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The Bologna Process, globalisation and engineering education developments

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Abstract

Purpose – The purpose of this paper is to report on the Bologna Process in the light of globalisation and examine how it affects curriculum and engineering education developments.

Design/methodology/approach – The growing need for creative competitiveness and the striving for specific profiles of engineering qualifications that are of high quality whilst taking account of diversity, transparency have resulted in the declaration of the Bologna Process. The qualifications framework proposed involving the cycle systems are examined taking account of globalization, quality assurance, management and diversity of needs. The future opportunities are explored taking account of global expectations.

Findings – The present research reveals that the Bologna Process provides a means through which higher education institutions (HEIs) can be encouraged to provide more attractive curricula for the younger generation for differing cultures whilst catering for the broad range of engineering fields where they could become more active later. The point is made that it serves to re-invent engineering to meet the needs of the twenty-first century.

Research limitations/implications – The present investigation focuses on the Bologna Process and its implications on engineering education in Europe. Future work hopes to extend this to other disciplines and to examine global effects in diverse cultures and also from gender, economic and development perspectives.

Practical implications – This paper could provoke HEIs outside Europe to evaluating their policies, revise strategies and moderate existing provisions, thereby assessing impact of the Bologna Process on engineering education in different countries and cultures.

Originality/value – Account is taken of the diversity and transparency which have resulted in the declaration of the Bologna Process. The paper discusses and reports on developments, prospects and challenges faced in the engineering curriculum provision following the introduction of the Bologna Process in the culturally diverse European higher education area. The new field of process systems engineering is also reported.

Keywords Globalization, Systems engineering, Education, Process planning, Quality assurance, Europe

Paper type Viewpoint

Introduction

The demands on graduates of engineering now and in the coming decades are different from the demands faced by earlier generations. A thorough overhaul is needed. The depth and complexity of the present era is such that the community finds itself in the midst of the most extreme societal changes in recorded history (Drucker, 1994). These changes challenge our abilities to manage our institutions and to learn collectively. The US Accreditation Board for Engineering Education (ABET) now requires programmes to graduate engineers with the ability to function in multidisciplinary teams and for broad education necessary to understand the impact

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of engineering solutions in a global and social context. Engineers now are expected to adjust their knowledge and problem-solving skills to new forms of capital formation. New engineers need to understand the nature of engineering, optimizing a huge variety of technical, practical and political concerns to meet a business need. Engineering encompasses providing something that can be sold at a profit in a given amount of time, at a given investment cost at a given price (ABET, 2002; Harvey, 1989). The Bologna Process involves more than 45 countries in Europe and began in 1998/1999 as an intergovernmental initiative (Augusti, 2005, 2006). The aim of this process is to set up throughout Europe a system of easily readable and comparable degrees and establish by 2010 a European Higher Education Area (EHEA) in order to ensure suitability of accredited engineering educational programmes as entry route to engineering profession. Emerging and well-developed engineering fields stands are suing the process to inform developments. One of such field is the process systems engineering.

Process systems engineering

Process systems engineering education is an area receiving attention which also stands to benefit largely from implementation of the Bologna Process. As a sub-discipline, two complementary approaches have been used to although process systems engineering conference was inaugurated 26 years ago.

This is a field that has developed from the areas of manufacturing, production and chemical engineering. Chemical engineers' interest in process systems engineering (PSE) stems from the use of systems approach in the design and operation of chemical processing plants (Huckaba and Monet, 1963). The new branch of systems engineering was reported to have been the result of the advent of computers. It gives broad consideration to interaction between the performance of individual units and the requirements of a given process (Sargent, 1963). Process systems engineering is concerned with the development of techniques and tools to address the generic manufacturing problems of design, operation and control for the process industries. Control and design are considered separately and presented as different course in curricula.

Process control treats the characteristics of control loops and of system dynamics. Emphasis is placed on the use of existing knowledge and equipment. That the full benefits of automatic control come with everyone's cooperation.

The Bologna Process

The Bologna Process provides a unique opportunity to revise pedagogical concepts by introducing student-centred learning being utilized in practically all countries, and introducing modular structures and clearly defined learning outcomes for the various degree awarded. It has led to a great number of higher education institutions (HEIs) expressing a sincere determination to overhaul the entire approach to teaching and learning rather than simply comply with legal obligations at a formal level (Trends IV, 2005 – EUA). The traditional teaching/learning process is being revisited with more emphasis on the needs of the learner.

Engineering education challenges

There is more need for engineering education, compared to other subjects, to respond to fast-changing demands of the twenty-first century. This implies continuous development of its programmes and improvement of curricula and teaching and

learning arrangements. Engineering is characterised by problem solving and innovation. This results in an approach of adapting its learning objectives and contents to the most recent findings in engineering sciences and practices as well as to new areas of specialization (Heitmann, 2005). Some of the challenges facing engineering education include globalisation, increasing pace of change, demands of society, decreasing number of students numbers and the advent of ICT and new technologies.

