

FUTURE OF ENGINEERING EDUCATION

KEY DRIVING IMPACTS AND RESPONSES

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ENGINEERING EDUCATION FROM DIFFERENT GLOBAL PERSPECTIVES

GLOBAL
EDUCATION
MARKET

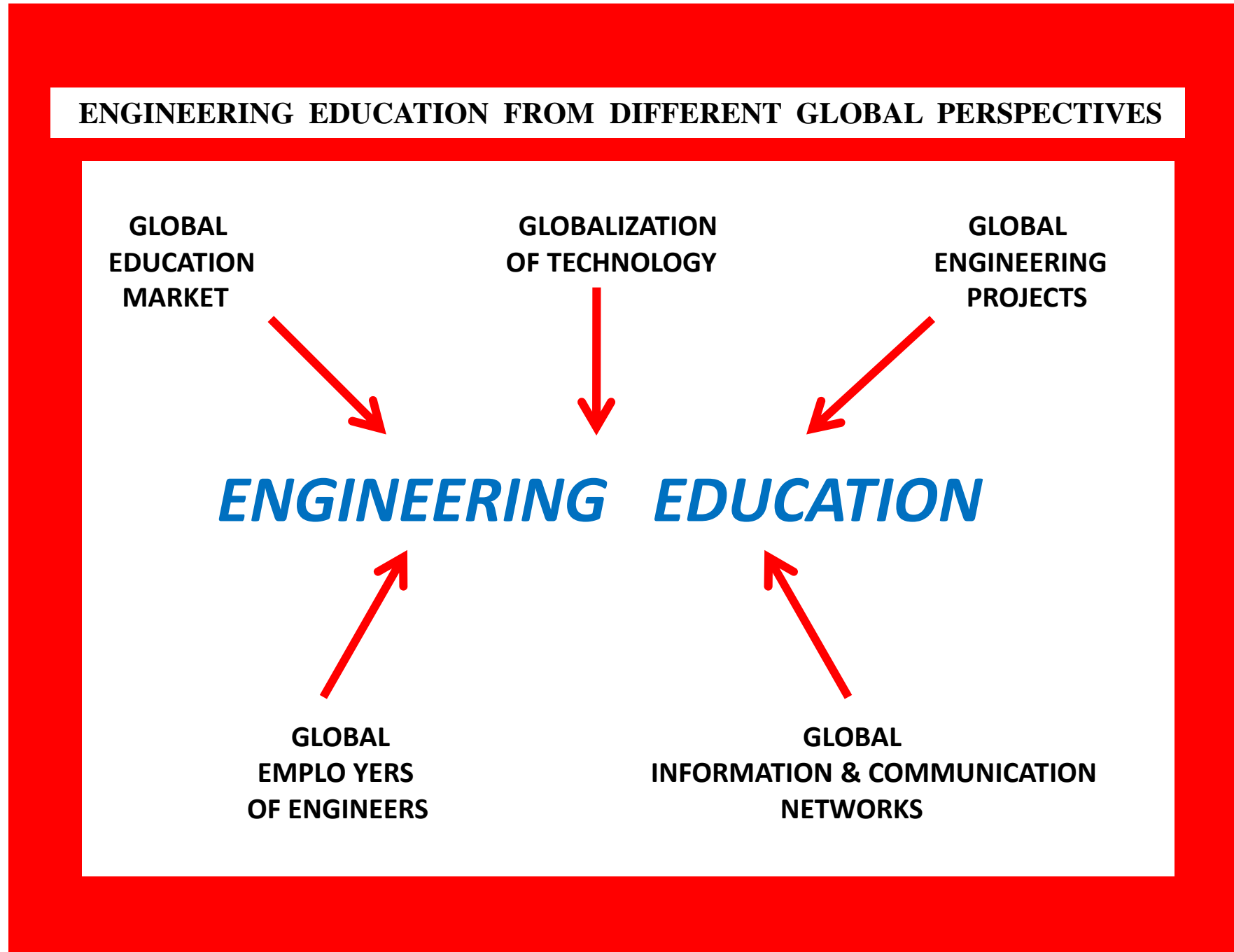
GLOBALIZATION
OF TECHNOLOGY

GLOBAL
ENGINEERING
PROJECTS

ENGINEERING EDUCATION

GLOBAL
EMPLOYERS
OF ENGINEERS

GLOBAL
INFORMATION & COMMUNICATION
NETWORKS



Global Education Market. Engineering Education perceived in terms of economy: internationalization of supply and demand for education services, export and import of the services, costs and benefits of providers and customers.

Globalization of Technology. Since antiquity technology has played an important role in the convergence of societies. Presently the number of globally spread technologies is increasing rapidly as well as the level of advancement of the technologies.

Global Engineering Projects. Global Hi-Tech challenges in the areas of : energy, global transportation and logistics systems, space systems, environment protection, disaster monitoring and relief - but also Low-Tech challenges in the areas of facilitation and improvement the quality of human life (water supply and purification, sewage systems, roads) in the poorest regions of the world .

