



Innovation in research and engineering education:
key factors for global competitiveness

*Innovación en investigación y educación en ingeniería:
factores claves para la competitividad global*

PRACTICE IN BULGARIAN UNIVERSITIES FOR ADAPTING TO PRESENT EDUCATIONAL CHALLENGES

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Abstract

Technology developments nowadays face universities with many educational challenges – to integrate technologies in educational processes, design new electronic educational materials, change teaching styles, and better meet the demands of the technology-savvy generation, as well as the requirements of the labor market for skills and knowledge of future employees. On the other side, universities have a special role in the triangle of knowledge – to generate new knowledge, disseminate it in economy and society, and collaborate with industry for integrating it into new products and services. All challenges for universities today face them with the need to ensure proper management of their knowledge assets. In Bulgaria, universities have introduced various changes for meeting the challenges they face. Many of them have changed their technology environment in order to facilitate the access to educational, scientific and administrative resources. Ensuring easy-to-use learning management systems, accessible not only from computers, but also from mobile phones, represent objectives of many on-going projects in Bulgaria. At the same time, many universities have amended their educational programmes, adding new courses or learning styles aimed at better meeting the demands of industrial stakeholders for skills and competences of their future employees. The European Union Structural Funds play presently a key role in supporting Bulgarian universities to become more competitive and integrate themselves into the European university area. The paper provides initially an overview of the challenges that Bulgarian universities are facing. It focuses on the environment in Bulgaria for research, higher education and innovation, as well as on the e-skills agenda and the industry-academia collaboration problems. Second, the paper presents good practices at three leading Bulgarian universities – Sofia University ‘St. Kl. Ohridski’, Technical University – Sofia and New Bulgarian University. These examples show the university responses to the labor market needs and the respective changes in curricula and courses, as well as the changes in the technology environments in universities for better knowledge management.

Keywords: knowledge management; new curricula; adapting to labor market needs; skills

Resumen

Por los desarrollos tecnológicos las universidades se enfrentan hoy en día con muchos retos educativos - para integrar las tecnologías en los procesos educativos, el diseño de nuevos materiales educativos electrónicos, cambiar los estilos de enseñanza y satisfacer mejor las demandas de la generación de conocedores de la tecnología, así como los requerimientos del mercado de trabajo para las habilidades y el conocimiento de los futuros empleados. Por otro lado, las universidades tienen un papel especial en el triángulo del conocimiento - para generar nuevos conocimientos, su difusión en la economía y la sociedad, y colaborar con la industria para la integración en nuevos productos y servicios. Todos los desafíos para las universidades que se enfrentan hoy con la necesidad de garantizar la adecuada gestión de sus activos de conocimiento. En Bulgaria, las universidades han introducido varios cambios para afrontar los desafíos que enfrentan. Muchos de ellos han cambiado su entorno de tecnología con el fin de facilitar el acceso a los recursos educativos, científicos y administrativos. Garantizar fácil de usar sistemas de gestión de aprendizaje, accesible no sólo de ordenadores, sino también de los teléfonos móviles, representa los objetivos de muchos proyectos en curso en Bulgaria. Al mismo tiempo, muchas universidades han modificado sus programas educativos, la adición de nuevos cursos o estilos de aprendizajes dirigidos a una mejor satisfacción de las demandas de los actores industriales de las habilidades y competencias de sus futuros empleados. Los Fondos Estructurales de la Unión Europea desempeñan actualmente un papel clave en el apoyo a las universidades búlgaras para ser más competitivos e integrarse en el espacio universitario europeo. El documento proporciona inicialmente una visión general de los retos a los que se enfrentan las universidades búlgaras. Se centra en el medio ambiente en Bulgaria para la investigación, educación e innovación superior, así como en la agenda de la capacitación y los problemas de colaboración de la industria y la universidad. En segundo lugar, el documento presenta buenas prácticas en tres universidades más importantes de Bulgaria - Universidad de Sofía "St. Kl. Ohridski", Universidad Técnica - Sofía y Nueva Universidad Búlgara. Estos ejemplos muestran las respuestas de la universidad a las necesidades del mercado laboral y los respectivos cambios en los planes de estudio y cursos, así como los cambios en los entornos de tecnología de las universidades para mejorar la gestión del conocimiento.

