East-West cooperation for the enhancement of teaching and learning engineering

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Abstract

This discussion paper considers the fundamental differences between engineering higher education in the former Soviet countries and those described by leading pedagogical researchers in the 'west'. In particular, considered here are aspects of student centred active learning to develop 'professional and transferable skills' and the involvement of industry in the curriculum. The paper was written to stimulate much needed discussion and provide a vehicle for possible future co-operations by reporting on a 2013 symposium, held at Bauman Moscow State University "Preparation of Engineers – sharing the experiences of the UK", promoting academia working with industry. The event was attended by representatives of eleven companies with interests in Russia. A centre for excellence is proposed to form an international hub for sharing good practices and pedagogic principles that promote education relevant to today's global employment market.

Keywords: *International cooperation, industry, curriculum development*.

1. Introduction

This paper is intended to stimulate discussion and promote potential future cooperation between teachers and researchers in the West and in the former Soviet and East European states, particularly in respect of providing appropriate, exciting and pedagogically sound curricula for employability within global industries. While educational methods can vary massively within any particular region, underlying stereotypes can still be detected in some loosely defined areas and while the on-going Bologna Process has certainly helped to draw international academia closer together, it was designed primarily to ensure comparability in output standards and higher education qualifications, but not to specify the pedagogic method. In any case, a closer inspection soon reveals large remaining differences in definitions and timeframes both within the broad regions considered here and between them.

In a rapidly changing world, it is easy to observe that different historical legacies provide, in large part, the fundamental basis of the present-day engineering curricula at the majority of institutions, east and west. Engineering students, however, graduate into an increasingly global world where most major industrial companies and corporation are multi-national and most far-thinking universities are actively promoting internationalisation and diversity policies.

The differences in approach between the leading edge pedagogies of the 'west' and the traditional former 'Soviet' system are stark: on the one hand, Enquiry Based and Active Learning topographies are being heavily promoted and on the other, we have a preponderance of science intensive didactic courses.

2. Background

The system of engineering education in the USSR and East European aligned countries was historically notable for its size and its diversity; being a complex and varied system; it was not well understood by outsiders. Since the mid-1980s, the entire educational system, and the economic system on which it was based, has seen massive change and there has been serious discussion of changing to a "European" or "American" system.

A series of reports from The Royal Academy of Engineering (RAEng., 2006, 2007, and 2010) and Massachusetts Institute of Technology [1] confirmed that change in western undergraduate engineering education is also urgently needed to ensure graduates remain equipped for the new and complex challenges of the global 21st century. One particularly interesting aspect of this compressive survey of international 'experts' was that the recent drive for research excellence in the west is partly responsible for reducing the proportion of faculty that have significant industry experience and that these individuals were previously, significantly more likely to support and drive educational change than those who have not spent much time working in industry.

Education, under the Soviet system was always strongly conflicted between academic and vocational purposes. Although students encountered a curriculum designed by highly qualified academic specialists and were encouraged to grapple with highly complex mathematical topics beyond those encountered in most US and Western European Schools, and as a result, the teaching of an imaginative curriculum often resulted in requiring rote memorisation and solving problems under fixed conditions. [2] where students study for at least 5 years with an average of 35 to 50 contact hours per week compared with, typically 4 years and 15-18 hours in the US or 16-22 hours per week in the UK.

3. The need to Grow Internationally

Internationalisation of education is manifested in the form of a growing transnational flow of students and also through mutual exchanges of teachers and researchers. Perhaps of greatest relevance here, however, are the growing use of foreign curricula, textbooks, literature and sources of information; the sharing of best-practice pedagogical methodology and various kinds of inter-university cooperation.

The need for greater cooperation has been brought about firstly by toughening competition in the world market for educational services. Apart from the traditional forms of receiving foreign students, the new multinational sector of "big business" in education has emerged. It operates through offshore campuses, curricula franchising and "on-line" education. In that sector, one can see intensive and wide coverage of students outside the education provider country either in developing or in advanced states. Leaders of this trend of educational business today are the USA, the UK and Australia. [3]

Secondly and of potentially greater significance for developing optimum curricula that are fit for purpose, higher education is increasingly becoming exposed to the influence of new global economic development imperatives and the need to produce graduates that are highly employable within international companies and corporations. This liberalisation of international trade demonstrates the need for an international system of licensing, certification and accreditation to provide quality assurance of professional training.

