Metaphors used by some engineering academics in Australia for understanding and explaining sustainability

Anna L. Carew\textsuperscript{a} and Cynthia A. Mitchell\textsuperscript{b}
\textsuperscript{a}University of Wollongong, Australia; \textsuperscript{b}University of Technology, Sydney, Australia

Metaphors can be powerful teaching and learning tools which may help us to understand novel, complex or abstract concepts using familiar language and thought structures. Academics routinely use metaphors in their university teaching to explain new or difficult ideas to students. In this article the authors argue that tertiary teachers’ metaphors for sustainability warrant formal investigation, as they will likely influence the construction and delivery of sustainability curricula. Based on this contention, we conducted in-depth interviews with eight Australian engineering academics which centred around the question ‘What do you mean by sustainability?’. From the interview transcripts, we explicated and described four distinctly different metaphors. These were: sustainability as weaving, sustainability as guarding, sustainability as trading, and sustainability as observing limits. We describe each of the metaphors in detail and speculate on some of the underlying assumptions which underpin them. In conclusion, we advance the idea that sustainability might be taught using an explicit multiplicity of metaphors and that each metaphor would express important aspects of the phenomenon of sustainability. This approach would capitalise on the diversity of existing metaphors in the academy, and could result in curricula which reflect the richness and depth that a variety of perspectives can bring to understanding a complex, abstract, flexible concept like sustainability.

Introduction

Academics as sustainability advocates

The higher education sector has the potential to be an important contributor to current international efforts to address what some perceive as a global ecological and social crisis (Clift, 1998; Wright, 2002). In broad terms, higher education institutions...
have three key roles to play: the operational role, which requires universities to address social inequity and minimise resource consumption resulting from their day-to-day operations; a leadership role, in which universities publicise their working examples of environmentally, socially and economically responsible operation; and the role of advocate, which requires the tertiary sector to equip and inspire individuals to enact sustainability throughout and for the duration of their personal and professional lives (Sharp, 2002; Wright, 2002). The advocacy role was promoted in Chapter 36 of Agenda 21 (United Nations Conference on Environment and Development, 1992) as a call to infuse undergraduate and postgraduate curricula with sustainability principles and practice.

Some professional bodies and tertiary organisations have responded to the need to integrate sustainability into the tertiary curriculum by providing in-principle support (for example, signing declarations and issuing policy statements), commissioning reports and/or promoting case studies of best-practice sustainability teaching and learning at university level. The provision of in-principle support such as signing sustainability declarations could well be seen as creating ‘paper tigers’ or allowing tertiary institutions to garner green credibility without taking effective action towards integrating sustainability into their operations, teaching and learning. While this may be the case in organisations lacking a genuine inclination to pursue sustainability vigorously, such seemingly rhetorical support can lay the groundwork for fundamental reorientation. The Institution of Engineers, Australia (IEAust) provides an example of curricula reorientation toward sustainability that originated from a few key in-principle commitments. The broader significance of the following example is that ‘paper tigers’ may represent the first step in a slow journey of reorientation toward sustainability.

IEAust is Australia’s leading professional body for engineers and administers the accreditation of Australian engineering baccalaureates. In 1994, IEAust made an in-principle commitment to sustainability in two formal documents. The Institution’s Code of Ethics (Institution of Engineers, Australia, 1994a) directed engineers to ‘promote engineering and facilitate its practice for the common good based upon shared values’, which included ethical behaviour, equality of opportunity, social justice and sustainable development. In addition, the Institution’s Policy on Sustainability (Institution of Engineers, Australia, 1994b) required that ‘members, in their practice of engineering, shall act in a manner that accelerates achievement of sustainability’. In 1996, IEAust commissioned a review of engineering education in Australia. The resulting report was called Changing the Culture and contained a raft of recommendations urging the inclusion of sustainability as a core part of the Australian engineers’ formative training.

These in-principle commitments to sustainability were followed by requirements for attention to, or understanding of, sustainability as part of the Generic National Competency Standards (Institution of Engineers, Australia, 1998). These Standards are used to assess engineers seeking chartered membership and registration on the National Professional Engineers Register and the National Engineering Technologists Register. Inclusion of sustainability in the Generic National Competency Standards
signalled an important shift from in-principle support, to a requirement for demonstrated sustainability competence. Furthering the requirement for sustainability competence in their profession, IEAust overhauled the accreditation process for undergraduate degree courses and produced a new, sustainability-rich accreditation process which was implemented in 2000. The new process was outcome focused and mandated all undergraduate students ‘understand sustainability’ as a condition of graduation (Institution of Engineers, Australia, 1999).

