Should standardisation or diversity be embraced in the development of future engineering education curricula?

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ABSTRACT: The ever-increasing gap between the wealth of a few privileged nations, so-called developed countries, and the rest of the world has caused an urgent need for a new philosophy and strategy to be devised and developed in order to ensure the provision of a decent education in less privileged countries. Quality education, as the major human capital in any nation, has had a tremendous impact on the wealth and welfare of a country, and has been quite rightly regarded as a one of the major factors influencing global peace and stability. Those nations with a well-developed education infrastructure have demonstrated enormous achievements in building up their wealth, progress, prosperity and, even more importantly, democracy. Therefore, unlimited access to proper education should be a fundamental human right rather than a privilege for a few. The current global situation, as well as issues of concern in the context of education disparities between developed and developing countries, are discussed in the article. A so-called global engineering education curriculum is suggested and discussed in the article to be urgently designed, developed and implemented in order to remedy the present critical situation.

INTRODUCTION

There have been great discussions and debates about the problems that arise from the various different standards, accreditation, recognition and diversity of engineering programmes across the globe. These problems would not be an issue if all engineers after graduation would find work and remain making a living in their local countries; but the reality of the issue is that engineering is becoming a global profession due to the impact of globalisation. This provides a great opportunity for many engineers to gain first hand experience in working overseas. The other obvious reason is that many are forced to travel abroad to seek employment due to the shortages of jobs in the local environment.

In order to overcome this problem, engineering educators need to close up this gap of the different educational standards and accreditation that exist between nations and provide for some form of standardisation in engineering education. In this article, the researchers suggest one way of achieving standardisation, which is through a so-called global curriculum, with the initial focus on environmental engineering, to be implemented.

ENGINEERING BECOMING A GLOBAL PROFESSION

Increasingly, engineers conduct their work in more than one country and in countries other than where they received their education. Those countries have different laws, cultures, procedures and standards concerning the education and practice of engineering. It is anticipated that the growth of major trading blocs, such as the European Community, the Pacific/Asian area and the Americas, will intensify this process of mobility. Also, instant worldwide communication is a strong catalyst for the development of the global practice of engineering and engineering education. It is appropriate for the world's engineering profession to recognise this developing situation and to take steps to ensure the orderly transition into the worldwide practice of engineering, and the education of engineers in particular [1].

Yeargan, suggests that one method by which this can be accomplished is through the establishment of international accreditation of engineering educational programmes, the recognition of academic equivalency between institutions, and reciprocal agreements between engineering licensing agencies [1]. The alternative, which is put forward in this article, is through the establishment of one common or so-called global engineering curriculum, which can be used globally. Such a curriculum would eliminate the need for any recognition and accreditation problems between countries.

PROBLEMS WITH THE RECOGNITION AND ACCREDITATION OF ENGINEERING PROGRAMMES IN VARIOUS COUNTRIES

Before discussing the problems with recognition and accreditation in various countries, it is important firstly to define what is meant by these terms.

The term recognition of qualification was defined at the Convention on the Recognition of Qualification concerning Higher Education in the European Region in Lisbon of April 1997 [2]. Recognition is a formal acknowledgement by a competent authority of a foreign educational qualification with a view to access to educational and/or employment activities and qualification of any degree, diploma or other certificate issued by a competent authority attesting to the successful completion of a higher education programme.

Recognitions can be further broken up to academic recognition and professional recognition. Academic recognition refers to the recognition of courses, qualifications, credits or diplomas

from one (domestic or foreign) higher education institution by another [3].

Professional recognition refers to the right to practise and the professional status accorded to a holder of a certain qualification. Its aim is to ensure that certain satisfactory standards of qualification are achieved [3].

The term accreditation has not been commonly used in Europe but has been often applied in the USA by the Accreditation Board of Engineering and Technology (ABET). It is defined here as a system, which assures that graduates of an accredited programme are prepared adequately to enter and continue the practice of engineering.

Why is Recognition and Accreditation Important?