The functions of the state in the field of education are changing. Many countries have pursued a policy of deregulation, delegating more rights and powers to the universities, which leads to greater emphasis on the market approach in education as a whole. The growth of competition and a relative reduction of public financing act as strong incentives for the universities to become involved in activities outside their national borders and this is enabled by ever improving information technologies that serve to amplify this process.

3.1 Bologna in the UK and Russia

One of the key features of the Bologna process that has existed since 1999 has been that each country should develop a national framework for higher education qualifications and it was always intended that these frameworks would be mutually compatible to better enhance the mobility of graduates. However, exploration of the UK and Russian systems, for example, quickly reveals that, despite Bologna, substantial differences still exist at the time of writing.

In the UK a master's degree is normally based on 1800 hours of study (180 U.K. equivalent to 90 ECTS credits) conducted over one year of full-time study. However the Bologna Process requires that master's degree programme normally carries 90 - 120 ECTS credits, which is equivalent to 2250 to 3000 hours of study and typically takes more than one year. The UK is also one of a small number of countries that allows candidates to move on to PhD study without first studying at master's level, even though most do.

Specifically in engineering, the UK has also very successfully embraced the integrated undergraduate master's (MEng) degree. The MEng, which is a 4 or 5 year degree designed for higher achievers, was introduced in the 1990s at the behest of the UK Professional Engineering institutions, working together as the Engineering Council. It has since become the prime standard academic qualification for professional registration as Chartered Engineer (CEng)[4] and sits alongside the alternative undergraduate Bachelor + postgraduate Master (BEng + MSc) route.

Since 2003, Russia has taken part in Bologna and this has certainly assisted in developing higher education as an area of cooperation between Russia and Western Europe, but, just as in the UK, progress has been slow and a number of problems persist. According to a case study by Gänzle et al, [5] implementation problems are generated by institutional path-dependency (personnel, institutional resistance, etc.) and the lack of quality control systems ensuring the proper implementation of Bologna objectives, such as curricular reforms. The Russian higher education framework was, however, basically incompatible with the Process: the generic "lowest" degree in all universities since Soviet era is the *Specialist* which can be obtained after completing 5–6 years of studies. Since the mid-90s, many universities have introduced limited educational programmes allowing students to graduate with a bachelor's degree (4 years) and then earn a master's degree (another 1–2 years) while preserving the old 5–6 year scheme. In October 2007 Russia enacted a move to two-tier education in line with Bologna Process model. [6]

4. Encapsulation Employability for Engineering Graduates; enhancing the role of industry in academia.

Much has been written of the need to involve industry in engineering education and the potential benefits are rarely disputed. The majority of Loughborough engineering graduates find their first employment in industry, so it follows that this is the primary reason for studying an engineering degree. It is, therefore, logical to suppose that industry should be closely associated with education and that engineering students should be immersed in the kind of things industrialists do. (*Six months after graduating in 2012…. 94% were in work or further study; 92% were in professional roles and of these 80% were in manufacturing and related industries.– LU careers centre statistics).*

The UK government Department for Business, Innovation and Skills commissioned the Royal Academy of Engineering to identify how to increase the number of engineering graduates with the skills industry needs, against a background where the UK competitive advantage depends increasingly on raising the level of Science; Technology; Engineering; Mathematics (STEM) skills. [7] There was recognition that UK business and industry would be disadvantaged if not provided with an adequate supply of well-educated and motivated engineering graduates; straightforward facts that can be equally applied to other industrialised countries. The research findings also indicated a tight labour market for high quality engineering graduates. There was some evidence, of skill shortages (where there is a lack of appropriately qualified graduates available to be recruited) and skill gaps (where there are particular deficiencies in the skills of those graduates that are available) in the UK graduate engineering labour market, although the picture in the latter case was rather mixed. Equally worrying was the concern that the grade of degree awarded can be a poor indicator of a graduate's actual abilities at work, which leads to questions about the appropriateness of the educational curriculum across universities as a whole.

With society's increasing dependency on technology and the global built environment, the pace of change in industry is expected to intensify in both the technological and non-technological domains. Particular themes that emerge include an increased need for firms to focus on solving customer problems; a growing requirement to provide system solutions to those problems; and the increasing complexity of the management and leadership tasks.