The reorientation of engineers’ undergraduate training in Australia is by no means complete as it is not yet clear to what degree and in what spirit the Australian academe will respond to these new requirements. The preceding example, however, illustrates how IEAust’s initial in-principle support for more sustainable practice has developed into a mandatory requirement for sustainability education in all IEAust-accredited undergraduate engineering courses. The example also highlights the pivotal role that will be played by academics and university teachers in championing and delivering sustainability teaching and learning.

The next part of the article opens up this notion of tertiary teachers as champions of sustainability. Specifically, we begin our explorations of how academics’ preconceptions of sustainability will likely influence their construction and delivery of sustainability teaching and learning.

Academic conceptions as formative in curriculum development

Internationally and in Australia, many academics enjoy a high degree of autonomy in the construction, content and delivery of undergraduate teaching and learning. When an Australian academic agrees to teach a subject, they will often have a more-or-less ‘free hand’ to formulate content, delivery and assessment, provided it complies with fairly generic faculty-level and university-level teaching and learning plans. The Student Course Experience Questionnaire provides academics with some feedback on the success of their chosen teaching approach, and the accreditation of some undergraduate degrees by professional bodies provides a certain amount of control over teaching and learning processes. In most cases, however, review for accreditation is at a macro-level (for example, course offerings and resourcing) as opposed to a micro-level (for example, specific content and teaching approaches). This tradition of academic autonomy is particularly pertinent given a growing body of empirical evidence from educational research that supports the notion (self-evident to most academics) that teachers’ existing knowledge and beliefs have substantial influence over their approach to teaching (see, for example, the review by Prosser & Trigwell, 1999, Chapter 7).

As Samuelowicz and Bain’s (1992) review notes, much of the phenomenographic research into the link between existing knowledge and teaching approach has focused on teachers’ conceptions of ‘teaching’ and ‘learning’—in other words, what teachers think it means to teach, or to learn. Such studies have demonstrated that teachers who viewed teaching as imparting or transmitting information (teacher centred) tended to use approaches that resulted in students who had memorised and could regurgitate
content. By way of contrast, teachers whose intention was to generate conceptual change in the learner (student centred) used strategies that resulted in their students adopting deeper approaches to their learning (Trigwell et al., 1999). Martin et al. (2002) extend this research in a small-scale study which examines the relationship between teachers’ conceptions of subject matter and their approach to teaching. They found that teachers’ conceptions of subject matter influenced the approach they took to teaching, in terms of both content (what was taught) and structure (how the content was presented to students). For example, of the two history teachers participating in the study, one of the history teachers viewed history as a range of stories that could be viewed and interpreted from many different perspectives. His approach to teaching involved presenting examples, evidence and problems to the students, engaging them in debate and encouraging critical analysis and interpretation of evidence. The second history teacher saw history as ‘a body of knowledge which students [must come to] know…remember and recount…’. This teacher’s approach was largely focused on giving students material or information for them to internalise and remember.

The review by Samuelowicz and Bain (1992) and the study by Martin et al. (2002) both infer a relationship between the way that academics conceive of learning a particular subject, and the academics’ subsequent approach in teaching that subject. In light of the impetus to infuse tertiary curriculum with sustainability learning, tertiary teachers’ conceptions of sustainability are interesting, pertinent and warrant formal investigation as they will likely influence teachers’ selection of content, choice of structure and delivery of sustainability learning.

An additional motive for investigating and publishing on academics’ conceptions of sustainability is to refute the idea that there might be a singular, generalisable or uniform ‘right way’ to practise sustainable engineering. Several authors have demonstrated that there is not just one but a myriad of different ways of conceptualising sustainability (for example, Gough, 2002; Robèrt, 2002; Scott, 2002; Wright, 2002), and in recent publications we have documented an array of different dimensions of sustainability described in the engineering education literature (Carew & Mitchell, 2001, 2002). We believe this variation in conceptualisations of sustainability reflects the nature of the concept: abstract, complex, incorporating values, contextual and necessarily flexible. For this reason and based on our earlier arguments, we suggest that investigation of the various ways academics construe the term ‘sustainability’ is warranted.

