

## Engineering Education for the 21<sup>st</sup> Century: Challenges in Designing Curricula for a 21<sup>st</sup> Century Graduate

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### 1. Introduction

Prior to the early 20<sup>th</sup> century, engineering was taught in Guilds. In 1920's and 1930's, Universities too began to offer courses in engineering. During this period, the Ceylon Technical College at Maradana commenced training engineering graduates for the University of London external degree. It was the seedbed from which the first Faculty of Engineering at University of Ceylon's Colombo Campus was born. Today there are many engineering degree programs at Public Universities and Non-State Higher Educational Institutes.

At present, the global engineering and technology education has a well defined qualification framework: four years of academic training leading to an Honors Engineering Degree for Professional or Chartered Engineers, three years of academic training leading to an Engineering Degree for Incorporated Engineers or Engineering Technologists and two years of academic training leading to a Diploma for Engineering Technicians.

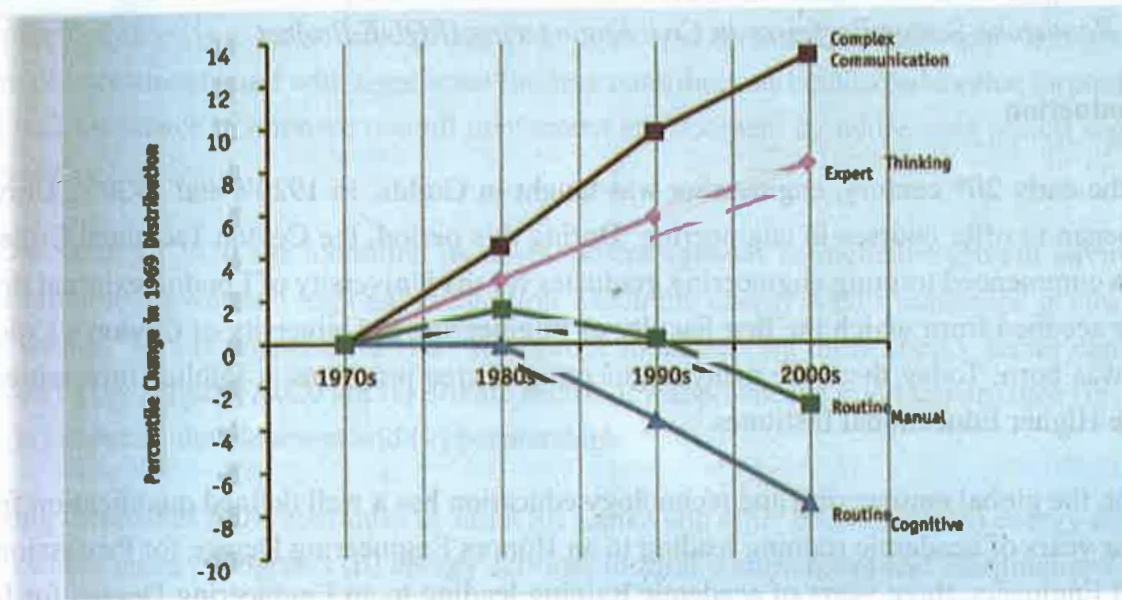
When engineering graduates are trained to be Professional Engineers or Chartered Engineers, they need to have a sound mathematical, analytical and scientific knowledge to solve complex problems, be able to face new challenges which no other engineers have faced in the past. The standard of a four year (consisting of eight academic semesters) Engineering Degree and the attributes of an engineering graduate are specified in the Washington Accord and the competencies required for a Professional Engineer is very well defined in this document.

When engineering graduates for a three year degree program are trained, they too should have a good mathematical, analytical and scientific knowledge; but they are expected to be involved in routine engineering design, construction or manufacturing etc. There are more jobs in this sector in any economy. The standard of a three year (consisting of six academic semesters) engineering degree, the attributes of a graduate and the competencies required for an Incorporated Engineer are specified in the Sydney Accord.

When Engineering Technicians are trained, they need to be given a good practical training with basic mathematical, analytical and scientific issues involved in carrying out operations and maintaining routine engineering skills. An Engineering Technician requires a two year Diploma qualification after the G.C.E. Advanced Level and the competencies required for an Engineering Technician is well defined in the Dublin Accord.

