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ANNEX B – DESIGN IN DEGREE PROGRAMMES

Context

The JBM requires that design is integrated into existing teaching and learning, and must be pervasive throughout the engineering education programme; a design thread will therefore run though the programme.

In engineering a central activity is design, and the interpretation and execution of design. This may be as an individual or as part of a team involved in creative activities for which imagination, intuition, intellectual rigour, and choice are orchestrated to arrive at a particular solution; or as part of the engineer's role in developing new products, markets or strategic ideas; or on site, seeking to interpret and translate into reality someone else's design. Whatever the role, the engineer will normally be involved in the design process requiring the exercise of continuous judgement, adaptation, modification, ingenuity and nearly always a need for imagination and flair. In proposing solutions, deciding how they can be built and managing parts or all of the process from conception to production, the intellectual activities that are often referred to as "engineering design" play a central role. It is vital, therefore, that engineers receive in their early education a thorough grounding in those activities that are central to the design process.

The environment in which design projects are undertaken is extremely important. The design studio is the designers equivalent of the building site, and in much the same way it needs to contain the materials, tools, information and other resources for student design teams to perform effectively. Universities should endeavour to provide an environment and resources for students to undertake design work that reflects the best to be found in engineering practice. Such design studios should thus include facilities to allow and encourage the students to draw, make physical models, relax, reflect and obtain stimulation and inspiration.

Aims

The aim of undergraduate design teaching is to provide students with the basic design skills to allow them to progress smoothly into engineering practice.

Knowledge and understanding

The art of engineering design is probably best explored by examining some of the activities in which the design engineer is involved. While not exhaustive, the following represent some of the more important design attributes of a competent engineer:

- An understanding that design is a creative process in which experience and a thorough knowledge of historical precedent can inform both intuition and conscious choice.

- An ability to cope with the uncertainties associated with the multitude of factors making up the design brief. It is rare for a unique solution to emerge, and more commonly there will be any number of possible solutions for which the "best" solutions will represent an intelligent compromise.
- An ability to ‘think outside the box’. Could a better design be achieved if unnecessary constraints (explicit or implicit) in the brief were renegotiated?
- An ability to interact with clients to help both client and other team members develop a better understanding and definition of the brief and the functional, social and economic objectives.
- A knowledge of how to gather relevant information on environmental and planning issues, site conditions, material suppliers, collaborators, specialists and other contractors. All this information is needed to inform the design process.
- An ability to sort and synthesise all information so that proposed solutions can be tested against the criteria identified in the brief and the overall functional, social and economic objectives.
- Be comfortable working in a system which enables people to work together, and which allows them to plan and track progress towards a developing solution. This applies to both the sub-components of design and the overall design process.
- An ability to justify the chosen solution to stakeholders.

Although the above suggests a sequential pattern of inception through conception to production, it is rare that the art of design can be performed in such a linear set of steps. There is almost always a need for backtracking. Design can be thought of as a "highly iterative process" involving "necessary compromises between conflicting needs, possibly with flashes of brilliant intuition, but also much hard work, self criticism and discussion" in which "both visual and engineering understanding need to be combined from start to finish" of the design process (James Sutherland in "Bridge Design" The Royal Fine Art Commission, Seminar, 29 October 1992, HMSO).

Students will undertake a variety of different design tasks over the course of their studies and design teaching should form a thread running through the programme. Design tasks should include:

- The design of structural elements or hydraulic systems for example, where typically the brief is simple, the options few and obvious, the tests technically very challenging and numerical in character and the judgements objectives in character.
- The design of “realistic projects” such as railways, airports, hydropower schemes, bridges, skyscrapers, water treatment works, highways or the like. These sorts of projects are characterised by extremely complex briefs full of diverse and often contradictory aspirations and well as numerous and often obscure constraints or opportunities realting to the site and the socio-economic context. The conception of plausible solutions is usually very demanding and complex. The tests required are similarly diverse and sometimes highly subjective and the judgements correspondingly challenging.
- In practice design is almost always a team activity and as such students should work in groups for a substantial part of their design learning.

Creativity is a mental process involving the generation of new ideas or concepts, or new associations between existing ideas or concepts. Real engineering projects are all unique and hence their design requires creativity. It is important that students develop their creative skills through design projects and other activities within their studies.

Intellectual ability

Design activity is capable of achieving a wide range of learning objectives. The emphasis in a particular degree programme will be expected to be varied, but should seek to cover an appropriate range of the following objectives:

- Develop a stimulating environment for creative, clear and logical thinking.
- Stimulate and encourage student interest and appreciation of engineering as an intellectual and professional activity.
- Make students more responsible for their own learning and intellectual development.
- Develop the habit of and ability for effective independent learning.
- Provide a platform for the improvement of oral and written presentation skills, both individually and as part of a team.
- Encourage clear communication through sketching and drawing.
- Develop an appreciation of the importance of the study of engineering history, the forces that have shaped that history and equally, how engineering developments have affected our material culture.
- Appreciate the relationships between art history, architecture and engineering, as part of the development of greater visual awareness.
- Through the study of past failures, develop an appreciation of the causes of failure and the need to "think failure to avoid it".
- Raise awareness of the complexity of engineering systems, and the need to listen to and interpret client needs, so as to be able to develop clear briefs.
- Provide a context in which the principles of engineering science, and other parallel taught courses, may be applied in the creative design process.
- Develop an appreciation that everything we do in design can be seen as a process that can be harnessed to encourage creativity.
- Increase awareness of and develop the skills for planning, tracking and evaluating the processes in design.
- Understand how the construction method, issues of safety and legislation, and the concepts of buildability can drive design.
- Understand how economy, sustainability, ethics, politics, and the impact on society can affect design.
- Understand how to identify and assess risks throughout the design process and decide on methods of elimination and/or control.
- Design teaching helps to motivate students generally and after entering practice graduates also routinely report that design projects are the most useful and exciting part of their undergraduate studies.
- Contextualise their theoretical studies.

Practical skills

The student should be able to:

- Demonstrate through design work, project, coursework and/or examinations a strong awareness of and commitment to the principles of sustainable development as outlined in Annex C.
- Demonstrate that they can evaluate the process in design.

General transferable skills

The student should be able to:

- Demonstrate team working skills.
- Demonstrate clear communication skills through their sketching and drawing.
- Develop their creative skills through design projects and other activities within their studies.
- Communicate knowledgeably about design issues especially to those with a non technical background.

Method of teaching, learning and assessment

Design is best taught by giving students the opportunity to practise, albeit within an education environment and utilising case studies, reflective learning and other techniques as appropriate.

It is recognised that high level design skills and experience are often hard to find in universities. As such, it is encouraged that practicising engineers have an involvement both in the development and delivery of design teaching. Typically, this can be achieved through advice on setting projects and partial supervision of group design projects. In addition, any connections to clients and contractors would be beneficial.

A proper understanding and relevant skills in relation to Sustainability as well as Health & Safety are fundamental to the teaching and practice of design. Moreover, design projects provide a natural place for students to demonstrate their knowledge and practise their skills in relation to sustainability and Health & Safety. The JBM recommends that the three sets of guidelines (Annexes B, C & D) be considered together, especially in relation to teaching and learning methodology and assessment.