Issues about changing working conditions and labour market have resulted in a shift in attitude towards the social competence and transferable skills of graduates. Lifelong learning and ways to encourage flexible and independent learning with increased emphasis on andragogy for the adult learner has become vital. Much of what is covered by engineering today touches on the environment, sustainability, economic development, entrepreneurship and ethics, all of which are tampered with culture and legislation that are different for the many regions of the world. There is the trend of decreasing number of students enrolling in science, technology, engineering and mathematics courses in higher education throughout the world. This calls for immediate action to be taken and for new measures to be put in place for the provision of attractive programmes of study to be delivered in challenging and stimulating learning environments. The emergence of information and communication-based teaching and learning technologies requires appropriate integration and use.

Engineering education in Europe including the UK and Ireland follows two models namely the long cycle engineering education or integrated second level degree education model and the short cycle engineering education model. The former is characterised by an initially strong theoretical base followed by a strong orientation to research, altogether lasting about five years. The latter lasts four years focusing on applications with stronger emphasis on formal teaching.

The Bologna Process seeks to create a common EHEA so as to facilitate mobility of students and staff and graduates, promote internationalization and global competition, raise quality and contribute to economic growth and development and enhance European integration. A set of ten action points agreed in 2005 include (The Bologna Process, 2005):

(1) adoption of a system of easily readable and comparable degrees;
(2) adoption of a system essentially based on two main cycles;
(3) establishment of a system of credits, favourably the European credit transfer system (ECTS);
(4) promotion of mobility;
(5) promotion of European cooperation in quality assurance;
(6) promotion of a European dimension in higher education;
(7) inclusion and development of lifelong learning;
(8) involvement of the HEIs and the students;
(9) promotion of the attractiveness of the EHEA; and
(10) linking the EHEA to the European research area.

A three-cycle system was added to the traditional two-cycle system of undergraduate and graduate scheme resulting in bachelor, master and doctoral levels of attainments in higher education. A European Higher Education Qualifications Framework was accepted.

This is specified by respective national frameworks which determine qualitative denominators in terms of learning outcomes linked to the three defined levels. A joint quality initiative (Dublin descriptors) provided an ECTS attached to programmes or the degree levels. This gives a frame of quantitative denominators with a structure of 3-5-8 years to the length of the three cycles. In relation to the ECTS credit system which is based on 60 credits per year for a full-time student, this gives 180-240 credits for the three to four years of study for the first cycle degree and 60-120 credits for additional second cycle degree.

A key challenge is that although engineers even if educated elsewhere have always been able to find employment, the different accreditation practices in different countries create confusion and obstacles to the international recognition of degrees. Europe in defining EHEA places emphasis on physical and virtual mobility. This places the need for trans-national accreditation. Throughout the world, several recognition agreements are active some of these include the Engineering Mobility Forum and the Washington Accord. These require some form of harmonisation.

Globalization and the role of engineering education in economic development

Studies have shown that higher education provides significant effect on economic development and that engineering and natural sciences play the most prominent role in this process (Lee *et al.*, 1994; Lau *et al.*, 1993; McMahon, 1998; Lin, 2003). It must be noted however that higher education can go on for various lengths of time. Universities and colleges may take three years with exceptions involving teachers, dentists, doctors and some other vocational fields. Employments areas can also be in any of the sectors, which include industry, services and agriculture. Higher education overall provides significant effect on economic growth. The engineering and natural sciences play the most prominent role. It is in the interest of society that issues relevant to developing, implementing, and supporting the subject are dealt with using such means as the Bologna Process.

Engineering education provides room for experimentation and manoeuvre and more competition. The quality of research and teaching is aimed at promoting greater internationalization, improving the recognition of external academic achievements and attracting more foreign students.

Quality assurance and management

The working environment and the job market for engineers is being altered by globalization of the world's economy. Universities are having to compete for students. Admissions have fallen. The demands being placed on engineers are on the increase. There is fall in the number of admissions. Using the case of the German university admissions, a lot of reasons have been advanced to explain this decline. Studies suggest that that besides socio-political factors, developments in the job markets for engineers has large effect (Catenhusen, 1999). In deciding what to study, many young school leavers also only have access to limited knowledge about work prospects open to them.

Quality management and diversity of need

Workers assume greater responsibility for defining what they do, how well they do it and for seeking ways to improve in quality management. Since what happens in the

classroom affects what can be done in administration and vice versa, the introduction and sustenance of innovation in education means a change in the methods of school administration and management. Recent studies show there still exist a high degree of diversity in the signatory countries with Bologna action lines. In most regions, it is taken as a frame or inspiration for needed reforms in existing systems while keeping traditional structures.