Global Information & Communication Systems. Development of international distance learning and teaching, increasing reach of education, possibility of worldwide publishing and availability of literature (textbooks, manuals, research papers, lectures, presentations), access to databases, improved teacher - student communication, development of virtual forms of education, facilitated lifelong learning.

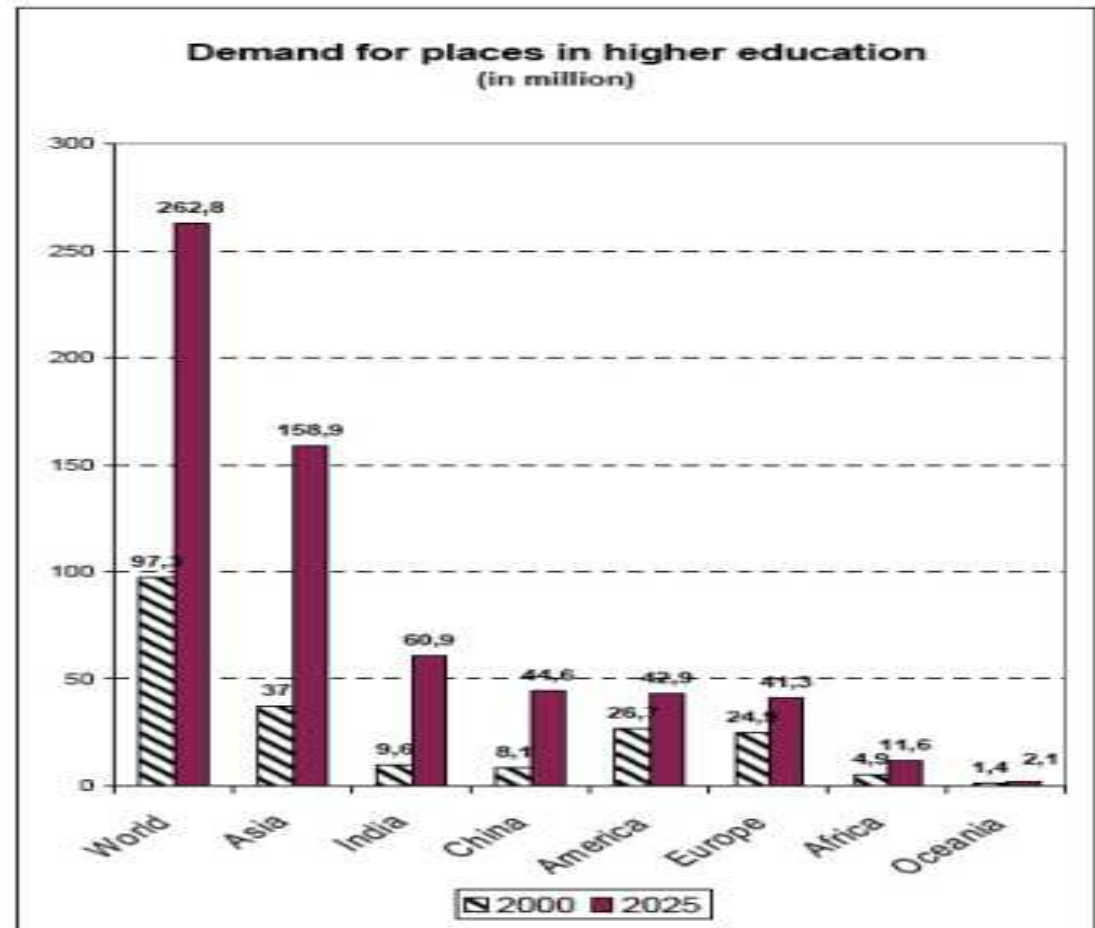
Global Employers of Engineers. Transnational corporations, global institutions and superstructures employing engineers but also providing supplementary education and training programs to meet the requirements of their global-scale activities.

GLOBAL EDUCATION MARKET

According to 2013 Global Industry Analysts Report [1] the global market for Education Services is projected to reach **US \$ 357 billion** by 2018, driven by growing demand for Education and Training Services in developing countries.