Major employers, like IBM, operate on a global platform and a survey from Monash University [8] asked employers of ICT graduates to suggest ways in which universities could better prepare their alumni for work in industry. The most popular response by a factor of 2, were that universities should provide students with more work experience and this agrees with findings of many other surveys. Others suggested that there should be more channels for communication between universities and employers, e.g. that industry should play a greater role in course and curriculum design and students should be made more aware of what to expect in industry and be given more training in generic (transferable) skills. Only 9% of respondents were seeking more specific technical skills

Loughborough University has a proud reputation for its strong links with industry dating back to its founder in 1906, Herbert Schofield, introduced the concept of "training on production" in the "institutional factory" and set the scene for the development of 'sandwich' courses & practical short courses. Education for engineering was the staple, training on production the method and in those days, students attended lectures in gowns and workshops in overalls; they clocked-in and out when working in the instructional factory. All engineering departments were constantly engaged on production orders alongside their academic duties; for example, they manufactured demonstration steam engines, hydraulic machinery, gauges, and electrical devices for use in schools, colleges and universities. Clearly, these methods are no longer current but the ideas and philosophy behind them still remain embedded in the current engineering curriculum in the form of plentiful internal projects sponsored by industry, industrial research links and year-long student placements and internships.

Partly because of this history, and also because Loughborough University is one of the largest providers of Engineering graduates in the UK, it has benefitted from a series of evolving support centres specifically to support excellence in teaching and learning of engineering and design education during the past three decades. The current Centre for Engineering and Design Education (CEDE), continues the legacy and builds upon a formidable heritage in pedagogic method and technology support left by a series of similar organisations that have responded to the particular needs of their time and attracted significant external funding from national bodies. The key to success has been to co-locate and establish a team of professionals working in partnership with academics for the mutual benefit of staff, students and the University as a whole. Over sixteen years the Centre has gone from strength to strength and, although it was not the original intention, the Centre's influence has now spread beyond the University, having widespread recognition of its achievements nationally and internationally both within higher education and industry. [9]

Bauman Moscow State Technical University (BMSTU) has an arguably even prouder tradition through its many scientific achievements and noble alumni. In the Russian federation there is a growing acknowledgement in the professional classes that and outward looking approach has many benefits. BMSTU is one of the biggest and oldest universities in Russia with the annual enrolment of over 3,500 students and the total number of more than 170,000 graduates. 18 Faculties and Research Institutes are organized in the 8 Research and Education Units offering a huge range of courses in manufacturing engineering, computer science, control systems, integrated automation, radio electronics, laser technology, medical engineering, power engineering, special-purpose engineering, fundamental sciences, engineering business and management, jurisdiction, social science, and linguistics. The BMSTU also has strong relations with industry and external research institutions.

For example, the BMSTU hosts an IBM Mainframe Centre of Excellence founded in 2007. This was to become a special incubator for relationships between university and enterprises to promote better education. It is based in the Computer Systems and Network Department. The Centre of Excellence now works with many different enterprises using necessarily flexible policies. The second author of this article is the Centre's director and also an associate professor at Computer Science department, while Professor Vladimir Suzev is the scientific advisor and heads the Computer Science department. Other professors and instructors from this and other departments are also actively involved in its operation. It is used by scientists, doctoral students and undergraduates.

The centre has proved to be the focal point for attracting significant externally funded research and development projects financed by the Russian Government and IBM that have now been successfully completed. One of these projects, funded by RF Ministry of education and science from 2010 - 2012, studied the quality of engineering education and student competences. It involved 4 professors, 14 scientists, 6 PhD students and 15 undergraduate students, and the practical results of this work have been widely disseminated. E.g. [10]-[11].

5. Evolving optimum educational methods

University level education in engineering should provide a firm grounding in the principles of engineering science and technology, while inculcating an engineering approach that enable graduates to enter the world of work and tackle "real world" problems. The best degrees, worldwide develop in their students a scientific and technical understanding alongside a practical application to problem-solving. This synthesis calls for skills like communication and negotiation; team working and inter-disciplinary working; and planning, costing and other key business process skills. Graduates with these skills are highly attractive to industry. This was confirmed in the UK by the Royal Academy of Engineering [12] who confirmed that industry seeks engineering graduates who have "practical experience of real industrial environments". Specifically, "industry … regards the ability to apply theoretical knowledge to real industrial problems" as the single most desirable attribute in new recruits. These problems have been or are being addressed in many UK universities there are wide variations in the level to which these issues are being addressed, and external drivers are constantly changing.

There are also a lot of problems in engineering education in Russia. Issues concern new types of engineering applications (for example, internet oriented engineers: web-designers, web-programmers), new types of educational means (for example, the use of online, video and e-learning techniques), new methodical approaches in education quality estimation and new types of educational processes such as design-based learning, problem and project approaches.

