INTERNATIONAL FACHHOCHSCHULE-UNIVERSITY COLLABORATION IN THE DELIVERY OF A PROFESSIONALLY ACCREDITATED MENG PROGRAMME

Dennis McKeag¹ - Frank Owens¹

¹University of Ulster,
Shore Road
Newtownabbey
Co Antrim, BT37 0XL
Northern Ireland, UK
d.mckeag@ulster.ac.uk
f.owens@ulster.ac.uk

Abstract: The University of Ulster has, for some years, been operating a joint Masters of Engineering (MEng) degree with the Fachhochschule Augsburg and the Fachhochschule Kempten. In all three organizations there is commonality of programmes in the final four semesters leading to the award of the fully accredited MEng degree. Students can therefore graduate with the German qualification of Dip Ing (FH) and the British MEng qualification.

Approximately 46 countries have signed up to the Bologna agreement, which aims for transferability of qualifications across member countries. This has a significant implication for engineering degree programmes across Europe where there are traditionally two types of undergraduate engineering degree each in general of three years duration, the vocational degree and the academic degree. In general only the academic degree permits students to advance to two years further study leading to the award of the professionally recognised qualification of Master of Engineering.

The knowledge taught to students in engineering degrees falls into three categories: scientific, which seeks to understand the created environment; technological, which seeks to manipulate the created environment; and philosophical, which is what is important to people. Fachhochschules traditional teach vocational degrees, those that focus on technology, whereas universities traditionally teach the academic degrees which have their basis in scientific study. However both types of institution teach design, which falls into the category of philosophy, and in the context of engineering design embraces both science and technology.

This paper will outline how the Fachhochschulen brand of education has successfully merged with the university style of education to produce highly innovative engineering graduates.

Key words: Design, innovation, science, technology, philosophy, creativity

1. Bologna, The Background
The Sorbonne declaration (1), signed in Sorbonne, France on 25 May 1998, was the forerunner of the Bologna Declaration (2), signed on the 900th anniversary of the foundation of the University of Bologna, the world’s first university, on 19th June 1999. The objectives (3) of the agreement are:
Adoption of a system of easily readable and comparable degrees
Adoption of a system essentially based on two main cycles, undergraduate and graduate
Establishment of a system of credits
Promotion of mobility
Promotion of European co-operation in quality assurance
Promotion of the necessary European dimensions in higher education

The driving force behind Sorbonne and Bologna was recognition across European countries that they faced problems with regard to employability of graduates and the shortage of skills in key areas, but perhaps more importantly the drive for harmonisation was an economic one, forced by global competition particularly in the areas on information and knowledge.

In the knowledge economy it was perceived that economic, social, security and health systems are dependent on knowledge derived from technological innovations. Universities and third level institutions are responsible for the academic research on which many new technologies are based, and education of the people responsible for subsequent development of the innovative products (4). The fragmentation of the higher education system across Europe was seen as a weakness in Europe’s global competitiveness. Analysis demonstrates that the only areas where it is possible to increase GDP within an economic community are education and innovation (5). It can therefore be determined that the key objective of the Bologna Accord is to improve the global competitiveness of the 46 participating countries, most of whom are within the EU although they can be as far away as Australia (6).

2. Evolution of German and UK Engineering Systems
The Bologna process commenced initially to standardise qualifications between member states of the European Union and thereby permit mobility of students across national boundaries within their educational discipline. Concurrently the process should permit equality of standards across member states of the EU leading to mutual recognition of awards in every participating country. Although this paper deals with a particular collaborative venture between Universities of Applied Science in Germany and the University of Ulster based on engineering programmes, the Bologna Agreement covers all academic disciplines and in this context engineering provision is only one discipline within the agreement.

Within the Engineering discipline there is traditional demarcation between technician education leading to vocational awards, and academic education leading to academic degrees and professional recognition. In the context of the UK this demarcation was, until the 1970’s, clear. The vocational stream traditionally served a five year apprenticeship in engineering industry, and concurrently could study one day per week for two years at a local technical college for the award of an Ordinary National Certificate. Assuming success they could proceed to a further two years of study for the award of a Higher National Certificate (HNC). In academic terms the latter award was academically demanding and was the equivalent of a bachelor degree in engineering science (BSc) at pass level. The academic route was direct entry to University from school, and following
three (or four) years of study gain a BSc or BSc with honours. Candidates from both routes could apply for professional membership of an engineering institution.