Having focused our attention on the significance of academics’ conceptions of sustainability, we will now explore a means of characterising these conceptions. In the following section we discuss metaphors and the role metaphors may take in explaining and understanding complex, abstract, or novel concepts like sustainability.

Metaphors as characterisations of mental models of sustainability

In the broadest terms, metaphor is the description of one thing in terms of another, and is a familiar device in literature and rhetoric. We, and others, hold that the utility
and influence of metaphor extend well beyond literary flourish. Metaphors are variously seen as: fundamental units of cognition (Lakoff & Johnson, 1980); potentially useful tools for explaining, understanding, constructing and cogitating on new concepts (Lakoff & Johnson, 1980; Kittay, 1991; Haack, 1994; Bowdle & Gentner, 2005); and vehicles for the transmission and enforcement of culture and ideology (Armstrong, 1997; Bowers, 2001).

The notion of metaphor as a fundamental unit of cognition is not new. Haack (1994) describes Plato’s, Sextus’ and Locke’s use of metaphors for conceptualising and communicating philosophical arguments about the nature of reality, scepticism and mind, respectively. She holds that the metaphors used by these authors not only communicate their ideas but also allow their readers to interpret, reformulate and speculate on the philosophical arguments in question.

More applied examples of metaphors as cognitive structures can be drawn from any discipline or field of academic endeavour. Examples include the use of the ‘wave’ metaphor to conceptualise, explain and debate electron functioning (Walach & Römer, 2000); comprehending the structure of the Internet via ‘(spider) web’ or ‘(fishing) net’ metaphors; understanding macroeconomic management in terms of ‘creating a level playing field’; conceptualising psychological dysfunction using machine terminology like ‘breakdown’ (Lakoff & Johnson, 1980); and learning the finer points of legal argument through the metaphor of military strategy (Lakoff & Johnson, 1980). In each of these cases, metaphors allow us to explain, understand and explore complex, abstract or novel concepts using familiar terms and thought structures. In each case, explication and critical examination of the accustomed metaphor have the potential to reveal underlying cultural and ideological assumptions.

Closer to home, this was all illustrated in a recent special issue of *Environmental Education Research* (Volume 11, No. 1, 2005) which explored and critiqued the metaphor of ‘natural capital’ and its role in learning about sustainability. The articles document the formative nature of the metaphor under review by highlighting its various roles in, for example: shaping and framing what is important in terms of environmental learning and responsiveness (Bell, 2005), and supporting exploration and learning about key environmental ideas like *environmental capacity* and *intergenerational stewardship* (Reid, 2005). In the same issue, Gough (2005) discusses a complementary metaphor, that of ‘real options’, and in so doing, raises questions about the value of accessible alternatives to the ‘natural capital’ metaphor for supporting diversification of understanding and action within the broader objective of promoting sustainability.

Returning to our original theme of academics as sustainability advocates, we conclude that the metaphors academics use to explain, understand and explore the concept ‘sustainability’ will likely act as foundations for the development of sustainability curricula. Investigating and documenting some academics’ sustainability metaphors would provide interesting insights into different ways of understanding the concept, and would allow us to speculate on the implications of these different mental models for infusing tertiary education with sustainability learning.
The remainder of this article describes an investigation of some of the metaphors that a group of Australian engineering academics used to describe, explain or discuss conceptions of 'sustainability'.

Method

Exploring academics’ sustainability metaphors through interview

The research under discussion was an exploratory study consisting of semi-structured, one-to-one interviews with eight engineering academics on the topic of sustainability. Each interview was audiotaped and lasted between 45 minutes and 1.5 hours. Subsequently, each academic was allocated a participant identifier and interviews were transcribed. The transcribed interviews constituted the data for this study.