Following KEY FACTORS shaping the market could be distinguished:

- Supply and demand imbalance between educational needs and educational capacities, particularly in the developing world ,



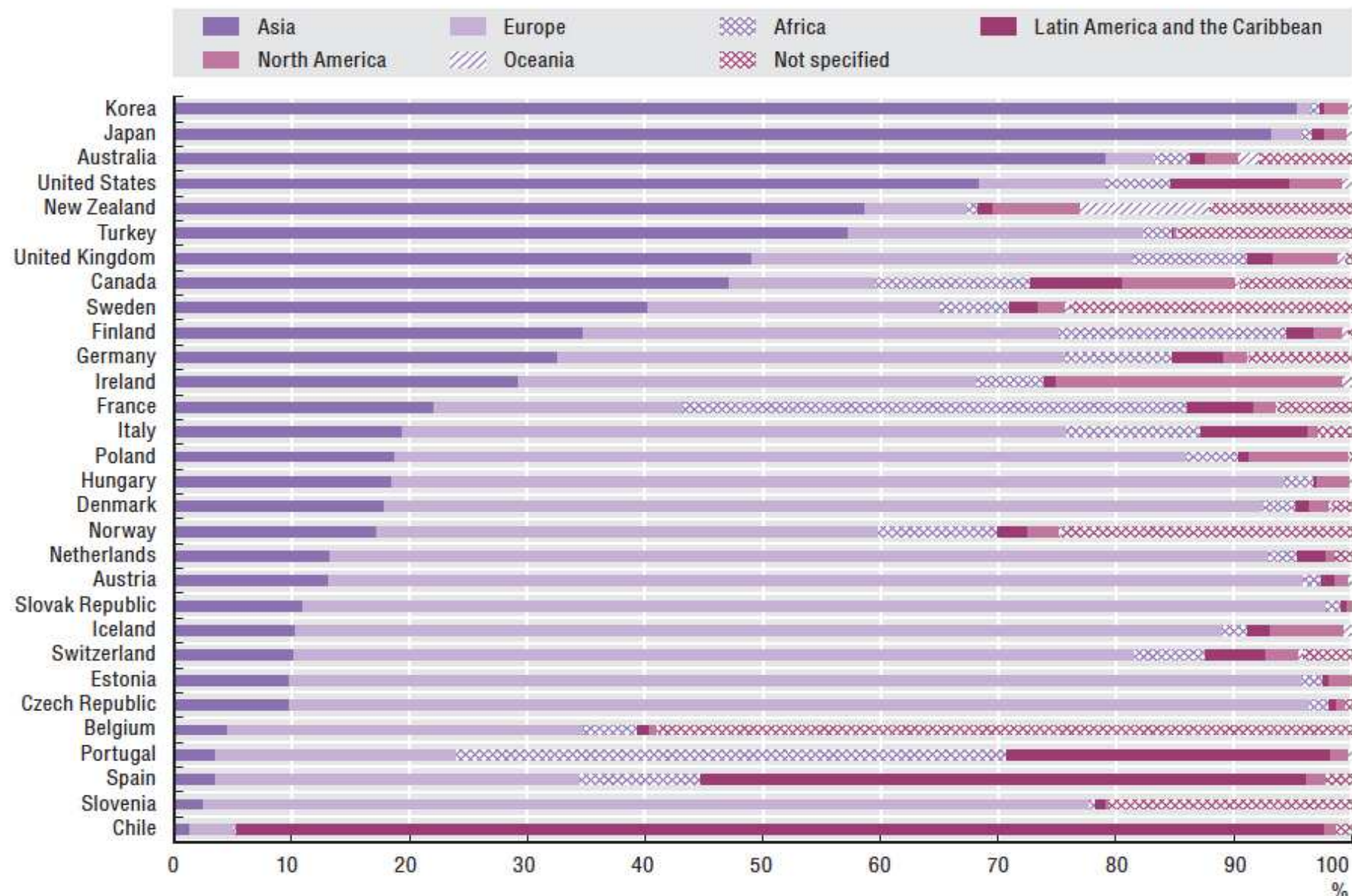
- **Mismatch in education quality (graduates knowledge and skills versus employers requirements),**
- **Growing competitiveness in the labor market,**
- **Appearing opportunities to take under control the international flows of education services,**
- **Increasing needs for comparativeness and recognition of qualifications.**
- **Employers demand for cross-cultural awareness and international adaptability of graduates.**

In response to the mentioned above impact factors following solutions and trends have appeared:

- **Organized exchange(ISEP, WISE, ASSE, ERASMUS Programme, SOCRATES Programme) as well as export-import trade of education services,**

Figure 1.18. **Distribution of foreign and international students in tertiary education, by region of origin, 2009**

This figure shows the regional origins of international and foreign students studying in OECD countries. The majority of students studying abroad come from Asia (52%), followed by Europe (23%) and Africa (11.5%).



Source: OECD (2011), *Education at a Glance 2011*, Table C3.2, available at <http://dx.doi.org/10.1787/888932464486>.

- **The rise of supplementary education and training to meet the demand of employers,**
- **Despite (or maybe as a result of) the economic crisis people tend to upgrade their skills or obtain additional educational qualifications in attempts to improve their employability,**
- **Emergence of the global superstructures and multi-national corporations in the education and training sectors (Apollo Group Inc., Cambium Learning Group Inc., Career Education Corporation, CL Educate Ltd., Daekyo Co. Ltd., ITT Education Services Inc., New Oriental Education & Technology Group),**
- **Establishing international branch campuses overseas, expansion of international affairs offices in universities.**
- **Creating international accreditation systems enabling validation quality of education (e.g. EUR-ACE), worldwide rankings of universities, adoption of international academic credit systems (e.g. ECTS),**
- **Modifying the old and creating new programmes, courses and curricula oriented to international skills and competencies of students (cross-cultural communication and management, linguistic skills, personal and professional adaptability in international environment).**

Global education market, global competition in education have reshaped many aspects of engineering education.