Traditional school of thought

It is traditional practice amongst universities across the European continent to provide a cycle of integrated programme of study for five years culminating in a qualification perceived as comparable to a master's degree from an Anglo-American higher education system. The introduction of a first degree after three years is only considered as an access level from which students could decide on the different profiles of graduate studies and entry into professional life providing satisfactory degree of employability.

The duration of study programmes at traditional institutions such as Fachhochschulen, Hogeschoolen, university colleges or colleges of further and higher education, poses some difficulty with the three-year programmes. Parts of the curricula which ensure the application-oriented profiles like internships, placement in industry, project and final thesis work. These parts come under threat with the advent of Bologna Process.

Qualification frameworks and professional recognition

There has been some resistance against the replacement of the traditional higher education system in respective countries. This is based on lack of trust in the quality of the new degrees from the employers' perspective. There is also the challenge to shift from an input driven system defined by years of study, content catalogues and contact hours to a system primarily based on learning outcomes characterised by a great variety of ways to achieve required or intended learning outcomes, for reasons of international comparability, flexibility of the system, recognition of prior and experiential learning and quality assurance (Heitmann, 2005). The European Accredited Engineer (EUR-ACE, 2005a, b) defines accreditation as the primary result of a process used to ensure the suitability of that programme as the entry route to the engineering profession.

It has always been a challenge to tackle or solve the problem of accreditation of educational programmes in engineering and related fields as there continues to be confusion and obstacles due to different practices for professional recognition and the lack of clarity of the distinction between quality assurance and accreditation. Procedures for accreditation varies across countries (Augusti, 2007). In Great Britain and Ireland, accreditation standards and procedures are the responsibility of professional institutes (often endowed of a "Charter"), and HEIs are only involved through the assessment of education programmes, although sometimes they have to adapt the curricula in order that their programmes be accredited. In the UK, since 1981, the accreditation procedures of engineering institutions are being coordinated by the Engineering Council UK. In France, since as early as 1934, "habilitation" is granted to engineering programmes and relevant HEIs (often *Grandes Ecoles*) by the Commission des Titres d'Ingénieur", in which the academic world, the profession and the employers

are represented on a parity basis. In Italy, it is traditionally maintained that the conformity of an academic programme to rules set by the Ministry of Education (or another national authority) makes that programme automatically accredited. In several other countries there are no formal accreditation systems for engineering.

Opportunities and the future

The Bologna Process has resulted in several initiatives and provided opportunities for development and enhancement of engineering education throughout Europe and beyond. EUR-ACE was made up of accrediting bodies from eight countries which developed engineering education framework standards. The participating countries were UK, France, Germany, Italy, Ireland, Portugal, Romania and Russia. The standards show very little difference compared to other recent accreditation standards throughout the world content wise. They are outcome-based with provision for accreditation at the first and second cycle, consistent with the Bologna Process. They include:

- knowledge and understanding;
- engineering analysis;
- engineering design;
- investigations;
- engineering practice; and
- transferable skills.

First-cycle graduates are expected to have:

- knowledge and understanding of the scientific and mathematical principles underlying their branch of engineering;
- a systematic understanding of the key aspects and concepts of their branch of engineering;
- coherent knowledge of their branch of engineering including some at the forefront of the branch; and
- awareness of the wider multidisciplinary context of engineering.

The second-cycle graduates on the other hand should have:

- an in-depth knowledge and understanding of the principles of their branch of engineering; and
- a critical awareness of the forefront of their branch.

Guidelines and procedures have also been developed for programme assessment and accreditation. These must be seen as positive steps and opportunities which must not be wasted, but exploited to create a consistent accreditation system of engineering education on a continental scale.

The set up of a European Network for Accreditation of Engineering Education provides the structure and means of coordinating and supervising implementation of the accreditation system. Some more systematic and comprehensive approaches may have to be used in curricula and course design. In the absence of shared international

standards for describing learning outcomes and learning objectives, some form of threshold have to be realized in specifying programme, and in designing core curricula and active and experiential learning. The Bologna Process provides an opportunity for internationalisation. This is a driving force for restructuring engineering education systems, competing on a global education market, revising curricula and providing teaching and learning facilities for promoting an engineering education with a robust international profile.

An engineer of the future is expected to have such skills as technical competence, methodological skills, systematic skills, social competence and entrepreneurial skills. Teaching should impart engineering principles and selected specialist knowledge. Encouragement should be given to students to use their acquired technical knowledge to resolve new problems. Students should be shown how to develop ability to think coherently, examine and analyze problems. They should possess communications skills, ability to work in teams, set priorities, judge what is feasible, set priorities and implement decisions.

The Bologna Process has the potential to result in the development of new elements for study such as product engineering, environmental and life sciences process engineering and production logistics and process (Villadsen, J., CESc. 52, 1997; Rauch, 1998). A balance between technical and theoretical coverage of materials in the curricula could result. The process provides an opportunity for institutions to develop their engineering education profiles with specialization in selected fields of choice.

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