The interview script and procedure for this study were designed to allow the participant as much freedom in discussing and exploring their views of sustainability as possible. Our primary intention was to generate ideas about engineering academics’ schemas and conceptions, rather than to map exhaustively and definitively each academic’s knowledge of sustainability. Each interview opened with the question, ‘What do you mean by sustainability?’ Throughout the interviews, the interviewer attempted to keep the participant on the topic of sustainability, sought clarification for cryptic terms or phrases (for example, environment, resources, quality of life, development) and periodically summarised the participants’ statements to clarify their meaning and generate further explanation. Three follow-up questions on environmental, social and economic aspects of sustainability were used either if the interview stalled, or if the participant did not independently raise the topics during the interview. The follow-up questions were, ‘What do you mean by environmental sustainability?’, ‘What do you mean by social sustainability?’ and ‘What do you mean by economic sustainability?’

Interviews were conducted in September 2000 with eight engineering academics employed in research and teaching at the University of Sydney. It should be noted that the relatively small number of participants emphasises our earlier point that this study was exploratory in nature with the primary objective of generating ideas as opposed to testing a hypothesis or theory (Kvale, 1996). Participation in the study was voluntary and not all of the academics approached agreed to be involved. The group of academics who participated was representative of the academic complement in terms of seniority, gender and cultural background.

Conducting the metaphor analysis

We employed metaphor analysis to identify some of the structural analogues the participants used to understand and explain the concept of sustainability. During the metaphor analysis, the analyst read and reread the transcripts looking for obvious examples of both implicit (Lakoff & Johnson, 1980) and generative metaphors (Schön, 1983). The term ‘implicit metaphors’ comes out of a more linguistic research
framework and we use it to mean those situations in which the phenomenon is described using terminology from another domain (for example, describing teamwork using the language of sport). Munby (1986) and Martin et al. (2001) offer worked examples of analysis for implicit metaphor. We use the term ‘generative metaphors’ to mean those metaphors in which a phenomenon is described directly in terms of another phenomenon (for example, ‘the human body is a machine’). Bowdle and Gentner (2005) describe two functions of generative metaphors: comparison (where interpretation of the metaphor is effected through feature matching between target and base) and categorisation (where the properties of the metaphoric base category are attributed to the target concept, in this case, sustainability). We looked for both of these functional generative metaphor types in our analysis as there is some evidence that as metaphors for a relatively novel target concept (like sustainability) become normative, there is a shift from using metaphor for comparison, toward using metaphor for categorisation. Given that we were unsure of the participants’ level of familiarity with the target concept, and given the exploratory nature of the study, we felt analysis for a broad scope of metaphor types was appropriate. During analysis, quotations from the transcripts that illustrated metaphors or metaphor fragments were identified for inclusion in the results section.

Results

Four qualitatively distinct metaphors were apparent in the interview transcripts and we describe them below. For each of these metaphors, there was at least one academic who used the metaphor consistently and almost exclusively in describing what they meant by sustainability. The remaining four academics either used incomplete versions of these metaphors to describe sustainability, incomplete or cryptic alternative metaphors, or a mixture of all or some of these four and alternative metaphors. A few of the academics explicitly described sustainability as being about continuity or longevity and we take this as an assumption implicit in all four metaphors. The four metaphors we identified were: sustainability as weaving, sustainability as guarding, sustainability as trading, and sustainability as observing limits. There was a degree of overlap in the content of these metaphors; however, each metaphor implied intrinsically different sustainability schemas, with distinct underpinning assumptions, governing principles, foci and approaches to the implementation of sustainability. We illustrate these in the following, along with each metaphor’s links to the wider literature.

Sustainability as weaving

In describing sustainability using the metaphor of weaving, the academics in this study employed both generative metaphors (‘to actually weave the fabric of society’) and implicit metaphors through the use of terms such as: integration, relate things together, inter-linked, connected, interact and attached to. We take this metaphor to mean that these academics view sustainability as drawing disparate elements together to
create a cohesive but flexible whole. It includes a strong focus on the context in which sustainability is to be enacted with an emphasis on understanding the disparate elements before weaving sustainable solutions (‘breaking them into bits and pieces so that we can study them better and make them more sustainable’). Those who used this metaphor perceived sustainable outcomes to be those based on a broad view (broadening, wider view, more varied perspective, awareness, looking at other things) and mediated by feedback from society (community values, looking at what society requires, serve society, social feedback, social control).