Palabras clave: *gestión del conocimiento; los nuevos planes de estudio; la adaptación a las necesidades del mercado de trabajo; la capacitación*

1. Introduction

In the triangle of knowledge, universities have a specific role for creation of new knowledge, its application in practice and its final dissemination in the educational process. As knowledge providers they are normally at the upfront of economic and societal developments. However, the pace of change in last decades, and the pervasive use of technologies and new engineering solutions have raised essentially the challenges for academic organisations world-wide (Nisheva, et al., 2008). One of the essential demands for universities is to supply the required skills and knowledge in economy and society. Subsequently, during the last decades, the issue of skills was put on the agenda at different fora focusing in particular on e-skills, entrepreneurial and innovation skills of future employees. Therefore, within the Bologna process the European universities have undertaken structural changes, and have focused on updating curricula, introducing new learning methods and tools. It was taken into account that companies are seeking in general a combination of three types of skills – technical, business and personal. In addition, the skills set of engineers includes management of intellectual property and innovation, project management, business planning, and leadership

capacity (Gourova, et al., 2009). Bulgarian universities have undergone deep changes in the last few years, as well. One of the challenges for them was to introduce the three levels of higher education. Another challenge was to ensure high educational quality with limited resources and old-fashioned technology base. Presently, many of them are looking for the opportunities of distance education and enhancing the collaboration with industrial stakeholders. This is, actually, the objective of this paper – to present some good practices in providing the skills required by industry.

2. Environment for higher education, research and innovation in Bulgaria

Bulgaria joined the European Union (EU) in 2007 after a difficult transition period towards a market economy. The EU membership influenced initially a high growth rate of investments in economy and its consequent uptake. Unfortunately, the financial crises stopped this growth and faced many enterprises with severe problems. Similarly to other countries, the industrial growth in Bulgaria is related to increasing demand for highly-qualified specialists. Their significant ‘brain-drain’ during the transitional period, however, makes it very difficult to ensure the proper skills supply. All Bulgarian universities have faced problems like ageing of staff and low interest by young people to researchers’ career, low demand for research services by industry, and insufficient investments in the material bases. Therefore, the Ministry of Education, Youth and Science stressed that the sustainability of higher engineering education is in danger as the simple regeneration of researchers is not possible. Subsequently, the last government emphasized the need for higher investments in engineering disciplines (Ionkov, et al., 2013). Among the problems that Bulgarian universities and research organizations face is the low level of collaboration with industry. Awareness and absorption capacity lacks in enterprises, whereas in universities lack entrepreneurial skills, competences for technology transfer and intellectual property rights. The collaboration with industry of most universities is focusing mainly on consultations, joint events and students’ practices. It is not surprising, therefore, that the European Innovation Scoreboard placed Bulgaria among the catching-up countries due to the insufficient linkages of its innovation system, characterised by (Gourova, 2011):

- Weak links between science and businesses;
- Not sufficient measures to develop innovation infrastructure, support services, technological brokerage, intermediary services, etc.;
- Not involvement of university students in scientific and technological activities;
- Low innovative culture of researchers and weak innovative culture of businesses;
- Low level of investment in new products and processes;
- Slow implementation of measures and not systematic and transparent evaluation, etc.

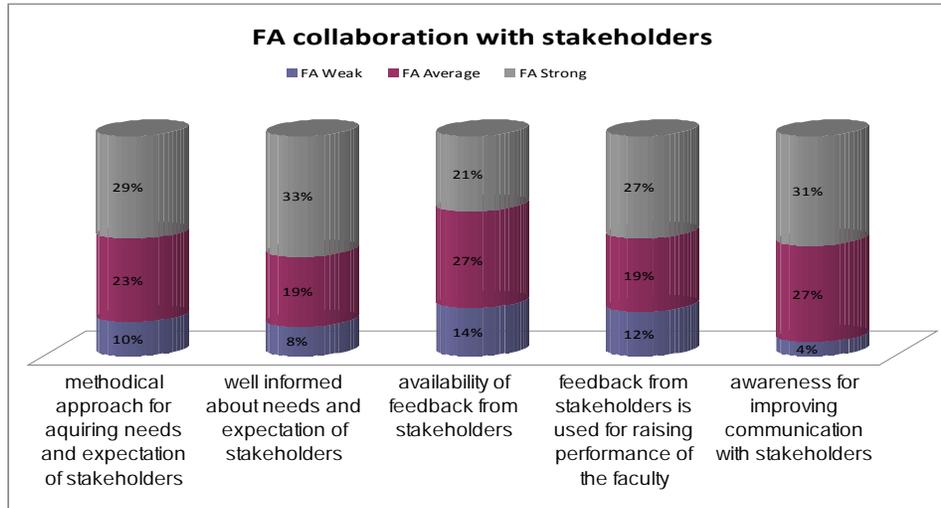


Figure 1. University – business collaboration (Gourova, et al., 2009)