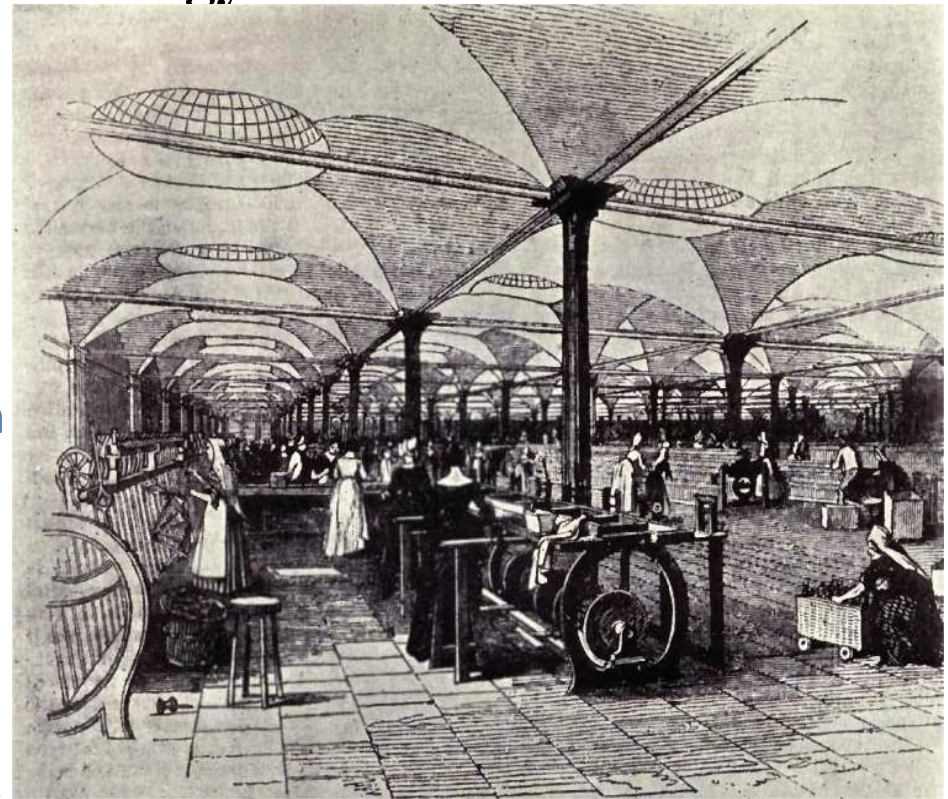
To what extent the **market orientation of engineering education and training is influencing the mission, the personality and professional profile of future engineer ? - seems to be one of the fundamental questions.**

Another important question is : What changes in functioning, in priorities and in resource allocation of technical universities have been driven by the global education market forces ?

GLOBALIZATION OF TECHNOLOGY

Technology together with economy, politics and culture has been always mentioned as **one of the fundamental driving forces of globalization**. Today it seems interesting to discuss the feedback i.e. the influence of globalization on technology or the mutual interactions of globalization and technology.

Although historians differ in distinguishing particular periods of globalization they generally agree that technology played crucial role in every period. In the 19th century industrialization allowed cheap production of household items using economies of scale, while rapid population growth created sustained demand for commodities [2]. 19th century Great Britain become the first global economic superpower because of superior manufacturing technology and improved global communications such as steamships and railroads



19th century manufacturing technology

Source: <http://en.wikipedia.org/wiki/History-of-globalization>

Following factors driving globalization of technology could be distinguished:

- **Globalization of trade, development of global market, mobility of capital,**
- **Multinational production, international fragmentation of production, foreign outsourcing,**
- **Development of international technical standards and regulations,**
- **Increased mobility and migration of people and products,**
- **Growing SIMILARITY OF DEMAND FOR HOUSEHOLD DEVICES In different regions of the world.**



Mongolian yurts equipped with modern devices

Sources: http://www.xor.org.uk/travel/siberia2004/graphics/dcq_5547d.jpg
http://www.lowimpact.org/blog/2013/Jan/yurts_in_mongolia.htm

Following tendencies have appeared as a response:

- **Growing demand for new technologies of worldwide use required by global market, transmission of ideas for new products and new technologies around the globe,**
- **Increasing number and level of advancement of globally spread technologies, rapid transfer of technologies,**
- **Increased sales of licenses and patents, mutual recognition of patents,**

- **International servicing and spare parts logistics, cross-servicing, international logistic supply chains for spare parts, modules and maintenance media,**
- **Development of international R&D labs (within corporations and universities), internationalization of R&D publications,**
- **Students participating in international projects within university-corporation collaboration, international competitions for students in designing new technologies and innovations organized by transnational corporations.**

Globalization of technology influences education programs, courses and curricula as well as research programs of most of technical universities and faculties making them more and more similar. From the perspective of globalization of technology it does not seem too early to discuss on globalization of engineering education. The important and urgent subjects of the discussion seem for instance knowledge and skills given for future engineers working in the area of service, maintenance and logistics as well as for those employed in the sphere of international sales of new technologies and products.

