Engineering Graduates for Employment

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Introduction.

1. Education is important as a long term investment by both individuals and society, and one of the purposes of that investment is employability. This presentation reviews the contribution to employability of engineering programmes in universities. It does not attempt to address other important purposes of education, both inside and outside universities, or the wider aspects of student experience of university life.

2. The content of this presentation is entirely my responsibility, and should not be assumed to represent the policy of any of the organisations to which I am, or have been, affiliated.

3. Engineering programmes in universities are expected to achieve a balance between education and training, that is between knowledge and understanding of the fundamental underlying science in a particular subject, and the ability to apply that knowledge effectively in a variety of employments. These two aims are sometimes represented as engineering science, which is consistent with the historic academic traditions of universities, and engineering technology, which is much less so. The tension between the joint aims of engineering programmes is of long-standing, as evidenced by a Carnegie Foundation 1918 report on engineering education [1]:

> "… the great body of students fail to gain, on the one hand, a satisfactory grounding in the fundamental sciences; and on the other hand do not fulfil the expectations of engineers and manufacturers in dealing with practical problems with which they are confronted on leaving the engineering schools."

Employability and the Curriculum.

4. A basic assumption of engineering programmes in universities is that the graduates will be employed as engineers in some sector of the economy, manufacturing, service or state. Two immediate problems follow for programme developers. The wide diversity of employment that can be followed by graduate engineers means that the content of a programme, even restricted to one of the traditional specialisations such as civil, electrical, mechanical, etc, must be a compromise, and not tailored to a specific sector. Secondly, the rapid development of technology means that engineering graduates will, in their subsequent careers, use methods, equipment, techniques and processes that did not form part of their degree programme. The usual response of programme developers to these problems is to concentrate on the underlying fundamental principles, that is engineering science, and as a consequence graduates will not be trained in all aspects of current practice.

5. The engineering profession has responded by introducing accreditation of programmes, that is specifying the minimum standard of degree programmes that lead to qualification as an engineering professional. There is a measure of international agreement of what the standard should be, usually expressed as Learning Outcomes, Although there are differences in the way they are expressed, reflecting different local

traditions and practices, Learning Outcomes usually contain statements at both First and Second Cycle of the minimum standards to be attained in:

Fundamental science and mathematics;
Problem solving knowledge and skills;
Engineering design;
Practical knowledge and skills;
Personal skills.

6. Accreditation is now widely accepted as being a useful tool for supporting programme development, and for aligning standards internationally. But it can have drawbacks; if implemented rigidly it can inhibit innovation in programme content and teaching methods. Further, as a minimum standard, it may limit the ambitions of programme designers, particularly if ambition has resource implications. Increasingly accreditation is seen as a means of programme development, and not exclusively as a tool for deciding if a programme has achieved a specified level.

Other Influences on the Curriculum.

7. All universities have their individual histories and traditions, and value their autonomy and academic freedom. In general they now recognise the value for engineering programmes of employment considerations. However there are implications for the financial resources to support engineering programmes, equipment for teaching laboratories, number of staff and their expertise, opportunities for industrial placements, etc. Programme designers also have to work within the constraints of mundane matters such as room availability, module timetables, the requirements of programmes in other disciplines, etc.

8. The staff teaching an engineering programme are also pursuing their individual careers as engineering professionals, either in research or consulting. There is an obvious benefit in having teachers who are also practicing at or near the leading edge of the subject, but it is recognised that the balance between maintaining expertise and transferring it is not a universal skill.

9. Wider society also has an indirect interest in the effectiveness of engineering programmes, and this is usually expressed by Government setting parameters and establishing targets and goals for universities, which may include student numbers in engineering subjects.

10. All of the above factors have an influence on the curriculum experienced by students. Conversely, students also influence the curriculum in two ways. Firstly, the knowledge base, both level and breadth, of the entry cohort is important in shaping a programme. Secondly, feedback from students during the programme is essential to a successful programme. This feedback can be both indirect, attendance at lectures, examination results, etc, or more direct, questionnaires, student committees, tutorials, etc.

Discussion.

11. The above review explains why there is a wide range of engineering degree programmes, and why the expectations of employers of engineering graduates are not always realised. This wide range has advantages and a disadvantage. The advantages

are that there is almost certainly a programme well matched to the requirements of a particular employer of engineering graduates; that there is a programme suited to the interests and aspirations of each individual student; and that there are many opportunities for sharing good practice between programmes. The disadvantage is that the number of different programmes makes it impossible for employers and students to evaluate each programme in sufficient detail in order to identify the one that is best suited to their respective interests.

12. A suggestion to reduce the difficulty described above is for employers to specify collectively, and in general terms, the attributes they want in engineering graduates. For example, the following items are adapted from a similar list produced some years ago by the UK Engineering Professors Council (EPC).

What an employer would like to see:

- Understanding of the fundamental principles of the technology studied;
- Analytical thinking applied to problem solving;
- Practical appreciation based on project work;
- Awareness of the effect of real components and operating conditions;
- Familiarity with principle of measurement and test procedures;
- Ability to plan and organise own work;
- Communication skills;
- A capacity for learning.

13. Some of these items are expressed in more detail in the requirements of accreditation agencies, and so would not be unfamiliar to teachers of engineering degree programmes. If, and it is a big if, employers were able to agree on the items in such a list, it should be made available not only to universities, but also to students applying to engineering degree programmes. Prospective students can then ask universities for information about how these items are addressed within the degree programmes in which they are interested. The last three items are non-technical skills, and require student input. Nevertheless it is reasonable to expect that programmes would provide structured opportunities for students to develop these skills.

14. The EPC also produced a list of additional items that could be included, and a modified version is below. Some of the items can be regarded as options that give a particular programme its individuality.

Items that would support employability of a graduate:

- Familiarity with design process;
- Appreciation of statistical methods;
- Awareness of commercial factors;
- Further technical skills, eg programming;
- Non–technical skills eg languages;
- A positive attitude.

15. A third list identified what employers did not expect in graduates from graduates of First Cycle programmes, although some might form the core of specialised Second Cycle programmes.

Not expected in First Cycle graduates:

- Fully formed experienced engineers;
- Expert competence in specific skills;
- All graduates academically strong;

- Managerial expertise;
- Understanding of the impact of volume manufacturing.

Conclusions.

16. The many influences on universities result in a wide range of programmes. It is suggested that employers explain directly to prospective students what they regard as the important characteristics of engineering graduates that strengthen employability, and thereby enable students to make more informed choices of programme, and potentially influence the balance of the curriculum.

17. It is recognised that the employability of engineering graduates has been debated for many years. One interpretation of this longevity is that no single arrangement will apply in all circumstances, particularly as technological developments drive changes to engineering degree programmes. However it is important that the interested parties, students, employers and universities, continue to discuss how to adapt and develop engineering programmes, and a neutral forum, such as this Conference, is essential to the process.

Reference.

[1] Mann, C. R. A Study of Engineering Education: Carnegie Foundation Bulletin Number 11. www.carengiefoundation.org/publications/engineering-education-bulletin-number-eleven.