A survey undertaken at Technical University – Sofia (TU) shows that its Faculty of Automatics (FA) has not adopted systematized processes for identification of industry' needs. While FA is regularly inquiring external information in order to improve its internal processes and activities (Figure 1), it is not effectively used. On the other side, FA is not considered as participative and communicative organization – it rarely issues messages to stakeholders, which subsequently are not aware of its research results, and educational outcomes. Therefore, in a strategic action plan prepared within EU project it was stressed as an essential challenge for FA (except its staff ageing) the need to establish more structured contacts with industry for joint research projects, exchange of staff, internships and joint supervision of students thesis, etc. Higher transparency of research results and regular communication with business organizations might be a first step towards establishment of strong intersectoral collaboration and linkages (Gourova, et al., 2009).

While universities are struggling with limited finances, decreasing participation and difficulties to ensure their competitiveness at educational markets, the industry is undertaking initiatives to ensure the proper skills supply. A group of ICT stakeholders in Bulgaria disseminated recently a report on the “Strategic requirements of the software industry for the educational system reform” (BASCOM, 2012). They expressed a clear demand for a specific set of knowledge and competences of future software engineers. The essential message for universities is that they need to ensure a balance of skills and competences, including business and market analysis, project management and leadership, design, creativity and innovative solutions development, customers' relations and good communications. The industry underlines a need for building real competences and knowledge, and strengthening the 'soft skills'. This would require deep changes in teaching methodologies and learning styles, as well as focus on interactivity, learning-by-doing, mentoring rather than just delivery of lectures, real practice experience, etc. Raising educational quality and focusing educational programmes on labour market demands should be the result of the proposed reform (BASCOM, 2012).

3. Good practices of university – business collaboration

Despite all problems of Bulgarian universities, real measures to overcome them started recently. This was mainly due to the opportunities provided under the EU Structural Funds in Bulgaria, and more specifically

under the Operational Programme 'Human Resources Development'. Some of the projects funded under this programme are targeted at PhD students and young researchers, while others – on adapting academic curricula to industry demands, and introducing distance education at universities. Some of the good practices to be presented in this paper show the results of such ongoing projects.

3.1. Experience at Technical University - Sofia

TU is the leading Bulgarian engineering university. More than 100 000 students graduated TU within the years, and afterwards incorporated their professional skills in building of modern Bulgaria. Its Department of Electrical Measurement (DEM) at FA has developed as a leading research and higher education centre in the field of Electrical Measurement (EM) in Bulgaria. Among DEM achievements could be pointed out (Ionkov, et al., 2013):

- DEM scientific work has followed the industrial demands, and DEM researchers have participated in more than 50 projects with industry and external partners.
- DEM has strong contacts with a large number of companies (e.g. Nuclear Power Station – Kozloduy, National Electrical Company, UniTech Co.), based on contractual research and consultation, students' practices and joint events.
- DEM has been recognised as a leading centre in EM in Bulgaria by the main public bodies in the area - Bulgarian Institute for Metrology (BIM), State Agency for Metrological and Technical Surveillance.

The contacts of DEM with industry in the area are based on old traditions for compulsory students' industrial practice. The main goal of this practice is to acquaint students with real production, enterprise organization, marketing, human resources, company policy, etc. The teaching methodology envisages visits to production facilities, explanations from accompanying lecturers and enterprise staff. The main specializations of the industrial partners is production of machine tools, DC motors, machinery and automatic transfer lines for packing, bottling and labeling, automatic transfer lines and machines for recycling of industrial goods, etc. The good contacts with BIM – a big employer of DEM students, also reflect in student practices, and in particular visits to labs for measurement of time and frequency, acoustics, vibrations, optics, electricity, temperature, pressure, electrochemistry, etc. (Gourova, 2012).

Presently, the students' practices are not organized on a sound base – only on personal contacts of DEM researchers with external stakeholders. The department, therefore, recognizes the need for more structured and long-term collaboration patterns. Subsequently, in April 2012 DEM launched a joint project with the department on 'Precision Engineering and measurements instruments' of TU for adapting curricula in metrology and technical quality assurance according to industrial needs. A partner in the project is the Association of industrial capital in Bulgaria (AICB). The project will investigate the industry demands for skills set of metrology graduates of both departments, and on this base will prepare a new Masters programme in Metrology, as well as upgrade the present curricula at Bachelor level. One of the expected outcomes of the project is that the collaboration with AICB and its members will help for strengthening the collaboration with industry, and more specifically:

- Integrate industrial guest lecturers in the educational process;
- Ensure industrial supervision for thesis preparation;
- Enhance students' practices and industrial visits;
- Launch students' summer practices in industry;
- Conclude partnership contracts with businesses.