GLOBAL ENGINEERING PROJECTS

The term **“global engineering”** has been used in different contexts. In the names of companies it has usually reflected the company’s ability for worldwide business activity , manufacturing products that compete in the global market, providing engineering services or conducting projects in worldwide scale (e.g. Global Engineering & Construction, Global Minerals Engineering, Global Engineering Construction Company, Global Marine Engineering, Global Engineering Services).

“Global engineering” could also be interpreted as a human activity meeting the grand challenges of contemporary and future world - for engineering .

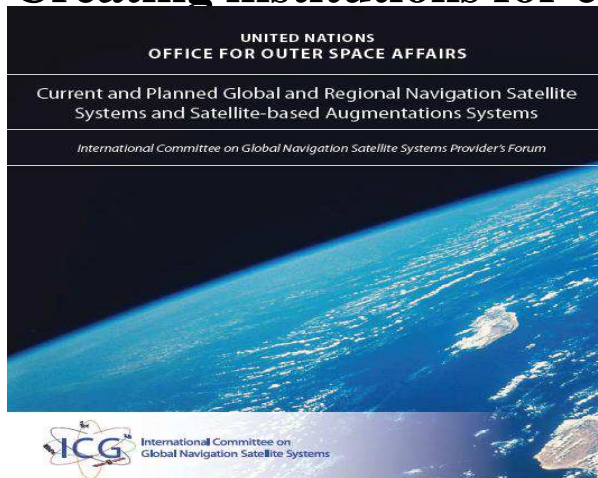
Those challenges - the phenomena and tendencies generating global problems are the key factors which are stimulating global engineering projects:

- **Climate change**
- **Natural disasters**

- Environment degradation, pollution,
- The running out sources of energy,
- Unequal quality of human life in different regions, poverty,
- Urbanization, population growth,
- Social unrests and threats to international security.

The responses are:

- Establishing international programmes oriented towards the mentioned above problems, e.g.: UN Environment Programme (UNEP), Transboundary Water Assessment Programme (TWAP), UN Development Programme (UNDP), International Hydrological Programme (IHP), UN Human Settlements Programme (UN-HABITAT), Disaster Management Programme,
- Creating institutions for conducting projects connected with the programmes,



e.g.:

UN Office for Project Services (UNOPS), Global Environmental Facility (GEF), UN Office for Disaster Risk Reduction (UNISDR), International Committee on Global Navigation Satellite Systems (ICG).



Publication of ICG on Global Navigation Satellite Systems Projects

Source: http://www.oosa.univenna.org/oosa/en/about_PSA.html

- **Sponsoring, supporting and funding the global programmes and projects by institutions like United Nations, World Bank, OECD, regional international organizations, national governments, transnational corporations and companies,**
- **Sponsored international education and research programs conducted by universities and R&D institutions participating in global programmes and projects.**