The importance of recognition and accreditation of engineering education was highlighted by Heitmann and Augusti [3]. It is important because it ensures equal value of an engineering degree in all European countries, which helps to increase the freedom of work and establishment, ie right to mobility for all European citizens, better exploit the availability engineers' work capacity and competition in Europe, improve the exchange and mobility of students in Europe and, generally, maintain quality assurance in education (programmes), institutions (universities, colleges, etc) and individuals (students). Heitmann and Augusti state that:

> *To ensure any form of mobility, it is necessary that academic degrees and professional qualifications granted in any European state be recognised in other member states, which in many cases does not happen yet – or at least not satisfactorily* [3].

PROBLEMS WITH ACCREDITATION AND QUALITY ASSURANCE EXPERIENCED BY DEVELOPING COUNTRIES

It appears that engineering schools, universities and colleges across the board are having to deal with issues of funding, management, accreditation, standardisation, harmonisation and quality assurance of engineering education programmes. These problems are a reality for many in developing and, to a lesser extent, developed countries. Yet according to Bordia, the problems between the two countries are completely different [4].

The developed or rich/advanced countries can be described as countries where the government provides a basic social security (or welfare) support system for its population. For example, in Australia, unemployment benefits are offered to the unemployed or low-income earners to assist them in meeting basic needs. Over recent years, the government has made it more difficult to participate in the social system of benefits by forcing the unemployed to either work or undertake some sort of training or course. This mainly consists of about 20 countries located in North America, Australia, New Zealand and most of the Western Europe.

In developing countries, which exist mainly in Africa, Asia and Latin America, there are no such government support systems, and many will have no choice but to depend on themselves or struggle to meet basic needs, such as food, water and shelter. Bordia also highlighted the differences in funding and quality of engineering education between the developed and developing worlds [4].

In developed countries, most of the educational funding is government funded with the exception of the USA, where most of the world-famous universities and centres of learning are still funded by private individuals and from endowment funds. However, during the most recent years, governments in even these rich countries, especially in Australia, New Zealand and the UK, have significantly cut education funding and are forcing many universities and engineering schools to seek private and fee-based funding to remain in operation.

In Australia, for example, all universities are charging local students Higher Education Contribution Scheme (HECS) and hefty educational fees also apply to international students to obtain a higher degree in Australia. The concept of free education was still available in Australia in the 1980s, but was slowly phased out and replaced by fee-based education.

Australia generates revenue of about US$4-5 billion per year from its education export and attracts a large number of full-fee-paying students, mostly from countries in Asia. The increase in cuts in government educational funding around the world mean that commercial and private entities will take a greater role in educational business. Education is slowly becoming a service industry similar to banking, insurance, travel, etc [4].

Fortunately, the situation is not as drastic in European countries where universities and engineering schools are still receiving large government grants. Overall, the quality of education in developed countries is still very good and strongly monitored by professional bodies, which are generally free of governmental or political interference [4].

The problem is worse felt in developing countries, for many engineering and technology degree programmes are seen as a saviour for many and their families; therefore, there is a demand for engineering and technical colleges. The problems of funding and quality are different in large and small developing countries [4].

There are three main problems facing engineering colleges and universities in developing countries, such as India, Thailand, the Philippines, Papua New Guinea, Fiji and Arab countries. These include:

- Funding issues;
- Management issues;
- Quality assurance issues of engineering education programmes.

As privatisation and commercialisation of education increases in developing countries, it will put even a greater burden on most people to gain access to a decent education. This is where offering a global curriculum in engineering education would assist those in developing countries.

The idea of a global curriculum is to share resources and educational materials and to have some sort of standardisation in engineering education between countries. A global curriculum will greatly benefit developing countries, as it would save time and financial resources in the process of developing and implementing their own educational material.

The global curriculum could be one way to reduced cost for engineering colleges and universities in developing countries and make it more affordable for those who want an education. Sadly, for many in developing countries, education will not be a top priority if they have difficulties in meeting basic needs such food, water and shelter. It would be ideal if the global curriculum could be subsidised by universities in developed countries so that developing countries would adopt and utilise the resources and materials to educate the population.

What Impact does the Reduction of Government Funding have on Countries?

In developed countries, the cutting in educational funds has virtually no effect on the quality of education or the living standards of the local population because the cuts are being compensated by export and commercialisation of education and through the acceptance and admittance of a larger pool of full-fee-paying foreign students. Further, about 90% of educational expenses are government funded.

