

Chapter 24

Designing Sustainability Curricula: A Case Following Chemical Engineering Curriculum Redesign

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ABSTRACT

Developing an engineering student's awareness of sustainability through the embedding of sustainability curricula is widely considered to be essential to modernising chemical engineering degree programs. In this chapter, the chemical engineering program at James Cook University is used as a case study to illustrate the design and sequencing of embedded curricula associated with developing a students' awareness of sustainability. There are a wide range of examples of skills, techniques, and characteristics associated with developing this awareness. In this chapter, an approach is described whereby a set of generic and interdisciplinary capabilities are developed to provide a degree of flexibility in how sustainability is interpreted and taught. A cognitive learning matrix is utilised as a design tool that facilitates determination of new subject learning outcomes aligned with the sustainability capabilities. A variety of curriculum examples are introduced and described.

INTRODUCTION

Sustainability is widely acknowledged to be essential to creating a more equitable future. An ability to incorporate sustainability into engineering design is also important for engineering graduates to be able to innovate and deliver improvements in the economic, environmental, and social impacts of

industry and business. At James Cook University (JCU) in Australia, sustainability has become a key element in the University's Strategic Intent, and over the past 5 to 10 years, an alignment to an ethos of sustainable practice has occurred across the teaching, research, and facilities management sectors. For example, a new sustainability degree program aligned with agricultural sciences is in its second year of offering, algae-based bio-fuel and bio-mimicry research is a recognised

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strength for the university, and a recent state of the art centralised cooling-water installation has received National awards in sustainability practice. Parallel with these developments, JCU's School of Engineering and Physical Sciences have been developing and embedding curricula within the undergraduate engineering degree program (particularly chemical engineering) that develops an engineering student's "awareness of sustainability".

Internationally, engineering educators and engineering leaders across the globe have recognised that engineering graduates should be aware of sustainability and should be able to incorporate sustainability into their designs. Over the past 10 years or more, sustainability and sustainable design has been an emerging feature of engineering and particularly chemical engineering higher education degrees. Key accreditation bodies such as Engineers Australia (EA), in consultation with industry, have strengthened their emphasis on sustainability, ethics, health and safety, interdisciplinary knowledge, innovation, systems approaches, contextual understanding, and emotional intelligence. These are all characteristics which are commonly aligned with the broad principles of sustainability. Even more so, the Institution of Chemical Engineers (IChemE) have provided a number of vision statements outlining their commitment to sustainability, health and safety, innovation, reduced resource consumption, and minimised waste production. For example, in their recent review of the "Roadmap for the 21st century" are the Vice President's (Ed Daniels) opening remarks:

The future is challenging and uncertain. The puzzle is complex, but chemical engineering remains central to the delivery of sustainable energy, water, food, and wellbeing in all parts of the world. (IChemE, 2013)

Furthermore, the IChemE's traditional design prize has been reformed into a sustainability

design prize. The specific objectives of which are to encourage students to think of sustainable development as a key element of their design projects and also to influence chemical engineering departments to position sustainable development at the heart of the curriculum.

In Australia, James Cook University, Royal Melbourne Institute of Technology, and Monash University, are examples of Universities where progress in embedding sustainability across the chemical engineering degree program has been most comprehensive. Murphy et al. (2009) and Allenby et al. (2009) both provide details on the progress in embedding sustainability into both research and teaching areas in higher education in the United States of America. Allenby et al. (2009) in particular, provides an interesting summary of the philosophical challenges and motivations in embedding sustainability. Although many institutions are shifting toward the incorporation of sustainability content into their degree programs, in the USA the University of Texas and Rowan University (Slater et al., 2007) provide exemplars of best practice in this area. In Europe, the progress made at Delft University to embed sustainability within engineering degree programs also provides a good case study (see for example: Mulder, (2006) and Segalàs et al. (2009)).

Apart from some exemplars of best practice and despite professional accreditation bodies such as Engineers Australia (EA) and The Institute of Chemical Engineers (IChemE) expecting that university graduates demonstrate an "awareness of sustainability" (in the EA's case, from 2014), there has actually been relatively minor progress made to update and modernise engineering training. As noted in Steiner's (2010) description of the state of Australian engineering education: "*There is little evidence of sustainability being embedded at the heart of the engineering curriculum*". Chemical engineering academics such as Azapagic et al., (2007), Davidson et al. (2005) and Byrne and Fitzpatrick (2009), have concluded in the past that most chemical engineering programmes have

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