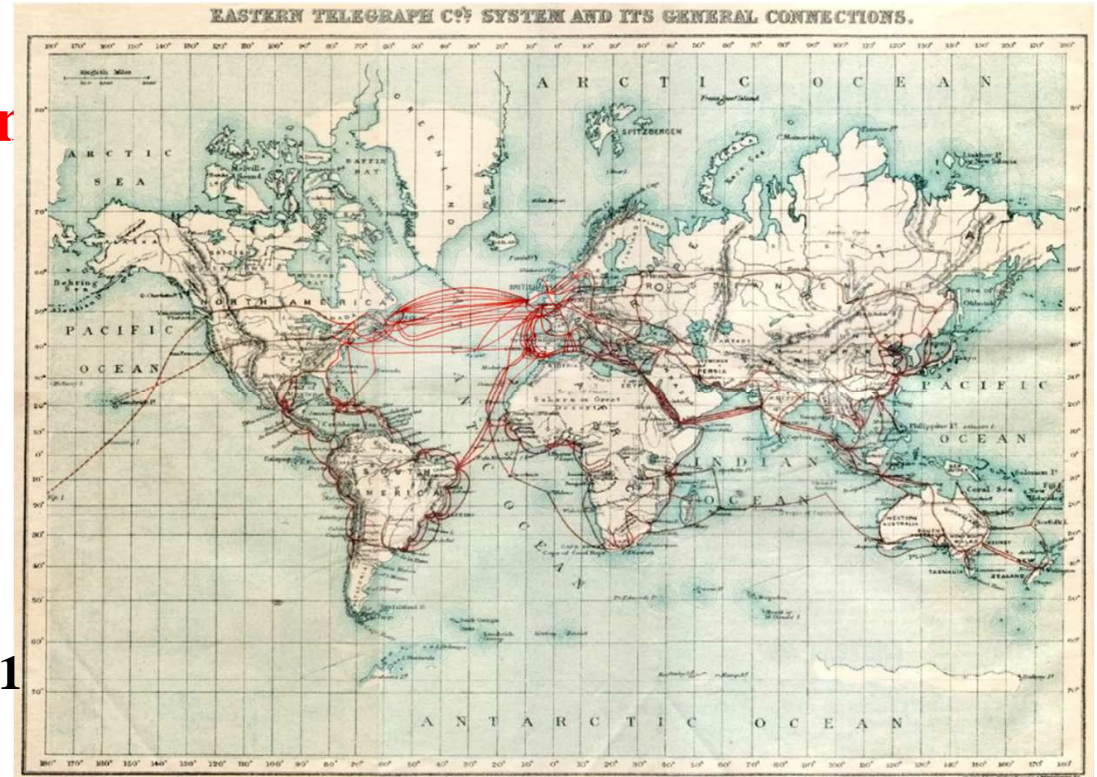
From the perspective of global engineering projects a new approach seems necessary in shaping personality and professional profile of engineering education graduates. Engineering projects that cover multiple countries, politics , cultures - create special challenges for future engineers – project executors and managers: project leadership, cross-cultural management, legal, conceptual and managerial responsibilities, project management contract laws, teams and inter-organizational relationship, conflict resolution etc. The subjects of education in this area would also be : international project phases, life cycle project management, tendering processes, risk evaluation, project realization, timing, casting, planning.

GLOBAL INFORMATION & COMMUNICATION NETWORKS

In numerous opinions global information & communication networks (I&CN) have constituted the essence of globalization – the core of globalizing society since the end of the 19th century .

Eastern Telegraph cable network in 1901

Source: http://en.wikipedia.org/wiki/Global_network



Today following key factors influencing I&CN can be distinguished:

- Increasing reach, density and traffic capacity of I&CN (expanding cyberspace),
- Strengthening feedback between globalization and the development of I&CN,
- Rapid development of information and communication technology (ICT), the optoelectronics revolution,

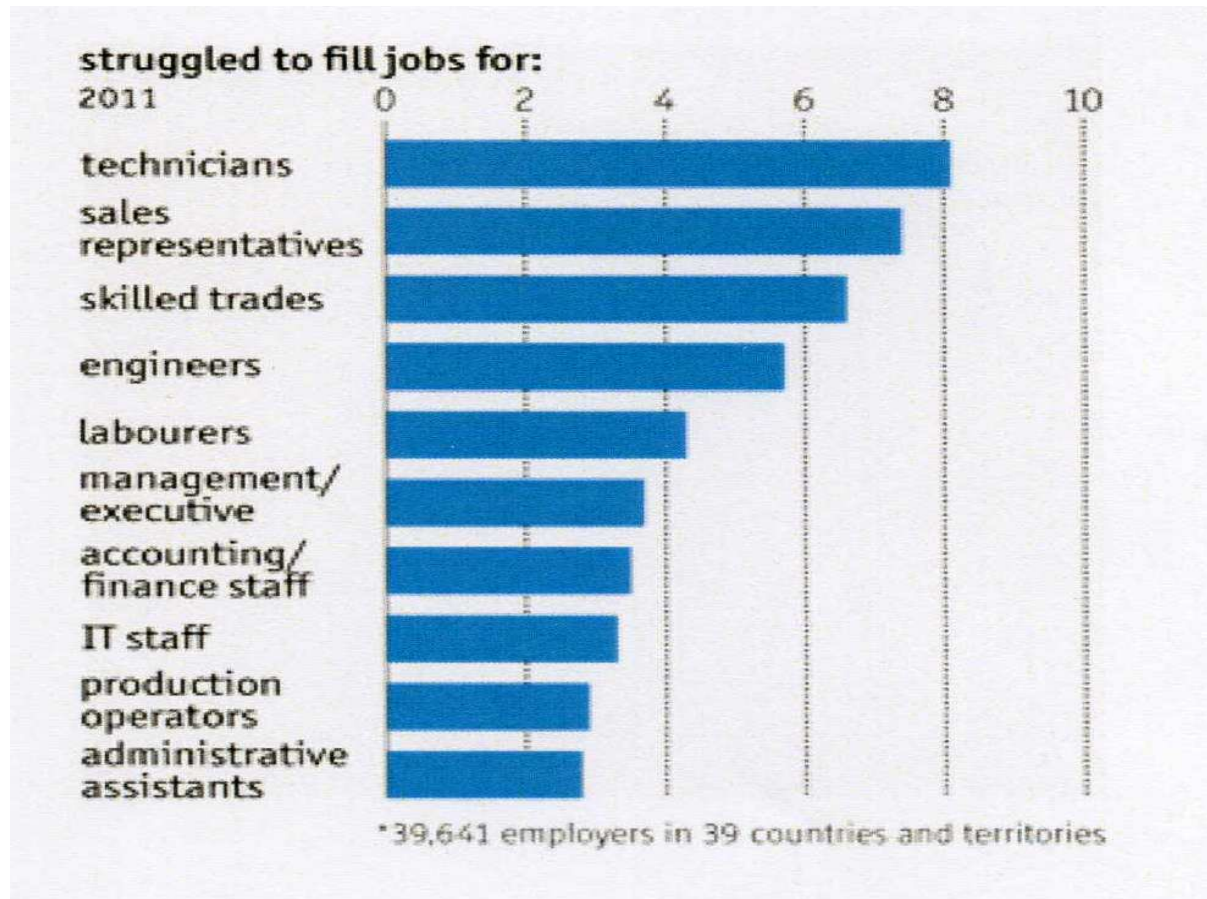
- **Continuous demand for enhancement of hardware (e.g. portability) and software (e.g. search engines) making the usage of I&CN in everyday work (business, banking, management, education, research, engineering) easier, more efficient and effective,**
 - **Appearance of crime and terrorism in cyberspace.**
-