In 1980, following from The Finniston report (7), the Council of Engineering Institutions was formed, the MEng was established and the norm for Chartered Engineer status was set as the newly founded BEng, and this was to be the standard for the main body of engineers. Finniston identified “erosion” of academic standards and sought to enhance the standing of those with an academic qualification. However practising engineers largely ignored chartered status and the standards of engineering education at universities was perceived as falling. More reviews in the 1990s produced a number of variants of SARTOR (8) which did nothing to address the problems. Within the past 10 years UK-SPEC was conceived (9), and this standard decided that the ability to practice engineering should be based on competences attained; it also determined that three Registration Categories should be maintained:

- Chartered Engineer (CEng) – Requires MEng
- Incorporated Engineer (IEng) – Requires BEng, BTech or BSc
- Engineering Technician (Eng Tech) – requires NC or ND

The European models of engineering education evolved from the French system established by King Louis XV in 1775 (10). From the beginning, engineering education on mainland Europe had its roots in the university system, unlike the British system which had its roots based on practice (11). Shortages of engineers in Germany and elsewhere in Europe led to formation of the Fachhochschulen system in the 1970s whereby technological or production engineers could be educated in three or four years. The aim of the Fachhochschulen system was to promote the practical application of knowledge. Students graduated with the award of Dip Ing (FH), the subscript was required by law to differentiate a Fachhochschulern student from a University graduate. Programmes with a minimum of five years duration were still required to produce theoretical or research/design engineers from the University system. Within the German system, universities were required to accept transfers from the Fachhochschulern system onto their longer academic programmes.

The move to the vocational and academic degrees under Bologna appears to have been reluctantly embraced in Germany but from 2010 all programmes must comply with the Bologna model. For the Fachhoschschules this means they will offer their own BEng and MEng degrees presumably in competition with the traditional universities. A fundamental difference between the German and UK societies is the attitude towards engineering education and manufacturing industry, so it is likely the German academic system will continue to attract high calibre students into engineering and the harmonisation of the qualifications between the Fachoschules and the Universities will enable more to take up engineering as their chosen profession. By contrast the UK system is suffering from dwindling interest in engineering from school graduates, closure of engineering departments, and low entrance standards to the remaining courses. This perhaps is the reason why the UK-SPEC focuses on engineering graduates demonstrating competencies on leaving university, and the dropping of minimum academic entry standards to engineering courses introduced under SARTOR (9).

3. The Collaborative MEng Programmes and Their Compliance with Bologna

The MEng Engineering programmes are the consequence of evolution based on a long established collaborative link, in excess of twenty years, with two German Universities of
Applied Sciences in Augsburg and Kempten. Original collaboration was on BSc programmes in Electronics, then BEng programmes in Microelectronics, and in the recent past (and currently) three programmes:
- MEng / BEng (Hons) Engineering
- MEng / BEng (Hons) Electronic Engineering
- MEng / BEng (Hons) Electronics & Software

Both German Universities contribute to the delivery of the programmes, and students from Ulster, Augsburg and Kempten can simultaneously obtain the Dual Award of MEng Engineering and Diplom Ingenieur.

All academic programmes at The University of Ulster are revalidated on a 5 year cycle to ensure relevance to the needs of society and to incorporate advancements in science, technology and innovation relevant to the programmes.

In the most recent validation, the MEng/BEng (Hons) Engineering was renamed MEng / BEng (Hons) Mechatronic Engineering to fully reflect the mechatronics theme of the programmes developed since the preceding validation.