This metaphor rests on a number of assumptions. It suggests that cohesion and flexibility are the primary objectives of sustainability, and while there is some support for this idea in the literature, dissenting authors question the practicality of attempting to operationalise these objectives in technical decision-making. Sustainability as weaving also implies that sustainability is a continuous as opposed to a discrete process, and one which is closely allied with the social contract model of professionalism. The social contract model requires that professionals give the needs of society precedence over other interests (for example, company loyalty or personal remuneration) (Taylor, 1995). Additionally, the strong focus on context embodied in this metaphor is reminiscent of Franklin’s notion of holistic versus prescriptive technology (Franklin, 1999). The term ‘holistic technology’ describes processes (not what is done but how it is done) that allow latitude for judgement, tailoring solutions to each unique situation and adaptation to changing context.

**Sustainability as guarding**

Some academics described sustainability using the metaphor of guarding. In this metaphor, sustainability was about guarding and apportioning exploitable resources and waste sinks to ensure they were not depleted too rapidly and/or were distributed equitably. One academic used a generative guarding metaphor to describe the engineer’s role for sustainability thus: ‘[They’re] the guardians of the playpen. They are the ones who have to make sure the playpen is there, that other kids don’t wreck the playpen’. Those transcripts in which the guarding metaphor was implicit appeared to prescribe centralised management as a key part of sustainability (control, manage, economic incentives, guard, legislation, environmental protection) and a requirement for rational bases for decision-making (objective decisions, objectivity, quantified, rational manner, concrete). The metaphor featured the frequent use of the following terms in reference to resources: depleting, replace, taking out, limited, borrowed from the future and access. A sense of techno-optimism pervaded the conceptual schemas of the academics who described sustainability as guarding. This manifested in statements about minimising waste (‘finding better methods to deal with it’), finding alternatives to limited resources (replacing the resource, good alternatives) and doubts about limitation of some resources (infinite quantities).

This metaphor focuses heavily on the resource conservation aspect of sustainability and appears to contain implicit assumptions about control of resources and the commodification of nature. These assumptions relate to who should control
resources (expert guardianship and centralised control), how decisions should be made about resource use and allocation (objective decision-making) and what are appropriate responses to resource depletion (strong focus on techno-centric solutions). The metaphor echoes Franklin’s notion of prescriptive technology (1999), which describes processes with an emphasis on precision, discipline, organisation and command. It is a model of process founded on external control and internal compliance. The assumptions that underpin the sustainability as guarding metaphor sit fairly comfortably with traditional engineering practice in terms of expert decision-making (Taylor, 2002). In essence, the traditional view is that objective experts equipped with technical knowledge are the appropriate people to initiate, control and monitor use of resources. The literature suggests, however, that this view of decision-making may conflict with the concept of inclusivity in decision-making processes that is prescribed by some sustainability commentators (Clift, 1998).

**Sustainability as trading**

Academics who used a metaphor of trading described sustainability as a process of quantifying the costs and benefits of a decision in order to trade them off against each other. With a trading metaphor, sustainability results in winners and losers. For example, one academic described sustainability, in part, as ‘there has to be winners and losers in a given situation. The [winner’s] benefits...can somehow be used to compensate those who lose’. Those academics using the trading metaphor sought valid metrics (evaluate, economic arguments, measure, real value, logic, decision framework, analysis, real costs) for assessing costs and benefits as a basis for sustainable decisions. One academic, however, used the term subjective valuation, which appeared to marry quantitative and qualitative metrics. Those who used the trading metaphor often referred to the need to work with complex and uncertain systems (no single objective, simultaneous objectives, multiple criteria). Interestingly, the motivation underpinning the trading metaphor appeared to be that of promoting human well-being and social justice (equity, quality of life, collective, values sets, impacted, rights of the individual, compensate, common goods).

This metaphor had a strong emphasis on quantification, and on winning and losing. Lakoff and Johnson (1980) identified win/lose outcome descriptions as closely allied with the war metaphor, which structures phenomena in terms of conflict and conquest, and tends to mask options like conciliation or compromise. Argyris and Schön (1974) critiqued the win/lose set of assumptions, and described the win/lose paradigm as culturally mediated. They proposed different outcome assumptions that spawned the ‘win–win’ management philosophy popularised by Handy (1990). The trading metaphor for sustainability seems to seek rational and quantitative methods to contend with the uncertainty and inherent unpredictability of complex systems. Franklin (1999) questions the compatibility of such a ‘production approach’ with the consideration of externalities and context. Another interesting aspect of this metaphor is its social justice motivation. This raises the relationship between the trading metaphor and the literature on gender and minority group preferences in learning.
about engineering. While the conflict approach indicated by the win/lose part of this metaphor could discourage the engagement of female and minority students, some would predict the social justice motivation could have the opposite effect (Lewis et al., 1999).