In parallel, DEM staff participates also in other projects for introducing e-learning at TU. These project ensure, first, technology upgrade and second, the skills needed for changing teaching methodologies and learning styles according to the needs of e-learning. In addition, a concept for knowledge management system is underway, trying to facilitate knowledge dissemination among teachers and TU internal and external stakeholders (Gourova, et al., 2013). All these projects will support TU to overcome its problems and the challenges of its environment.

3.2. Meeting the demands of software industry

Another good example is the Faculty of Mathematics and Informatics (FMI) of Sofia University (SU), leading supplier of software engineers in Bulgaria. **FMI researchers actively participated in the development of the first** Strategy for ICT education in secondary schools. They are involved in curricula development for schools, as well as preparing future teachers in mathematics and informatics. E-Learning technology and methodology are among the strengths of FMI research and practice, as well as building information and communication technology (ICT) professional skills. FMI staff is aware of the challenges of the knowledge-based economy for ICT skills and more then 7 years ago launched new Bachelor programs on Computer Science, Software Engineering and Information Systems. These curricula were developed following the ACM/IEEE (Association for Computing Machinery/Institute of Electrical and Electronics Engineers) Computing Curricula 2001 and the Career Space curricula guidelines (Gourova, et al., 2009). In the design of the curricula were taken into account the Career Space core elements (e.g. application base and system solution methodology; personal and business skills; scientific base; technology base; as well as thesis and industry placement) and provided a balance between them in the new BSc programmes, which, subsequently, found a high demand by the students and appreciation by industry.

More recent FMI achievements are the provision of a Masters programme on Technology Entrepreneurship and Innovation in IT which was launched in 2008, and was most demanded by students because of the provision of interdisciplinary skills and knowledge within the course on Technology Entrepreneurship (with lecturer from Intel Europe), the course on Establishing students company (with lecturers from Junior achievement - Bulgaria), and the opportunities to take part in world competitions organized by HP and Intel.

Despite these achievements, surveys undertaken among employers of FMI graduates pointed out their skills level in business intelligence and artificial intelligence needs a lot of improvement. In addition, it was suggested to focus on the skills related to business plan preparation and defense, launching innovation projects, etc. The result generally pointed out the remaining need to strengthen the entrepreneurial education at FMI, as well as to add new management or business-oriented courses in the BSc and MSc curricula (Nisheva, et al., 2009). Therefore, in 2013 was adopted a new Masters programme of Technologies for knowledge and innovation (TKI). During the preparation, FMI staff considered how to ensure a balance of different issues relevant to building the required mix of skills, and more specifically: How to determine a suitable set of courses; How to balance theory and practice; How to provide basic and applied theoretical knowledge; How to ensure teaching and self-learning (Gourova, et al., 2013).