Both authors have developed the project based approach in engineering graduate preparation within the remit of their respective Centres for Excellence. This common ground has led to initial collaboration between the two institutions. The CEDE at Loughborough University, was consulted to assist with the Russian Centre's development and provides ample evidence that hosting a Centre can prove to be a highly effective support mechanism for discipline-specific academics to develop and maintain valuable national networks and collaborations along with considerable esteem for the host university. The relationship started between BMSTU and CEDE in January 2013 when scientists from these two university took part in a Russian Federation Program (p220) competition and is set to continue through inter-university cooperative staff visits. From the beginning of its creation in 2005 the IBM Mainframe Centre of Excellence has been involving students in to its activity based on an actual enterprise's needs and led to the launch of an IBM Competency Center for employment at BMSTU.

6. An Exploratory Symposium

In June 2013, the first author was invited to visit BMSTU along with two colleagues from the CEDE, in order to meet staff and students and lead an international symposium "Preparation of Engineers – sharing the experiences of the UK", promoting academia working with industry. The symposium was opened by Professor. Valery Matveev, Head of Informatics and Control Systems Faculty and eleven industrial companies were represented at the event. And through these connections, researchers in Loughborough' s School of Mechanical and Manufacturing Engineering are starting to form links with counterparts at BMSTU.

The visitors described their past experiences of interaction with industry and illustrated their talks with video film. Drs Glynis Perkin and Andrea Wheeler spoke about developments in innovative processes and educational technology developments in education. The team then facilitated a lively discussion about the requirements that Russian industry has of the graduates they recruit and extending the possible ways of cooperation between universities and industry. While it was clear that recruiters were already keen to offer employment to BMSTU alumni, it was also clear that there was a growing demand for more rounded individuals with exceptional communications and business skills as well as technical and scientific ability. It is really unsurprising that, when asked what attributes were most important to them when recruiting new graduate employees, the industry responded with characteristics such as: high motivation; willingness to learn; teamworking ability; communication skills; but of course they also mentioned 'work ethic' and 'hands-on experience' which are traits that commonly thought to be built through placements and industry-university cooperation.

Interestingly, the industrialists also cited 'the reputation of the university' from which the candidate had graduated as an important feature but that causes one to reflect on just how these reputations are built. In this particular case, it seems to suggest; over time through good experiences with the employees they take on.

Figure 1. Industrialists at the Moscow Symposium.

Figure 2. Informal discussions with students and young teachers.

On a separate day, the Loughborough team were invited to learn more about the Russian university and met with a number of students and PhD candidates to gain a better mutual understanding of the different cultures and educational systems. Both institutions were quick to recognise that the potential benefits for collaboration extend beyond the potential for sharing best practices in educational methods but also that these liaisons can tap into a latent demand to share research results across language barriers and generally improve the international profile of institutions.

7. Future possibilities

This paper has provided a general discussion of issues surrounding East West collaborations. This is clearly a topic that must grow in importance in the coming years. The further one looks into the possibilities, the more that seem to emerge. The problem is how to identify and surmount the obvious barriers to success, including:

- Historical factors.
- Lack of knowledge about culture.

- Language barriers.
- Lack of finance for education-based projects.
- Engrained attitudes.
- Dissimilar practices.

Hence, the proposal to invite interested parties to discuss these issues at ICEE2014.

One concrete possibility that is being explored is to create a central ‘engineering education’ organisation in Russia or one of the former soviet states that might form a hub for sharing good educational practices and support for academics in the same way that the former engCETL funded by the UK government through the Higher Education Funding Council, provided support. The engCETL was an engineering centre for excellence located in the Faculty of Engineering at Loughborough University in the UK. It was established in March 2005. The vision of the engCETL became internationally recognised by engineering academics and students, and nationally recognised by professional bodies and employers, as a centre of excellence for research and development in, support for, and implementation of, industry-linked higher education in a wide range of engineering disciplines. Over the 5-year funded life of the organisation, the work centred around the following areas: Curriculum Development; Student Focus; Academic Support; Pedagogical Research; Learning Spaces; Partnerships; Dissemination and Management and Accountability and as a result of the project’s success, a number of external grants were awarded to develop learning technologies such as Web-PA and Co-tutor that are now widely available. This work has continued to date under the CEDE umbrella.

If such an education centre were created in the ‘East’, then it would be logical to learn from the past experience of such centres around the world.

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