Chapter 12
Integrating Ethics into Engineering Education

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ABSTRACT

In this chapter, the authors aim to explore the necessity of teaching ethics as part of engineering education based on the gaps between learning "hard" knowledge and "soft" skills in the current educational system. They discuss why the nature of engineering practices makes it difficult to look beyond dealing with engineering design problems, identify the difference between knowledge and risk perceptions, and how to manage such tensions. They also explore the importance of developing moral responsibilities of engineers and the need to humanize technology and engineering, as technological products are not value neutral. With a focus on Problem-Based Learning (PBL), the authors examine why engineers need to incorporate ethical codes in their decision-making process and professional tasks. Finally, they discuss how to build creative learning environments that can support attaining the objectives of engineering education.

INTRODUCTION

In the book *Educating Engineers: Designing for the Future of the Field*, Sheppard and his colleagues (2009) discussed that today's engineers, like other professionals such as physicians, nurses and lawyers, have to deal with an ever-increasing complexity in their fields of work while considering changing societal needs. The explosion of new information technologies, robotics, biotechnology, and the increased blending of invention with scientific discovery are powerfully affecting everyday life in unexpected ways. For instance, information technologies are not only speeding up communication and information exchanges but also increasing the complexity in how tasks

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are carried out and how business is organized worldwide. Environmental and societal issues require local and global solutions (Feest, 2008), and engineers at work, at the center of all these developments, are frequently challenged to grapple with the ramifying consequences of such rapid innovation (Bugliarello, 2010).

Engineering as a profession has come a long way from the era of Leonardo da Vinci and others when craft and science enjoyed a scared harmony to a widening recognition beyond technologies (Beder, 1999). Every major engineering innovation, from metal making to electronics, has brought changes in society. The development and practice of engineering is affected, in turn, by significant changes in society's goals, customs and expectations (Bugliarello, 2010). This calls increasingly for engineers' moral responsibility: engineering helps to provide basic needs such as water, food, shelter and energy, and does so on the scale necessary for a society to function, but it has also contributed to the huge increase in the destructiveness of weaponry and warfare seen over the centuries. It increases inequality and the global damage that inflicted on the world's ecosystems. As an engineer, it is crucial to understand the dual nature of the profession and to be vigilant regarding the engineer's role with employers, in order to maximize the chances of positive contributions to society. In essence, this is what it means to be a socially responsible engineer (Parkinson, 2010). Some of the important attributes of professional engineers are to have commitment to high standards, appreciation of personal and ethical responsibilities, the ability to handle uncertainty and to communicate effectively (Jones, 2010). Engineers are accountable for the results of their decisions within the context of economic, political, ethical, cultural and environmental issues (Bader, 1999). To cope with the demands and complexities of decision-making processes, engineering educators have to make more efforts to integrate ethics into engineering education. As emphasized by ABET (2007), engineering graduates must have an understanding of professional and ethical responsibility, broad education necessary to understand the impact of engineering solutions in a global and social context, recognition of the need for and ability to engage in life-long learning and knowledge of contemporary issues.

However, this has been ignored to some extent because universities have traditionally concentrated on providing "hard technological knowledge" where the "soft skills" become the "appurtenant" in engineering education. For example, Newberry (2004) surveyed the motivations for thinking about and trends in teaching of ethics in engineering education in the USA. The results indicated systemic barriers that impede the integration of such instruction in the curriculum. These barriers include a lack of emotional engagement with engineering works on the part of the students, which in turn is mainly focused on the technical aspect of the curriculum. Similarly, Sheppard et al. (2009) pointed out that although engineering educators put some efforts to inculcate ethical behaviour in their professional task, they face difficulties due to (1) the institution's role in promoting ethical responsibility and (2) figuring out how to integrate ethics into the engineering program. Thus, Sheppard et al. (2009) argued that designing an undergraduate engineering program for professional practice would enhance the usability of students' knowledge as well as strengthen their understanding about engineering design and other engineering-related skills. Thus understanding ethical codes impacts on professional practices that could lead to the social and ethical dimensions of engineering.

Therefore, with the aims of educating new-century engineers, a series of pedagogical strategies have been proposed by theories and/or explored in practice, such as Cooperative Learning (Richard, Woods, Stice, & Rugarcia, 2000), Problem-Based Learning (PBL) (de Graaff & Kolmos, 2007), Project-Centered Learning, Learning in Labs (Sheppard et al., 2009) and so on. The central emphases of such strategies are not only to acquire