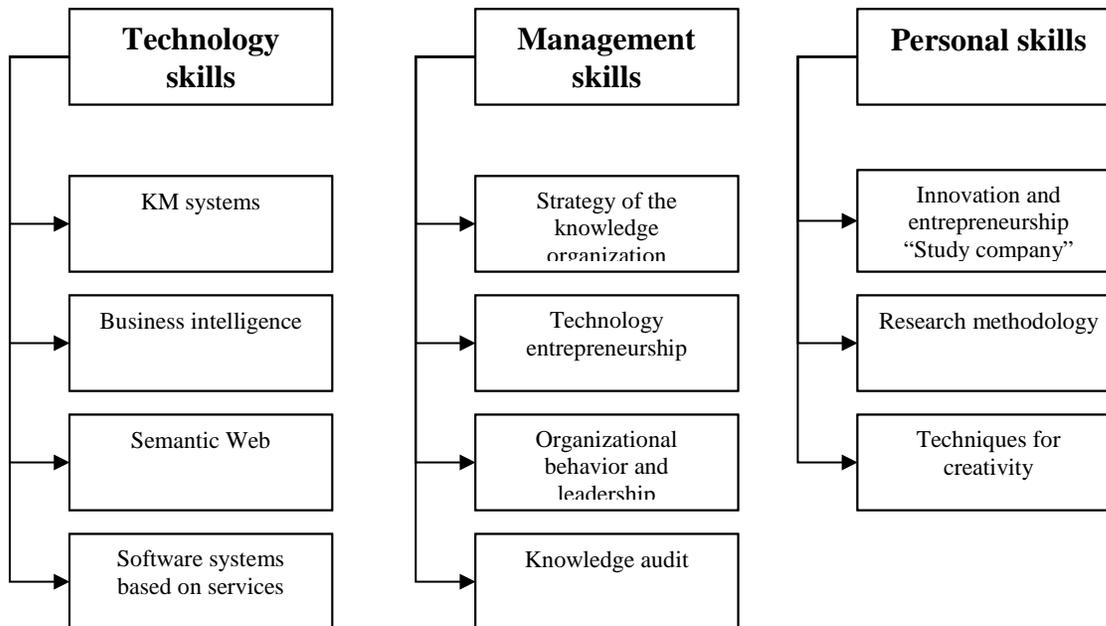


Figure 2. Main courses of the MSc programme on TKI (Gourova, et al., 2013)

As a main goal of the new programme was set “to develop informatics experts with broad managerial and interdisciplinary skills and competencies”. Subsequently, the courses were organised in three streams for building technology specific, management and personal skills of the students (Figure 2). The technology and management skills will be developed in a set of core obligatory courses. The elective courses will help students to deepen their knowledge (or gain knowledge if not in place) on Knowledge Bases, Internet technologies and Web programming, Communication networks and technologies, Object-oriented programming, Law in e-business, Techniques for creativity, and Technology entrepreneurship in Information technologies. The personal skills will be gained within some of the elective courses and mainly during the seminar classes of the obligatory courses. For this will help group work, discussions on case studies and development of own case studies for Bulgarian companies, presentations and defense of ideas, etc. With special importance for students is the course Innovation and entrepreneurship ‘Study company’ (with tutors from Junior Achievement – Bulgaria) which will support students to obtain soft skills to generate and communicate ideas, take decisions, transform ideas into actions for building their own Study company, etc.

3.3. Equipment of telecommunications specialists with interdisciplinary skills

The last example focuses on the experience of the Department of Telecommunications (DTK) of the New Bulgarian University (NBU). NBU is the first Bulgarian private university, and has flexible and efficient management structure, as well as shows readiness to respond to knowledge and skills needs by economy and society. DTK has unique programme on Telecom management, involving as teachers high-qualified professors with experience in Telecom and postal reforms, BTC, BNT, etc. It has close collaboration with Telecom Industry and Regulatory Bodies, with several Broadcasting and Telecom organizations and with the ICT Cluster. This reflects in offering students Practice, on the basis of frame contracts, in Bulgarian Posts, Siemens, Ericsson, Electron-Radiocom, Vivacom, M-Tel, Germanos, etc.

DTK offers Bachelor Programs specialization in Telecommunication technologies and services, Regulation and management in electronic communications, and Postal and courier technologies and services. Its Master Programs specialization comprises: Telecommunication systems and technologies, Radio communications and electronic media, Regulation and management in Telecommunications and Implementation of telecommunications projects. Recently, it recognized the need for interdisciplinary skills of telecommunications engineers. Therefore, in collaboration with the ICT cluster DTK is preparing a new interdisciplinary programme 'Innovation and entrepreneurship in high tech'. The proposed courses include: Economic and legal environment, Management, finance and market specificity, Strategic management, Innovation and technology transfer, Competitiveness and IPR management, Web-based marketing, Engineering design, Software architectures, Project funding for innovations, and Cultural and ethical issues of entrepreneurship. Similarly to DEM, DTK is working on a project with the ICT Cluster for fine-tuning of the curricula and better responding to industry demands for skills and knowledge of their employees.

4. Conclusions

All examples presented in this paper show that the three departments have achieved many successes. First, they have linked education programs to labour market needs and students demands. Second, all of them have university strategies in place, and are well positioned in Bulgaria and the region. The most essential for these departments is that they are driven by leaders understanding the global challenges for research and industry organizations. Nevertheless, a lot of challenges still remain: for the teaching staff to improve and widen competences, to strengthen the collaboration with stakeholders, and for changing universities environments to motivate the staff and attract young researchers. As the strategic documents stress, the way ahead should focus on the following:

- Undertake continuous efforts to progress the quality of education, training, information and research services to gain program competitiveness, high levels of achievement and a knowledgeable community;
- Ensure that education and research services are relevant to the needs of Bulgarian workforce, industry and local and state government;
- Release individuals of all ages with access to education, training and information services to develop their competences in order to be globally competitive workers, responsible citizens, and lifelong learners;
- Ensure greatest benefit from education and research resources through efficient operation and management of the education and research system and investments in student learning centered curricula.

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