# Chapter 59
# Integrating Sustainable Engineering Principles in Material Science Engineering Education

**Bandita Mainali**
*La Trobe University, Australia*

**John Russell**
*La Trobe University, Australia*

**Joe Petrolito**
*La Trobe University, Australia*

**Daniela Ionescu**
*La Trobe University, Australia*

**Haider Al Abadi**
*La Trobe University, Australia*

## ABSTRACT

*The increasing demands on earth's resources require the need for engineering disciplines to address the limitations of materials and energy as well as the need to reduce waste production. This requirement is particularly acute for material science engineers as their work has a lasting impact on our future sustainability. Recent developments and innovations in material science can be useful tools for achieving sustainable development, provided material science engineers are aware of the issues. They should be particularly aware of global sustainability challenges, and should be able to understand how they can contribute to the solutions of these problems. Therefore, this chapter discusses how sustainable engineering principles can be introduced into material science education. It also discusses the curriculum for the subject Sustainable Infrastructure that is offered at La Trobe University in Victoria (Australia) for senior Civil Engineering students.*

## INTRODUCTION

The Stockholm conference in 1972 highlighted the need for education about the environment and sustainable development (United Nations Environment Programme [UNEP], 1972; Thomas, 2004; Lozano & Lozano, 2014). In 2005, the UN Millennium Ecosystem Assessment was conducted by 1360 experts in 95 nations (Millennium Ecosystem Assessment, 2005). As a result of this assessment, a report was produced according to which there are no longer any scientific doubts that almost

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two thirds of the world's ecosystems are now in serious decline. Environmental and sustainability concerns have therefore become a major focus in today's world, and professional graduates from most technical disciplines must be competent to deal with these complex issues (Russell, Petrolito, & Legge, 2010).

This requirement is particularly acute for material science engineers because advances in technology are intimately linked to the materials that humans can design, manipulate and produce, and this is where the Material Science Engineering (MSE) discipline plays a vital role. As engineering underpins our modern way of life and engineering graduates play a major role in shaping the future, sustainable engineering practice should be given due consideration in undergraduate and graduate engineering courses, and hence it cannot be left as an afterthought or an optional topic. This is especially important since our way of life is directly connected to our abilities to use resources, to process materials and manufacture products, to develop and use non-traditional as well as traditional materials for an increasingly broad range of industries, and to research and develop high-performance materials for applications in the future.

The discipline of MSE is the generation and application of knowledge related to the composition, structure and processing of materials to establish their properties and uses (Claassen & Chynoweth, 1979). Hence, material science engineers have a lasting impact on our future global sustainability. The traditional tool-kit course for prospective young material science engineers is outdated, and the emphasis must now be on equipping students with real-world scenarios in an ever-changing environment so that (i) they can 'hit the ground running' once they gain employment and (ii) they are prepared for future leadership roles in sustainable development. Sustainability science is becoming an important topic in university education under the term "metadiscipline" (Mihelcic et al., 2003). The need to integrate sustainability into diverse academic curricula is essential for providing students with the skills and insights to help societies become more sustainable (Lozano, 2010). Taking these issues into consideration, this chapter discusses ways in which sustainability principles can be incorporated into the MSE curriculum. It also presents a detailed discussion of the curriculum for the subject *Sustainable Infrastructure* that is offered at La Trobe University in Victoria (Australia) for senior Civil Engineering students.

## BACKGROUND

In the early 1970s, a team of researchers lead by Professor Denis Meadows produced a report for the Club of Rome entitled "The Limit to Growth", which predicted a future where industrial production will fall to zero and where the air, land and sea will be polluted beyond redemption (Meadows, Meadows, Randers, & Behrens III, 1972). The report warned about a future created by the unrestrained linear growth of resource exploitation, environmental devastation and the blind march of industrial growth, all of which would contribute to the inevitable calamity. About twenty years later, the sequel to this book, "Beyond the Limits", was also published by the Club of Rome. The authors of the book argued that despite the over-exploitation of many of the world's resources beyond their capacity to regenerate, the catastrophic future is not inevitable (Meadows, Meadows, & Randers, 1992). To avoid this calamity, Samarin (2005) suggested two necessary changes. The first is a comprehensive revision of policies and practices that perpetuate growth in material consumption and population. The second is a drastic increase in the efficiency of the use and consumption of materials. The proper selection of materials and production technologies therefore play a vital role in bringing about these two changes.

Material scientists are responsible for establishing the properties and uses of materials, and hence introducing principles of sustainability