Although there is a well defined system for classifying engineering professionals to different groups, the importance of any of these groups should not be underestimated. As team players, all have specific roles to play in achieving the end result and the contribution of everyone is important.

### The Changing Composition of Skills Needed in Economies in the 21<sup>st</sup> Century



Source: Adapted from World Bank (2008b) and Levy and Mundane (2004).

Figure 1: The changing composition of skills needed in economies in the 21<sup>st</sup> century

Source: Adapted from World Bank (2008b) and Levy and Mundane (2004).

The ratio to be maintained among the above engineering professionals changed rapidly in the last decades. Overlaps can be seen in the work done by the Professional Engineers and Incorporated Engineers as well as the work done by Incorporated Engineers and Engineering Technicians. The manpower requirement of the 21<sup>st</sup> century has changed drastically and the industry requires people who can compete in complex situations. The number of Professional Engineers required at higher levels has increased due to the level of sophistication and complexity required by the industry. The changing composition of skills needed in economies in the 21<sup>st</sup> century is shown in the Figure 1.

The designs that are expected from contemporary engineers are much more complex than what was expected several decades ago. Therefore, being an expert in his or her field is an essential factor of becoming a successful Professional Engineer.

## 2. Paradigm shift in the engineering education

It is obvious that the engineering education has undergone a paradigm shift in order to cater for the changing requirements of the industry. Although imparting knowledge is still important, more emphasis is given to the development of competencies today. Therefore, engineering professionals need to develop certain competencies.

Unlike the past, the 21<sup>st</sup> century labour market gives high emphasis on the soft skills of the engineering graduates. From a research done recently, three soft skills have emerged as the most valued by the private sector employers; the ability to work for deadlines, the ability to work long hours and the

adaptability to new environments. These are considered as critical factors in surviving in especially the private sector organizations.

Communication is another important area that should be addressed in the engineering curriculum. In order to market the products of a particular industry, a complex system of communication usually takes place and an engineer is a central body involved in this communication network.

Graduates from different universities are usually branded in differently when they enter the job market. In UK, Oxford and Cambridge graduates are considered number one and have an edge over the graduates of the other universities. Many factors contribute in the ability of these universities in producing excellent graduates, and they enjoy special advantages due to their elite status as the best universities of the world. Their exalted status helps them in obtaining the highest funding irrespective of the funding mechanism used, hence they enjoy the best of the resources which contribute in producing excellent graduates. Another contributing factor is the traditions of these universities. Usually they get the elite group of students with excellent entry qualifications which make it easier to produce excellent graduates.

In the 21<sup>st</sup> century, we have to compete with each other even in providing university education. Although all are state universities under the University Grant Commission (UGC), still there is competition among graduates from different universities and different disciplines when they enter the job market. Especially most of the private sector organizations show preference to some universities, giving the graduates of these universities an edge over others. In this competitive world all universities have to identify their strengths and weaknesses and they have to optimize and produce the best possible graduates in whatever discipline they are involved in.

### **3. Curriculum design for a 21<sup>st</sup> century engineering graduate**

Professional Engineers are expected to plan, design, implement, construct, manufacture, manage complex and sophisticated situations and solve unknown engineering problems and situations for the clients. Therefore, the engineering student should be trained in such a way that they develop the necessary graduate attributes.

For Professional Engineers, the duration of the degree program should be four years with eight academic semesters. Also the engineering degree curriculum should be benchmarked to international engineering exemplars. Three important aspects that are considered in accrediting an engineering degree program are high quality student intake, employment of the graduates in the relevant engineering field and the student learning environment.

The high quality of the student intake is a major factor contributing to the course accreditation. According to the current regulations of the UGC, the minimum entry requirement for the state universities in Sri Lanka to be admitted to a Professional Engineering degree is three Simple Passes (S) in the G.C.E. Advanced Level, whereas the international norm is three Credit Passes (B). Therefore, unlike the Public Universities, private Higher Education Institutes in Sri Lanka maintain the minimum entry requirement of three Credit Passes as it is the usual standard acceptable to the foreign universities to which they are affiliated.