Course developments and rationalisation resulted in closer alignment of MEng / BEng(Hons) Electronics & Software and MEng / BEng(Hons) Electronic Engineering to the point where it was not deemed advantageous, or sensible, to maintain them as individual programmes. For a degree with software in the title it was felt that there was insufficient software content in the programme and over the last few years MEng / BEng (Hons) Electronics and Software has suffered a declining intake, whereas MEng / BEng(Hons) Electronic Engineering has experienced growth. In consequence the programmes on offer from 2011 are:
- MEng / BEng(Hons) Mechatronic Engineering
- MEng / BEng (Hons) Electronic Engineering

The collaboration between the three institutions will continue on the revised programmes, but in a different way. There will be separate collaborations between Ulster and Augsburg on the MEng Mechatronic Engineering programme and between Ulster and Kempten on the MEng Electronic Engineering programme. In both cases, students will be able to simultaneously obtain the Dual Award of MEng from The University of Ulster and the German Masters degree from Augsburg or Kempten. In accordance with the Bologna model, the two German Universities are in the process of replacing their Diplom Ingenieur provision with Bachelor/Master programmes.

An outline of the two year MEng Mechatronics Engineering joint with Kempten is provided in Appendix 1, and the outline of the Kempten Electronics programme is shown in Appendix 2. As before, staff from all three partners will collaborate on, and contribute to delivery of the two year MEng programmes.

The MEng/BEng(Hons) Mechatronic Engineering programmes are currently accredited, under the old title of Engineering by both the Institution of Mechanical Engineers (IMechE) and the Institution of Engineering and Technology (IET). The MEng/BEng(Hons) Electronic Engineering programmes are currently accredited by the IET. In all cases, the programmes are accredited for a period of 5 years for intakes 2006 – 2010. It is planned to seek continued accreditation for the programmes for intakes from 2011 onwards.

4. Programme Uniqueness through Industry Led Innovation and Design Based Research
A fundamental area of distinction and division within Bologna are the concepts of vocational and academic degrees. In the days of Polytechnics in the UK it was the aspiration of Polytechnics to be seen to be “academic” and this required they aspired to provide their own degree programmes. Erosion of the difference ultimately led to the polytechnics being upgraded to university status. It is in the nature of human beings to aspire to „the best“, and a similar scenario can be seen to develop within the Bologna classification of awards. Who is going to settle for second best when something better is to be achieved. Part of the problem is the perception that three year vocational degrees are an end in themselves, and regarded by many as a „dead end“.

However, scientists and philosophers seem to pursue very different paths. We must not forget, however, that their activities have a common background in history. From the foundation of the University of Bologna until around 1700 natural philosophy was studied at universities, and this is deemed to be the cradle of modern scientific thought (12).

The educational training scientists and engineers receive is almost identical and it is only later in academic programmes there is divergence between science and engineering education and training. Although closely related to engineering, technology is largely ignored by academic engineers. It could be said that science is primarily focused on the scientific method and the means by which scientific knowledge is generated, in other words understanding the created environment, engineering is primarily concerned with mathematical articulation of scientific theories, and technology is focused on manipulating the created environment (13). Another way of describing the difference is that science is concerned with what is, engineering is concerned about what should be, and technology is concerned with what is to be.

Common to both engineering and technology is design, and there are six core principles underpinning engineering design (14). It is appropriate to list these six principles and through simple analysis ascertain the knowledge, skills and understanding that support each:

1. **Fundamental design concepts**: these include principles of operation and configuration. These are more likely to be the result of creative thinking leading to innovation.
2. **Criteria and specification**: Best results will come from application of user centred design, inclusive design and empathetic design techniques.
3. **Theoretical tools**: Based on mathematical articulation of scientific theories.
4. **Quantitative data**: From published tables, investigative research and secondary research techniques.
5. **Practical considerations**: Based on known materials and production technologies.
6. **Design tools and techniques**: the result of training and experience

In this context design concepts means refined ideas that could lead to a product (process or system) design. This simple analysis demonstrates that at the core of engineering is creativity, engineering science (and by implication mathematics), materials and production technology. It can be further seen that these factors do not come exclusively from the traditional academic type of education found in universities, or from the applied science or vocational type of education found in the Fachhochschulern system; rather it is melding of
Innovation, which is the commercialisation of new and original ideas that give value to their intended audience, is based on creativity. The innovation module within the collaborative MEng programmes is the one compulsory module that engages students from all three institutions. It provides a unique insight into the relative merits of the different forms of education at the three institutions, and provides a unique educational experience for the students whereby they learn the principles and practice of multidisciplinary technological innovation, based on interdisciplinary teams and through real industry projects.