The responses are :

- **Worldwide network-based virtual organizations in different areas of human activity (also in education and R&D),**
- **Social Networks – new ways of sharing opinions, views and knowledge,**
- **Increased role of knowledge and innovation in world economy,**
- **Development of the so-called “Digital Economy”,**
- **Common usage of I&CN as a tool of self-education and getting knowledge outside the traditional education and R&D institutions as well as a tool of the lifelong learning,**
- **Development of the cyber security methods, tools and systems.**

GLOBAL EMPLOYERS OF ENGINEERS

The data from **global labor market** indicate an **increasing demand for engineers and technicians** despite the crisis and growing unemployment in many regions



Demand for technicians and engineers on global labor market in 2011

Source: Manpower Group, <http://www.economist.com/node/21528434>

The biggest transnational corporations (TNCs) are technologically oriented and are the main global employers of engineers in ALL the areas of their worldwide operations (production, services, sales, R&D, logistics, education and training, management and even in public relations and marketing).

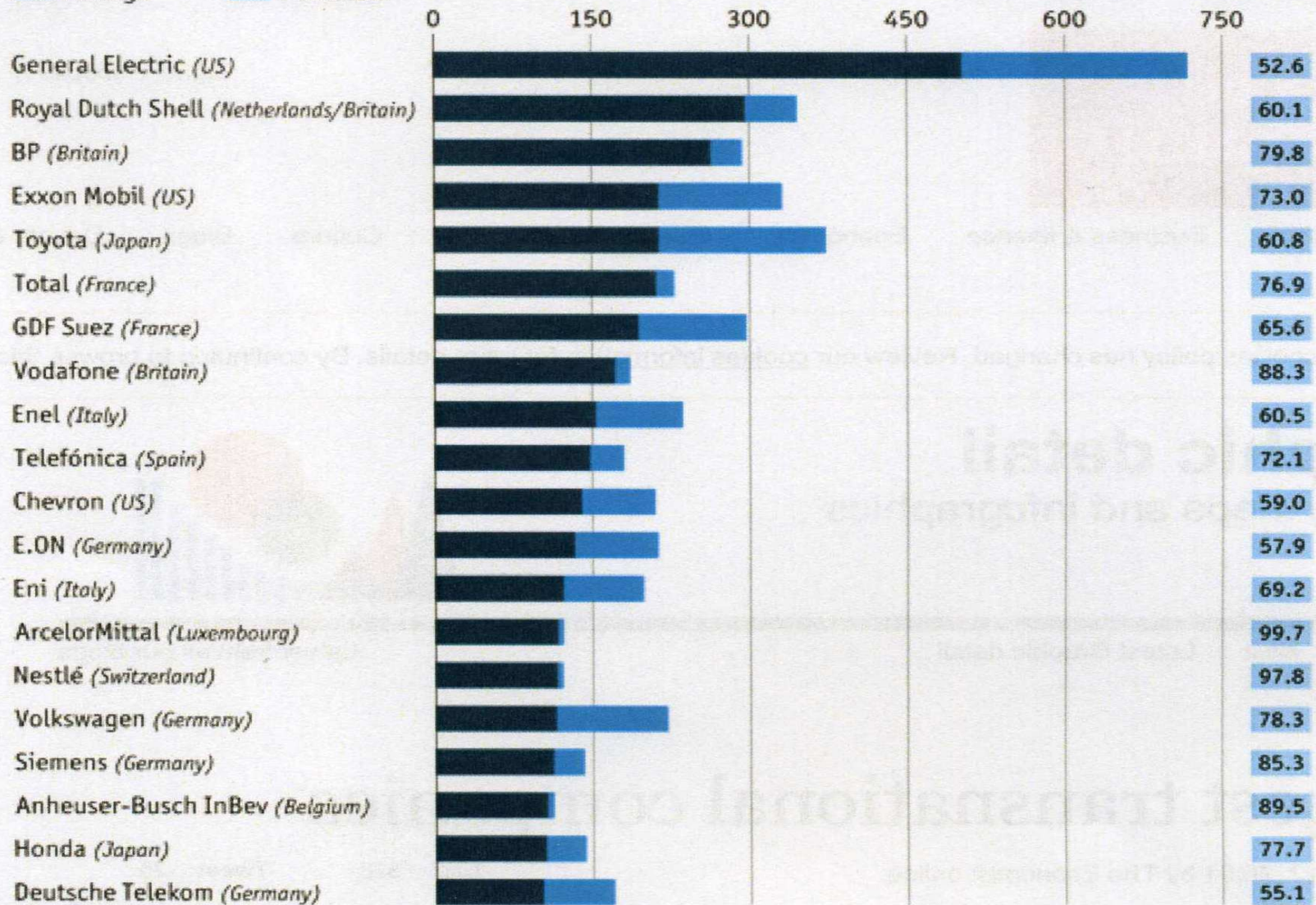
Since long time engineers have been also employed in different international, regional and global organizations, commissions, committees, working groups - as experts, advisors, executives , leaders and managers .