The effects of funding cuts pose more of a problem in developing countries. In India, for example, fees in the government-run colleges and universities are very low but fees in private institutions are very high. The high fees of private institutions are not affordable for many Indian families wishing to provide their children with quality education. Although the fees are low for government-run institutions, there are only a limited number of intakes so the demand does not meet the supply [4].

PROBLEMS OF RECOGNITION IN EUROPE

It appears that the problems of recognition in Europe at the national level seem to be solved more or less satisfactorily, even if some changes are still underway; but mutual recognition at the transnational level continues to be a serious challenge.

The diversity that exists in higher education across European countries due to the great variety of concepts, programmes and methods of engineering education, based on different traditions, social and economic conditions and political interest and power, makes this challenge of mutual recognition even harder to achieve. This is where the process of harmonisation could facilitate many problems of recognition.

Due to the expansion of the European Union (EU), the diversity in education will grow even further. Moreover, the impact of globalisation and, in particular, the globalisation of the education and training market will create more challenges and opportunities. Therefore, academic and professional recognition of qualifications, programmes, modules, credits and degrees must continue to be a matter of concern. It appears that many approaches applied so far, like lists of equivalences, EU General Directives or the existing European Registers of Engineers, are still felt to be insufficient and are not commonly accepted [3].

On an international level, professional recognition of programmes and qualification profiles may not concern the larger companies, but is still a problem with regard to employment in foreign public services, Small to Medium-sized Enterprises (SMEs), and for those who wish to work as freelancers or consultants in other countries. For the engineering profession in the European Union, the existing EU General Directive, as well as the FEANI Register, have not solved the problems satisfactorily. Demands on professional recognition are still fairly different not only in terms of procedures but also in terms of basic concepts and the determination of the necessary qualification standards and ways of their achievement. Therefore, additional activities are needed to increase the transparency of approaches and make them compatible, or to develop a common European solution [3]. This is the very idea put forward in the development of a global curriculum.

More work is needed to overcome the problems of professional recognition and to establish standardised European accreditation procedures for engineering education [3]. Higher education systems in many countries have now become so diversified that a mutual assessment of the nature of courses, and thereby the admission of foreign students and the recognition of studies carried out in other countries, create serious problems [5].

Dalichow and Teichler undertook a study of 227 programmes from various subject areas in the European countries, of which 42 were engineering programmes. From the study, it would appear that complete recognition of study abroad without any provisos is granted in 18% of the programmes. In a further 46% there is considerable recognition with only a few provisos. In 17% there is partial recognition. Lastly, in 20% of the programmes, little or no recognition is granted at all.

In regards to formal regulations on exchanges, that is regulations pertaining to the transfer from a home institution to a partner institution, say, being located in another country, as well as the reverse transfer after the completion of the study period abroad, one can observe many difficulties in recognising such a period of study. Research shows that there has been a relatively low degree of formulisation of exchange in engineering (50% complete or considered as equivalent) [5].

European integration is creating increasingly interwoven markets, the step-by-step realisation of a united Europe of its citizens and finally, the growth of the European states into a European Union. This makes a mutual recognition of educational and academic degrees, together with the removal of obstacles to studying in national universities and the possibility of working in a different country, even more of a necessity. This is especially true of the engineering profession [6].

Today, there is no indication of a tendency towards conformity in the educational systems within the European Union. The differences in educational and professional systems in Europe and the mobility of university graduates from one European country to another are rather low. In order to achieve a non-restrictive labour market for engineers throughout Europe, a system for the mutual recognition of university diplomas must be established. As a result, a number of bilateral and multi-lateral agreements have been established and signed to overcome some of the difficulties [6]. Although agreements of these types offer some resolution for some countries, it does not resolve the problem completely.

