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GOOD PRACTICE GUIDE – DIGITAL TECHNOLOGIES IN DEGREE PROGRAMMES

1. Importance of Digital Engineering

1.1 Computers provide powerful tools for addressing today's engineering problems. To be effective, the engineer needs to understand and be proficient in using digital tools. These tools play a crucial role in engineering design and analysis; collaborative multi-disciplinary work; and engineering management and have replaced entirely or in large part the slide rule, drawing board, filing cabinet and typewriter. At undergraduate level, engineers need to understand the central role digital technologies play in engineering and appreciate how their use can enhance, rather than distract from, investigation of fundamental engineering principles.

1.2 There is a need for undergraduate teaching to use digital technologies as tools to solve engineering problems, rather than to focus on mastery of the technology itself. In doing this, there is a need to develop undergraduate skills in both advanced computer techniques and in the checking of digital outputs through more approximate rules of thumb and sensitivity analyses. It is vital that the next generation of engineers gets teaching on digital technologies that:

a) introduces digital technologies as tools in the analysis and design of real-world materials, structures and behaviours;
b) enables engineers to calibrate and question computer models; calculations and assumptions as well as to create and manipulate them;
c) fosters understanding of how individual work in engineering design and analysis is shaped by and integrated into the wider work of the engineering project team; and
d) articulates the rationale behind standard processes and procedures for using digital technologies in co-ordination of engineering work.

1.3 Undergraduate teaching on digital technologies should not take place in isolation or focus on gaining competence in particular software solutions, but rather should seek to develop understanding of the rationale for using technology in engineering and the associated challenges and opportunities of digital technologies as tools in addressing fundamental engineering problems. It should be an integrated part of the relevant courses across the curriculum.

2. Context of Digital Technologies in Engineering

2.1 Digital technologies encompass a wide range of data-capture; design; analysis; and project and process-management tools (including modelling, simulation, visualisation, mobile communication and data-bases). Digital engineering is defined as the use of computers and digital data to accomplish fundamental tasks of engineering.

2.2 The scope of digital engineering is vast. However, the following represent some attributes of a competent engineer:

- An ability to identify the kinds of tasks in design, analysis and management for which the computer and its various types of associated software and hardware would be useful;
- An understanding of the calculations or processes being performed by the computer;
- An ability to use digital models as reflective tools and to reflect on the validity and efficiency of particular techniques and processes rather than simply input data;
- An ability to calibrate digital data with data captured from the real world and conduct the approximate hand sketches, rough mental calculations and physical modelling activities necessary to question computer models, calculations and assumptions;
- The capacity to critically assess the quality of the engineering proposition rather than assume content, completeness and accuracy when presented with highly polished images;
- A knowledge of the basic standardized digital processes and procedures, their use in coordination, work-flow management and the checking of design work; and
- An ability to interact and co-ordinate with other team members through digital technology on a shared engineering task.
- A sense of discipline in the digital world, knowing when to stop rather than engaging in over refinement of an idea or endless iterations of design ideas.

2.3 Technology is evolving rapidly and it is the principles and standards for using digital technologies in engineering that are important at undergraduate level.

3. Objectives of Learning about Digital Technologies

3.1 The objectives of learning about digital technologies are to:

- Identify, apply or develop appropriate digital tools for addressing fundamental engineering problems;
- Stimulate and encourage student interest and appreciation in the application and development of digital engineering as an intellectual and professional activity;
- Develop an ability for creative, clear and logical thinking using digital technologies;
- Develop an ability to interpret; test and calibrate digital data and models;
- Develop an appreciation of the issues of tolerances; material behaviours and buildability and how they are dealt with in digital models;
- Develop effective working habits and the ability to effectively co-ordinate with others;
- Make students more responsible for maintaining a systematic archive of work using standard processes and procedures;
- Increase awareness of the potential of digital ways of working

3.2 Gaining proficiency in the use of digital tools may reveal much about the nature of the underlying engineering principles. Hence digital technologies can also be used as a means of achieving a wide range of learning objectives relating to fundamental engineering principles. The major differences in the degree programmes should be of extent and depth rather than content and form.

4. Encouraging Effective Learning about Digital Technologies

4.1 The early education of the engineer should use digital technologies as a vehicle for learning fundamental engineering principles rather than as a primary focus. However, the use of digital data is fundamental to the engineers' role in the 21st century and there are elements that should be incorporated into all learning programmes:

- The focus in engineers' early education should be on developing a thorough grounding in the fundamental principles of engineering and how to apply them and teaching should focus on the role of digital tools and technologies in supporting this.
- Digital engineering should form a continuous thread through the engineering education programme, with opportunities to use basic digital software and techniques to address fundamental engineering problems in many parts of the course and to appreciate the potential application of advanced digital software and techniques to address these problems;
- There is a need to create a learning environment that encourages students to explore the limits as well as the opportunities of digital engineering for themselves, for example in engineering design work. Students should discuss the limits of digital simulations and models and the assumptions made in their use and should have an opportunity to calibrate digital models in the laboratory to real-world field situations. The best teaching will deal not only with the identification of poor data entry but the far more challenging problem of dealing with the plausible but incorrect assumption or critically but not obviously flawed data set.
- There is a need for a taught component to introduce students to contemporary work processes in professional practice, the rationales for standard processes and procedures in using digital tools, and the need for discipline in digital work to achieve commercial targets in terms of time, costs and outputs. In professional practice, much design work is carried out in teams, and the undergraduate course should cover basic use of standard processes and procedures in supporting team-work and introduce case studies to prepare the graduating engineer for practice as part of a professional team.

5. Link to Guidelines for Design and Sustainable Development

5.1 Many of the issues and principles described here in the context of digital technologies are mirrored in Annex B – Design in Degree Programmes and Annex C – Sustainable Development in Degree Programmes, particularly in relation to the development of effective learning processes and systems of assessment, the use of team working and project work. The JBM therefore recommends that the three sets of guidelines be considered together in the development of degree programme content, context and delivery.

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