COPING WITH COMPLEXITY

the ability to manage complex sustainability problems

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Wickedness, complexity and the role of education

In 1987, a commission led by Gro Brundtland identified a number of global issues which might fall within the broad area of sustainability, including:

- the burden of debt in the developing world, inequitable commercial regulations and a growing number of the world's population living at or below subsistence level;
- overuse of nonrenewable resources and growing competition for limited water supplies, threatening armed conflict over access to water and mineral reserves;
- reduction of biodiversity and increasing desertification;
- pollution of air, water and soil with detrimental influences on the global environment and climate change;
- continuing growth of the world's population, coupled with additional economic pressures caused by increased life expectancy;
- increasing nationalistic, political and religious extremism, terrorism, armed conflict, mass migration and social disruption; and
- the threats and consequences of climate change.

At first sight, some of these might appear to have little to do with formal education as it has been experienced until now, but politicians have a particularly short-term view of complex issues and time horizons dictated by the next election. Commercial organizations can be even more short-sighted, with a focus not far beyond the next balance sheet. Resolution and amelioration of complex global problems in the longer term therefore falls to the professions and, through the education of professionals, to educational institutions.

The Brundtland list exemplifies some very complex issues that have not only technological aspects, but economic, political and social aspects as well. The nature of these issues is such that they mostly fall within Horst Rittel and Melvin Webber's definition of *wicked problems* which:

- have no definitive formulation;
- have no clear end, no 'stopping rule';
- have an answer that is 'good or bad' rather than 'right or wrong';
- have no immediate or ultimate test of their resolution;
- have consequences to every solution -– there is no possibility of learning by 'trial and error';
- do not have a well-described set of potential solutions;
- are essentially unique;
- can be a symptom of another problem; and

- have causes with no unique explanation;

Not all of these determinants have to be present for a problem to be *wicked,* but the complex global issues illustrated above demonstrate many of them. How, then, do educational institutions prepare learners to meet these challenges?

Tackling the insoluble

Traditionally we have tended to look at developing 'problem-solving' skills in our learners, but these become irrelevant in the face of the complexity of issues of sustainability and global social responsibility. There appears to have been an increasingly reductionist approach to teaching: subjects have become narrower and more specialised and issues have been reduced and sanitised to make them solvable by learners. This creates the illusion of problem solving but fails to recognise that the approach makes exercises increasingly academic and divorced from reality. But how do we help learners approach real-world problems when they are necessarily complex?

A study into educating engineers for sustainable development (Tomkinson et al 2008) brought out a consensus view that such issues have to be tackled in a systemic way, using learner-centred approaches such as case study, role play and problem-based learning. Collaboration is central, involving small groups where the process of intellectual development is more important than a display of academic brilliance. A key feature identified by a number of leaders in the field is the need for interdisciplinary or inter-professional education. Complexity is best not tackled alone.

Finding a way forward

One approach is to develop problem-based interdisciplinary learning modules (Tomkinson 2009). The key to this approach is developing a range of complex scenarios for which there is no 'right' answer, and facilitating learners to work together on the problems in small, interdisciplinary groups. In terms of scenario design, the important things to consider are that scenarios are:

- topical
- contextual: the scenario is set in a situation that is realistic to the future professional interests of the learners;
- interdisciplinary: this can include disciplines that are not represented amongst the learners;
- integrated: learners become increasingly familiar with different disciplines and gain skills in applying relevant aspects of them to problems;
- complex: the scenario involves aspects of 'wickedness';
- unresolved: the task is not one that has been 'solved' already; and
- cumulative: each scenario builds on the experience of previous ones.

The set of tasks needs time for learners to examine what the problem might be, what experience they can collectively bring to the task, to research specific aspects individually, and bring the knowledge learned back to share with the group. The table below gives some examples of scenarios, drawn from a third-year undergraduate pilot module. In this case the

group was given two weeks to tackle each task, with set meetings at the beginning, middle and end of this period.

Table 1. Examples of problem-based scenarios

Title	Task	Sustainability aspects
Wheels	Recommend sustainable development initiatives for a large tyre manufacturing company, aiming to achieve change within the company through involving different functions within the organisation. A consultant's letter provides a list of existing sustainability tools and projects that learners may decide to investigate and could choose to include in their plan.	Enabling change within an organisation; Sustainability definitions, tools and techniques; Corporate attitudes; Understanding stakeholders' perspectives.
Shelter	Develop a strategy for transitional accommodation (housing, schools, clinics, etc) after a natural disaster. Analyse possible alternative approaches and propose a sound and sustainable strategy for their construction. Achieve a realistic and workable balance between international aid and local skills and manpower.	Enabling change across international and cultural boundaries; Impacts of natural disasters on communities; Stakeholder co-operation; Infrastructure and logistics; Cultural differences; Sustainable design.
Rules	As employees of a Regulatory Body, review the UK's implementation of recent EU directives concerning the electronics manufacturing industry, identifying strengths and weaknesses in minimising the negative life cycle impacts. Predict impacts on small businesses and advise on preparation required for implementation.	Implementing change via regulation; Impact of environmental regulation; Impact on supply chain: Minimising life cycle impacts.
Energy	For new-build housing, weigh up the social, financial and environmental impacts of incorporating micro-energy-generation technologies such as wind-turbines, solar water heating, geothermal heat pump and photovoltaic cells, through an initial cost-benefit analysis taking into account economic, social and environmental issues. Understand the implications of introducing new technology to the marketplace and how to overcome barriers to public acceptance of technical solutions.	Implementing change through new technology; Cost-benefit analysis; Barriers to new technology; Infrastructure support for new technologies.
Shops	Assess the sustainability of a major supermarket chain; evaluating the company against industry good practice in terms of the supply chain sustainability, in response to serious criticism by shareholders. Recommend actions to urgently address the corporate social responsibility issues identified.	Implementing change through company policy driven by investor pressure; Corporate social responsibility; Supply chain management; Assessing sustainability; Benchmarking.

Key elements of the success of exercises such as this are:

- literature search: learners are adequately briefed on information retrieval and reliability of sources;
- group work: learners are involved in setting their own ground rules and ways of working;
- problem recognition: scenarios are written in such a way that groups need to identify for themselves what the 'problem' is, if necessary redefining the problem in the process;
- stakeholder analysis: learners understand who the various players are in the scenario and where their interests lie;
- creative thinking: for some, the use of concept maps (see *Complexity, Systems Thinking and Practice*, this volume), mind maps (Buzan 2006) or 'rich pictures' (Checkland: 1999) may help to clarify the interactions of the various elements of the scenario;
- communication skills: the task may call for a response expressed in a number of different ways appropriate to different intended audiences; and
- feedback: feedback is given promptly to allow for cumulative learning.

Exercises such as this, if well constructed, can contribute significantly to the development of the abilities and skills of lifelong learning and towards becoming skilled change agents.

Conclusions

Gro Brundtland's report has passed its twenty first birthday but the issues it raises are still very relevant today. It is in the nature of *wicked* problems that they never go away; they simply regroup and come back in a new form, just as complex as before. Indeed, some of the issues raised seem to have become even more complex and more entrenched. Learning to tackle these complex, *wicked*, problems is best done as a learner-centred, group-based activity. Use of problem-based scenarios and cross-disciplinary groups can heighten this process. In the academic setting, the assessment of the ability to deal with such issues has to be directly aligned to the learning process. Learning how to use some of the environmental and problem-solving tools could be done in a reductionist, mono-disciplinary way, but the real world is complex and messy and a different approach is necessary in order to manage change and cope with complexity.

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