Problems faced by Austrian, Swiss and German Engineers

The European Community (EC) guidelines were set up in 1988 by the Council of the EC for the mutual recognition of university education. Under these guidelines, only those

graduates with a minimum of three years of university course would be recognised in the EC member states. Under this guideline, many engineering graduates from Austrian Technical Institutes of Higher Education would face major difficulties in obtaining recognition in other European countries. It was stated that an estimate of 70% of Austrian engineers would not be recognised in Europe [7]. Furthermore, the guidelines would create other problems for Austrian engineers to establish offices in other European countries, eg Germany. Many of the Austrian businesses would be discriminated against because their employed HTL (Technical Institutes of Higher Education) engineers would not be recognised as engineers but merely technicians [7].

Similar recognition problems are also found with HTL engineers in Switzerland due to the Swiss engineering educational structure [8]. Swiss HTL engineers are formally neither accepted as being equal to a chartered engineer of a German Fachhochschule nor to a Bachelor of a British polytechnic or a university in USA, let alone to a graduate from a French Ecole d' Ingenieurs. The main reason being that engineering schools in Switzerland are considered as providers of higher vocational training by Swiss law, instead of being recognised as academic institutions in their own right in tertiary education. Hence, their graduates will not obtain international accreditation. Moreover, the entry requirements of a completed 4-year apprenticeship, plus an entry examination, cannot compare with other European countries such as Germany and France. Another problem is that Swiss engineering education is becoming outdated and is not meeting the requirements of modern industry. Therefore, major restructuring and reforming of Swiss engineering education is necessary if it is to obtain European recognition [8].

It appears that maintaining quality in engineering education is high on the agenda in Germany. Higher education in Germany is trying to resolve the issue of how to ensure broad international academic and professional recognition of the German qualifications and degrees, as the current German system is different and does not compare to the Anglo-American structures [9].

There are strong political and governmental pressures imposed on universities and Fachhochschulen to improve the global competitiveness of the system by structural and curricular changes and by internationally accepted measures of quality assurance like quality assessment and accreditation [9]. It seems, however, that Germany is lagging behind international developments when compared to some other countries in the European Union and the USA [9].

GLOBAL CURRICULUM

For engineers to move freely beyond national settings and to venture into other countries, the above problems need to be resolved and there needs to be some form of standardisation established in the education system so that it fits into the global education standards. One way of achieving these global standards is through the use of a global curriculum.

A common curriculum could avoid the problems of a multiplication of course offerings and would also reduce substantial administrative overhead costs attributable to departmentalisation. The other advantage noted of a common curriculum is that it does not restrict the graduates' choices and opportunities upon entering the workforce [10]. A list of the benefits of a global curriculum is presented elsewhere [11].

THE CHALLENGE IN DEVELOPING A GLOBAL CURRICULUM IN ENVIRONMENTAL ENGINEERING

The challenge in developing a global curriculum, based upon the example of a curriculum for environmental engineering, includes (but is not limited to) the following:

- Removing problems found in traditional environmental engineering programmes.
- Identifying core features for inclusion.
- Building a curriculum suitable for global application with minor adjustments to suit local conditions.
- Creating a curriculum that is globally transferable and marketable.
- Providing subjects that will enhance students' knowledge and skills required for solving environmental problems.
- Avoiding overcrowding of the curriculum with unnecessary subjects.
- Ensuring that the key subjects are strongly visible in the curriculum.
- Avoiding overspecialisation and repetition of any one particular field in environmental engineering.
- Avoiding inclusion of too much subject matter from the civil and chemical engineering discipline currently found in traditional programmes.
- Including more subjects that will enhance those skills and knowledge that have been identified.
- Providing a broad coverage of subjects from all of the disciplinary areas (eg engineering, science, humanities, etc).

CONCLUSION

Engineering is becoming a global profession due to the impact of globalisation and the establishment of free trade agreements, as well as the General Agreement on Tariffs and Trade (GATT). This will open up more channels than ever before for engineers to seek employment, practise the art of engineering and interact with other cultures and countries.

This process may be restricted if engineering educators around the world do not address and resolve the differences of recognition and accreditation of engineering education that exist within and between countries.

In order to answer the question posed at the beginning of the article, that is whether standardisation or diversity should be embraced in engineering education, the researchers strongly believe that standardisation should be embraced in engineering education because of the great benefits it can offer to the engineering profession as already discussed in the article. The standardisation of engineering education is one step forward to achieving global education standards and hence a global engineer.

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