4. The MEng Innovation Module
The MEng innovation module is based on the universal approach to innovation developed at the University of Ulster (15). It is based on the premise that innovation cannot be defined but rather understood in relation to one’s own discipline by consideration of four elements:

1. **Observation**: Studying products (processes and systems) with a view to understanding what merits recognition as innovation and what does not.

2. **Knowledge, Cognitive and Practical skills**: Identifying those necessary for successful innovation

3. **The Creative and Innovative Process**: Knowing and understanding the processes that led to successful innovation

4. **Practice**: Learning through participation in innovation activity.

The teaching and learning programme addresses these four pillars of innovation. Initially students are taught through a series of largely on-line exercises, to recognise innovation in their own discipline. Then, through responding to a series of probing predetermined questions, they „discover“ the key skills, concepts, theories, process and knowledge underpinning the innovations. This makes them aware of what constitutes innovation in their discipline as distinct from the general media perception of innovation. This activity also helps them determine in relation to their own learning experience, the academic weaknesses in their own development, and hence they are in a position to identify how and where they need to direct their own professional development to enable them participate in technological innovation.

In collaboration with a company, and generally some months before the commencement of the innovation module, a „live“ project topic is agreed with the company. The „rules“ are simple, the innovation element of the project must be unique and potentially of value to the intended customer. It should be a project that will be live in the company in the near future, and it should have commercial potential. The project is delivered to the students by a senior person in the collaborating company, usually the MD or the person responsible for new product design and innovation. The project is presented on the same basis as it would be given to engineers in the company, and students have access to all the company's knowledge and know-how on request.

Students form themselves into teams consisting of four persons each and analyse the needs of the project in relation to their knowledge and skills base, and using information gleamed from the earlier exercise. They then draft their own taught programme for the remainder of the semester, to run in parallel with the group product innovation activity.
The taught programme is scheduled in collaboration with the students and delivered in line with their requirements.

Some of the recurrent elements identified for the taught programme and how they are addressed are as follows:

- **Subject specific knowledge**: rarely a problem and where it is the deficit is addressed by subject specific academics.
- **Industry based technology**: frequently a concern. This is addressed through a visit to the company where the students as a whole get the opportunity to view the technology and address questions to any company employee. Thereafter they may on request, arrange a private team visit to address specific issues.
- **Business knowledge**: Where there are concerns, subject specific staff will address the issues generally through focussed lectures at „M“ level.
- **Creativity**: a major problem with most engineering students, addressed through teaching and classroom activity based on both traditional approaches to creativity but also through techniques embraced by the more modern user-centred design, empathetic design and inclusive design techniques.
- **Innovation process**: the students are given guidance based on case study material, supplemented by refereed publications on the subject and also reference material like BS7000: Managing Innovation. However each team generates the innovation process that suits their needs in line with industry practice.

In team-based activity, assessment is a recurring theme with students. This is addressed by having each team submit a once weekly action based meeting report over the internet using a predefined pro-forma. Once every two weeks each team member submits a confidential report on the performance of their fellow team members, and awards marks out of 10 according to a predetermined scale of performance. These marks are tallied at the end of the semester to give relative marks for each team member. The final team report is marked out of 80 and the relative marks used to adjust the report marks to give an absolute mark for each team member based on contribution to the project. The absolute marks for each team member are determined as follows:

\[
\frac{Sr}{Gra} \times Ra = Sa
\]

Where:
- \(Sr\) = relative mark awarded to each student by peers
- \(Gra\) = group relative average mark
- \(Ra\) = absolute mark awarded for the report
- \(Sa\) = absolute mark for the student

For example, if relative marks awarded are 50, 60, 70 and 80 across each student in a group of four, the average mark is 65. If the absolute mark awarded for the report is 60, the absolute report marks for the students are 46.15, 55.38, 64.62 and 73.85 respectively.

The remaining 20 marks are based on team and individual performance at a team presentation to senior company staff that assess each student on presentation, delivery, mastery of topic, and response to questioning. The final marks for each student are hence determined as recorded in Table 1.

