Educating the Sustainability Engineer: Redesigning Curricula

There is a pressing need to graduate new kinds of engineers. These engineers must be competent across four domains – the traditional technical domain of engineering as well as the economic, the environmental and the social and political.

So, you might say, what's changed? Engineers have been dealing with the technical and the economic for the last 5,000 years. However, it wasn't until the 70s and 80s that the environmental domain became an issue. We solved that problem by educating 'environmental engineers', so most branches of engineering simply pretended that it wasn't their problem. In the 21st century, the social dimension is transforming engineering. Will we create 'social engineers' or will we wait for other professions to define the problem for us so that we can bring our technical skills to bear? Will engineering move beyond the technical/economic?

For example, water shortages in cities were once solved by building new dams. In the 70s and 80s, economists challenged this method by asking 'can we reduce usage by pricing the resource more realistically?', that is, by reducing demand. Recognising that half of urban water usage is in the garden (in Australia), people have been encouraged to plant native gardens that use less water (better suited to the local climate). In this century, we have also reduced water usage by educating people to use less. So, solutions are available in all four technical domains: the technical, the economic, the environmental and the social. Engineers need to be skilled in all these areas.

However, when we look at modern engineering curricula, we find them dominated by learning technical skills from 'fundamentals'. Many hours are spent learning to solve mechanics problems from first principles when sophisticated software already exists to do this. We believe that this is essential to understanding. However, the research in concept tests and concept inventories shows that passing our exams does not lead to fundamental understanding. We need to do this differently. There are many more fundamentals that must now be learned, which includes economics, environmental science and social sciences. How will we manage this?

We need different kinds of curricula that allow students to integrate their understanding across the four domains. Teaching these skills in isolation leads to isolated thinking. We already have quite a lot of experience in introducing students to complex problem solving in first year through the Engineers Without Borders Challenge in Australia, and now in New Zealand and the United Kingdom. However, years 2 and 3 are often given over to technical matters and many, perhaps most, students complete final year also entirely focussed on technical skills. This does not graduate engineers ready for work in the 21st century.

Curricula need to combine the complexity of practice with the fundamentals of the supporting sciences in every year and every semester. This engages students through experiential learning where they see the role of theory in helping them

act as better problem solvers. These complex problems will naturally include the four domains discussed above – not necessarily every problem but at least half of them. Students need to learn that engineering is about dealing with complexity and much of the complexity emerges from the social domain. We have already brought much of the technical complexity under our control through software.

Inevitably, students will increasingly use online tutorial systems to learn the fundamentals. These systems will be licensed by universities in the same way that we already license engineering software. Learning at university will be transformed from drafty lecture halls to engineering workshops using sophisticated modelling tools to build prototype solutions to real problems. Students will be actively engaged with communities, interacting with real stakeholders. Anyone who has seen the work of a Formula SAE team knows what this looks like. Given autonomy and a clear sense of purpose they proceed to master both the problem and their disciplinary knowledge. These are the engineers we need for the future.