fourier analysis.
6. Analysis of Volterra integral equations and Verhulst differential equations.

Physics:

1. Schemes of physical operation principles of critical technologies.
2. Research of physical operations.
3. Physical effects of critical technologies (for instance, acousto-optic effect, electro-hydraulic effect, acousto-magnito-electric effect, autoelectronic emission, adiabatic demagnetization, magnetic reversal).

Version II

Information technologies:

1. High-end computing systems.
2. Quantum computers.
3. Computer simulation.
4. Artificial intelligence.
5. 3D simulation of production systems in virtual reality classes.
6. Basics of information technologies in CAD/CAM/CAE/CAPP/PDM/CALS-systems.

Economics:

1. Consistent patterns of innovative economics.
2. Innovations and capital market.
3. Crediting of innovative processes.
4. Banking technologies for investment and innovative activities.
5. Investment project development, business-planning, etc.

Table 1. Example of "Innovatics" module design for training specialists of mechanical engineering major

№	Disciplines	Hours	Bachelor programme, hours								Master programme, hour				PhD	
			Semester	3	4	5	6	7	8		9	10	11	12	13	14
1	Innovatics	72		72							*elective course*					
2	Gas Turbine Engines of Next Generation*	72			72											
3	Nano-techno-logies and Nanoma-terials for Aviation*	72				72										
4	Patent Practice	72					72									
5	Innovative Processes in Mechanical Engineering	108						108								
6	Technical Production Support Work	216						216								
7	Technical Re-tooling of Machinery Production	144							144							
8	High-End Technology in Gas Turbine Engine Production*	72							72	Internship Thesis						
	Over whole module:	828		72	72	72	72	324	216							

№	Disciplines	Hours	Bachelor programme, hours							Master programme, hour				PhD	
			Semester	3	4	5	6	7	8	9	10	11	12	13	14
1	Prospective Materials for Aviation Technology*	144		*elective course*						144					
2	Innovative Technological Design	144									144				
3	Design of Digital Production	144									144	Internship	Thesis		
	Over whole module:	432								144	288				
1	Innovative Technologies and Technical Re-tooling of Production	207												99	108
	Over whole module:	207												99	108

3. MODULAR, NETWORK, ELECTRONIC AND DISTANT LEARNING IN THE FILED OF INNOVATICS

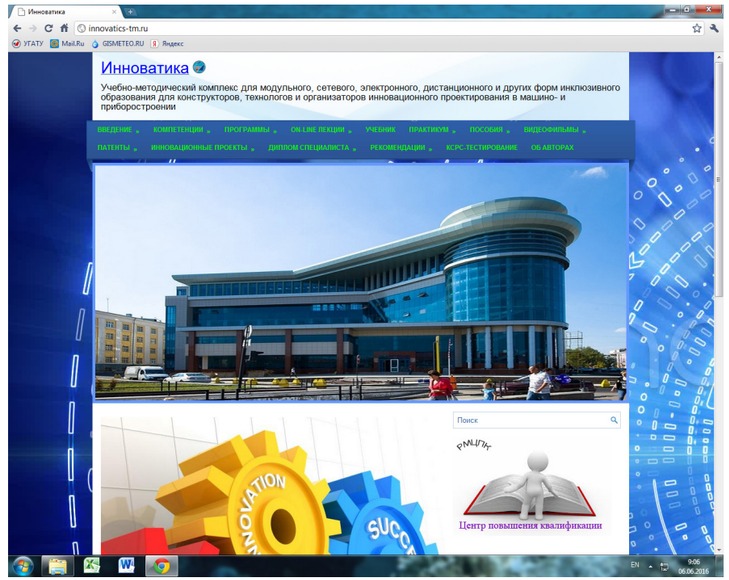
As has been stated above, in accordance with the requirements of the Federal Law on Education in Russian Federation No. 273-FZ of 29 December 2012, the most important study programmes and teaching and learning methods are modular and network programmes, electronic and distant teaching and learning methods.

In this context the "Innovatics" module (www.innovatics-tm.ru) and programmes for continuous innovative training for industry are currently equipped with study and guidance materials available through the Internet (fig. 2).

Study and guidance materials database includes the following electronic modules:

- Competence-based models and study programmes.
- Textbooks, workbooks, laboratory practicums.
- Lectures for students and public speeches of leading specialists.
- Monographs published in Russia and abroad.
- Automated system of scientific research of high and critical technologies, e-databases for innovative design.
- Videos on high technologies of best mechanical factories of the world.
- Regulatory documents and approaches.
- Patents and unified technologies for innovative design.
- Examples of innovative projects.
- Examples of Bachelor, Master and PhD theses in the field of innovations.