<table>
<thead>
<tr>
<th>Presentation (5)</th>
<th>Delivery (5)</th>
<th>Mastery of Topic</th>
<th>Response to questioning</th>
<th>Total for presentation</th>
<th>Report Marks (80)</th>
<th>Total (100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 1

5. In Conclusion
The Bologna accord is an attempt to improve the international competitiveness of participating countries through commonality of third level education standards and addressing issues such as mobility of graduates across national boundaries and enabling ease of international student exchange. In addressing the GDP of a nation it has been shown that the only one of the five areas commonly associated with economic growth that can be addressed proactively is improving the quality of labour through education, training and experience. In a modern industrial society innovation is the key driver in improving the national economy, and this is largely dependent on having the appropriate engineering skill set, both academic and technology based. The experience at the University of Ulster over many years has demonstrated it is possible to meld both types of education into one harmonious unit, and produce students equipped to deal with the totality of technological innovation issues, whether based on applied science or engineering science. The innovation module, developed and improved over many years, provides a sound basis for synthesis of all learning outcomes required of the three participating third level institutions from Germany and the United Kingdom.

References

All internet material was available for download on 15th June 2010
Appendix 1

MEng Electronic Engineering / German Masters Dual Award Course
Structure (Kempten)

**Semester 1**

**Year 4 (Level 6)**

- EEE529 Industrial Management (10)
- BME501 Signal Processing (20)
- EEE5xy Embedded Systems (20)
- GER 318 German A (10)

**OR**

- EEE524 Academic Placement- Kempten (Germany) (60)

**Year 5 (Level 7)**

- EEE824 RF Design (15)
- EEE826 Digital Signal Processing (15)
- EEE803 Embedded Systems RTOS Design (15)
- EEE828 Product Innovation (15)

**Semester 2**

**Year 4 (Level 6)**

- EEE529 Industrial Management (10)
- BME501 Signal Processing (20)
- EEE5xy Embedded Systems (20)
- GER 318 German A (10)

**OR**

- EEE524 Academic Placement- Kempten (Germany) (60)

**Year 5 (Level 7)**

- EEE824 RF Design (15)
- EEE826 Digital Signal Processing (15)
- EEE803 Embedded Systems RTOS Design (15)
- EEE828 Product Innovation (15)

**MEng Final Project (60)**
Appendix 2

MEng Mechatronics / German Masters Dual Award (3282) Course Structure (Augsburg)

### Semester 1

**Years 1, 2, & 3 common with BEng (Hons)**

**Year 4 (Level 6)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEE529</td>
<td>Industrial Management</td>
<td>10</td>
</tr>
<tr>
<td>GER 318</td>
<td>German A</td>
<td>10</td>
</tr>
<tr>
<td>EEE5xy</td>
<td>Mechatronics 1</td>
<td>20</td>
</tr>
<tr>
<td>EEE5xy</td>
<td>Embedded Systems</td>
<td>20</td>
</tr>
</tbody>
</table>

**OR**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEE532J1</td>
<td>Academic Placement-MEng</td>
<td>60</td>
</tr>
</tbody>
</table>

**Year 5 (Level 7)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEE824</td>
<td>RF Design</td>
<td>15</td>
</tr>
<tr>
<td>MEC878</td>
<td>Mech. of Sheet Metal Forming</td>
<td>15</td>
</tr>
<tr>
<td>EEE803</td>
<td>Embedded Systems RTOS Design</td>
<td>15</td>
</tr>
<tr>
<td>EEE825</td>
<td>Modern Control Systems</td>
<td>15</td>
</tr>
<tr>
<td>EEE826</td>
<td>Digital Signal Processing</td>
<td>15</td>
</tr>
</tbody>
</table>

**Options Select 3**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEE828</td>
<td>Product Innovation</td>
<td>15</td>
</tr>
</tbody>
</table>

### Semester 2

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEE535</td>
<td>ASICS &amp; VLSI Design</td>
<td>20</td>
</tr>
<tr>
<td>MEC515</td>
<td>Oil Hydraulics</td>
<td>20</td>
</tr>
<tr>
<td>EEE545</td>
<td>Mechatronics</td>
<td>20</td>
</tr>
</tbody>
</table>

**OR**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEE536</td>
<td>Industrial Control &amp; Automation</td>
<td>20</td>
</tr>
</tbody>
</table>

**Year 4 (Level 6)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEE828</td>
<td>MEng Final Project</td>
<td>60</td>
</tr>
</tbody>
</table>