Biggest transnational companies

By foreign assets, 2011, \$bn

Foreign Domestic

Foreign sales as a % of total



Source: UNCTAD

Biggest transnational companies - global employers of engineers in 2011

Source: UNCTAD, <http://www.economist.com/blogs/graphicdetail/2012/07/focus-1>

Following key factors influencing behavior and evolution of transnational corporations could be distinguished:

- **Increasing fragmentation and geographic distribution of production stages and logistic chains,**
- **Appearing opportunities to penetrate new markets (Central and Eastern Europe, Post- Soviet Asia, China, the post-local-wars stabilized regions in Balkans, North Africa, Middle East),**
- **Growing needs for versatility, mobility and adaptability of the employed personnel,**
- **Still existing and appearing new regions with political, social and economic instability,**
- **Demand for speeding processes of introducing innovations and new technologies,**

As responses following tendencies could be distinguished:

- **Evolution from traditional head office centered structures of management - to decentralized network centered structures,**
- **Decentralization of decision-making and growing self-determination of the corporations' overseas subsidiaries connected with the need for strengthening employees' awareness of corporation mission, goals, values and behavior patterns (appearance of the so-called "corporate culture"),**
- **Appearance of "virtual companies" created for executing a given project in given time,**
- **Ability to move jobs overseas in the cases of crisis or instability in the regions of operation,**
- **Simultaneous introducing innovations and new technologies in every unit of the corporation instead of the so far sequential steps (first in central company, then gradually in the overseas subsidiaries),**
- **Development of the internal (managed by the TNCs) education and training systems.**

From the perspectives of global labor market and global employers of engineers the fundamental issues for engineering education seem to be connected with the differences between the requirements of the employers and the knowledge and skills given by universities.

The main reasons of the differences or even discrepancies originate from the different assumptions or different views on the “specialization versus generalization” issues as well as from the different opinions on the spectrum of positions and areas of employment (also on future professional career) of graduates.

Most universities are still preferring traditional narrow, professional profile (justified , among others, by the limited time of education) whilst the global employers (particularly the TNCs) require additional knowledge and skills ,what results in the creating by TNCs of their own internal education and training systems.

CONCLUSIONS

From the considered global perspectives it seems not too early to start a discussion on future Global Engineering Education. First international engineering education programs appeared as a response to the needs of global education market rather than to the global challenges connected e.g. with the U.N. programmes oriented towards solving global issues (poverty, environment pollution, energy). The following future solutions could be discussed:

- **Virtual Global Technical University based on distance teaching and learning, able to create international virtual teams for solving given R&D problems in given time,**
- **Global EE Network of the so far existing universities in different countries with synchronized and coordinated courses and curricula in selected areas of engineering , broad exchange of faculty and students (the international networks of technical universities have already emerged not only in education but in the R&D areas as well),**

- **Multi-campus distributed university (World University of Technology) with an international chancellor's office subordinated to WFEO and with branch campuses located in different regions (mainly in the developing countries),**
- **Single-campus World University of Technology, subordinated to WFEO, located in one of the developing countries, totally oriented towards the U.N. global issues with the mission:**
“to educate humanity serving engineers”.

The idea of the above mentioned options presented by the author for the first time during the 7th World Congress on Engineering Education held in 2006 in Budapest has been then developed in details in a series of papers published in IDEAS [3, 4, 5, 6, 7]and discussed during following congresses.

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