Fig. 2. Front-page of the "Innovatics" module study and guidance materials database



- References and reading materials, foreign publications, glossary on innovations.
- System for knowledge assessment (testing) via the Internet.

The "Innovatics" module website provides direct access to profile websites of world leading universities.

CONCLUSIONS

As practice shows, the methods enlisted above provide opportunities for trained specialists focused on innovative activities to:

1. Significantly shorten time for development of new technologies and launching them into production.

2. Assure competitiveness of engineering products and enterprises by means of innovative design, development and introduction of technological innovations.

3. Increase technological level and efficiency of mechanical manufacturing up to the level of best national and foreign counterparts by means of introducing unique system of technical (technological) re-tooling of production executed in the process of innovative activity at aviation enterprises.

Introduction of the proposed system of continuous technological reconstruction to one of the enterprises has practically led to a fast-track launching to production of more than 50 new products of aviation technology, as well as to doubling of the production volume on the same premises and with the same workforce [1, pp. 338-349] and with minimum loans.

Introduction of the study and guidance materials database to the continuous innovative training of specialists, bachelors and masters within the study process fulfills the requirements of:

- The Federal Law on Education in Russian Federation No. 273-FZ of 29 December 2012.

- International ECTS requirements (*ECTS and Diploma Supplement – European Community Course Credit Transfer Systems*).

Authors of the proposed module and study and guidance materials database on "Innovatics" for the realization of study programmes in modular and network forms, and of e-learning and distant learning are confident that the disclosed method for continuous innovative training of specialists and the "Innovatics" module in case of their wide-spread introduction could assure the enhancement of engineering training at HEIs up to the level of the leading universities of the world.

REFERENCES

1. Selivanov S.G. Innovatika : uchebnik dlya vuzov [Innovatics: university textbook] / S.G. Selivanov, M.B. Guzairov, A.A. Kutin. – 3rd edition. – Moscow: Mashinostroenie, 2013. – 640 p.
2 Selivanov S.G. Innovatika I innovatsionnoe proektirovanie v mashinostroenii: praktikum [Innovatics and Innovative Design in Mechanical Engineering : Practicum] / S.G. Selivanov, N.K. Krioni, S.N. Poezjalova – Moscow: Mashinostroenie, 2013. – 770 p.
3 Selivanov S.G. Sistemotekhnika innovatsionnoi podgotovki proizvodstva v mashinostroenii [System Engineering of Innovative Pre-Production in Machine-Building] / S.G. Selivanov, M.B. Guzairov – Moscow: Mashinostroenie, 2013. – 568 p.

UDC 37.031.4

Concept of Subject Area "Technology" as a Way to Modernize Learning Content and Methods at Modern School

Moscow City Teacher Training University
D.A. Makhotin
Russian Academy of Education
A.K. Oreshkina, N.F. Rodichev
Academy of Social Management
O.N. Logvinova

The paper presents the main idea of "Technology" concept developed by the team in Russian Academy of Education. The concept distinguishes the basis and the main areas of learning content and methodical modernization in technology education at Russian schools.

Key words: technology education, design and technological culture, subject area "Technology", learning content, learning methods, engineering and technology training.

Problem statement

Recently, teaching communities and professional associations have been actively debating the need to modernize the learning content and teaching methods in the subject area "Technology".

The post-industrial society is in demand for highly-qualified specialists who are ready to live and work with ever-changing technologies and technological systems. The inconsistency between this demand and the level of school leavers' knowledge has become the reason for sharp critics of modern technology education at Russian schools.

Engineering competencies, systems thinking and creativity, communication skills, ability to analyze scientific and technical data, work with technical documents are the basic personal attributes that are in demand in the modern society. It is these attributes that shape the technological culture and should be developed within the subject area "Technology".

In the context of high-tech manufacturing and breakthrough technologies, the level of technological culture defines human resources of the economy and production of the country, its competitiveness on the global market, intellectualization of human capital and knowledge-intensive activities, as well as ensures security and culture of manufacture and other technological processes.

In foreign countries, the education system, in which the subject area "Technology" plays a significant role both due to its importance and high volume of content in the basic education, allows educators to shape strong human resources for further professional education and, thus, ensure competitiveness of manufacture on the global market. Great Britain, France, Germany, USA, Israel, South Korea, China, etc. are among these countries.

Worldwide, the competitiveness of the education system that is a key condition for sustainable development of the national economy, manufacture, defense capacity and national security is ensured by the following: 1) improvement of pupils' academic training, especially in the field of natural sciences and mathematics; 2) enhancement of science and technology literacy (culture) of school leavers, which would enable them not only to use effectively up-to-date technologies


D.A. Makhotin


A.K. Oreshkina


N.F. Rodichev


O.N. Logvinova