In order to make use of all the factors contributing to the transformation of the process of engineering education, the design and implementation of curricular has become very important. The uniqueness of the graduates produced by a particular university mainly depends on the system of assessment as well as the course curricular. A leading university of the world, the MIT publishes not only its curriculum but also all the course notes in their web site. But there are some hidden aspects such as the assessment system which highly contribute in maintaining the uniqueness of their degree programs. Some other party by merely copying their curricular will not be able to achieve the same quality or uniqueness. You have to develop your own curricular as well as the assessment system in order to make your degree program unique.

Therefore in designing engineering degree curricular these factors should be taken into consideration. For example the University of Sydney is committed in producing best graduates who are high level scholars, lifelong learners and global citizens in whatever the discipline. Their theme is to produce high quality graduates who can work anywhere in the world. They achieve this purpose through personal and intellectual autonomy, ethical, social and professional understanding, high level of communication skills and information literacy which are bound by research and inquiry. Their entire curriculum, irrespective of the discipline is based on these factors.

In order to produce higher level of intellectuals, universities are concerned with certain graduate attributes. Most of these graduate attributes are common among universities all over the world. Some of the attributes of engineering graduates shared by most of the universities are intellectual skills, practical skills, numeric skills, IT skills, communication skills, teamwork and interpersonal skills, professional development and self management skills etc.

#### **4. Object Based Education (OBE) approach for Engineering**

Today we focus on Outcome Based Education (OBE) in engineering where much emphasis is placed upon achieving outcomes. An outcome specifies what the student should be able to do at the end of the course related to the broad abilities. An outcome identifies not only knowledge, but a combination of knowledge, skills and abilities and it also provides clarity regarding the final product.

Earlier in the engineering education, the graduate outcomes were decided by the process of teaching. OBE does not allow the process to define the product. In OBE, the graduate outcomes and the attributes are defined first and the process was developed to achieve them. Although in the old system, the teachers transmitted subject matter content to the students, in the outcome based approach, the teachers have become merely facilitators in the teaching learning process.

In OBE the roles of the teachers and students have reversed due to the transfer of the teaching learning process from teacher centered to student centered. Compared with the earlier system where the students were passive learners, the students are now knowledge builders through active learning.

Outcome Based Education approach encompass the total range of competencies comprising knowledge, skills and attitudes rather than emphasizing on acquisition of knowledge. It is expected to produce Engineering graduates who can cope successfully in the dynamic industrial environment as Professional Engineers.

## 5. Conclusion

The engineering and technology education has a long history in Sri Lanka. Today many engineering degree programs are conducted by Public Universities and Non-state Higher Educational Institutes. Globally there is a well defined qualification framework for engineering education. The spectrum of engineering professionals ranges from Professional and Chartered Engineers to Incorporated Engineers to Engineering Technicians. Although their roles may be different, all are team players and their contribution is essential in achieving the team objectives.

According to the norm, a degree program which aims at producing Professional Engineers is of four years duration consisting of eight academic semesters. The Washington Accord details the graduate attributes and the competencies to be achieved in a degree program for Professional Engineers.

In the last decades a drastic paradigm shift is evident in the global engineering practice. The focus was shifted from routine engineering work to specialized problem solving involving complex communication and expert thinking. In contemporary engineering education, much emphasis is given to achieving competencies rather than merely knowledge. In the changing labour market of the 21<sup>st</sup> century, abilities to work for deadlines and work through long hours and the adaptability to new environments are valued highly by the employers. Also good communication skills are essential for an engineering graduate to survive in the industry as a professional.

In designing curricular for engineering degree programs the universities have to consider the shifts in the expectations of the labour market. The uniqueness of the curricular and the assessment system contribute highly in producing unique graduates who have edge over other in securing good job opportunities.

In current curriculum development for engineering degree programs, much emphasis is given to Outcome Based Education (OBE) concept. OBE focuses on achieving outcomes and appropriate graduate attributes rather than the process. Also opposed to the traditional education, OBE is more student-oriented and the teacher's role has changed from just imparting knowledge to a facilitator under the new system. Outcome Based Education approach is expected to produce Engineering graduates who can cope successfully in the dynamic industrial environment as Professional Engineers in the 21<sup>st</sup> century.

## Acknowledgement

The author wishes to extend his gratitude to Ms. RP Kumanayaka, Lecturer of the General Sir John Kotelawala Defence University for her contribution in preparing the manuscript.