**Sustainability as observing limits**

A fourth metaphor apparent in the interview transcripts was that of sustainability as understanding the existence of systems and system limits, and included a hierarchy in applying or observing those limits. This metaphor was described thus: ‘sustainability is about acknowledging that there are limits and that there is an order in which those limits ought to be observed’. It was characterised by the frequent use of terms like limits, hierarchy, system limit, ultimate bounds, contain, capacity and surround. The schema identified the biosphere as the ultimate limit and included a strong sense of interaction within and between systems and subsystems (feedback, balance, cycling, interaction, connected, capacity for exchange). According to the academics using this metaphor, an adjustment in information gathering, which de-emphasised traditional economic valuation, was required for sustainable decision outcomes; this involved bringing ‘things into focus which were not necessarily in focus before. You bring things out of the background and into the foreground’.

The metaphor of sustainability as observing limits prescribes alternative processes for informing decision-making and mandates the use of a hierarchy of limits. It was not clear from the interviews how such a hierarchy would be determined or applied in practice, apart from that the ultimate level of the hierarchy sat at the ecosystem or biosphere system boundary. This metaphor also stood in marked contrast with the preceding three in that it was not oriented towards the protection or promotion of human well-being, but rather called for bio-centric containment and restraint. This finding highlights a schism between anthropocentric and bio-centric views of sustainability. This schism manifests in engineering as a point of tension between the stated anthropocentric object of engineering practice (Institution of Engineers, Australia, 1994) and the greater emphasis on ecosystem-wide decision-making prescribed in some of the literature on sustainable engineering (Carew & Mitchell, 2001).

**Discussion**

**Some implications of our findings**

Our metaphor analysis indicates how some engineering academics may structure their knowledge and beliefs about sustainability into manageable, explicable schemas. We described four distinctly different metaphors for sustainability (weaving, guarding, trading and observing limits) and discussed some of the assumptions and shortcomings peculiar to each metaphor. Given the scale of our study (eight engineering academics participated), the explication of four distinct metaphors for sustainability suggests two things: there appears to be substantial variation in the way that engineering academics
(and probably academics in general) conceive of sustainability; and it is likely that there are many other metaphors for sustainability that are in use in the academe besides the four we described.

Our findings raise questions about the development of sustainability curricula in Australian engineering faculties and in tertiary institutions generally. As we discussed earlier, many academics are largely autonomous in the construction, delivery and assessment of undergraduate coursework, and their conceptions of sustainability are likely to be the basis for construction of teaching and learning. So, the range of metaphors we identified suggests that the sustainability content and approaches to teaching of academics who understand sustainability through these (or other metaphors) would likely be quite idiosyncratic or distinctive. When we consider the metaphors we identified as potential frameworks for teaching undergraduates about sustainability, we may ask:

- How might these various metaphors for sustainability serve as foundations upon which to build professional practice?
- What would be the outcome of the next generation of leaders and decision-makers applying these models of sustainability in their chosen fields?
- How could we teach and/or apply these (or alternative) sustainability metaphors within currently existing institutional structures in universities, industry and professional bodies?
- Specifically for Australian engineers, how do these metaphors complement the kind of sustainability that IEAust has mandated engineering undergraduates must understand prior to graduation? and
- How might the existence of an array of sustainability conceptions enrich sustainability teaching and learning at tertiary institutions?

This exploratory study also raises questions and offers ideas on the role that metaphor analysis might play in investigating and documenting the meanings and potential actions that individuals might ascribe to sustainability. For example:

- Given the idea that the role and use of metaphor may shift as concepts become normative, has the debate on sustainability made this shift? Given that individual values bases inform understanding of sustainability, will the concept become normative?
- Are there alternative metaphors for sustainability (other than those discussed in this study) that would be more effective in developing broader environmental, social or economic consciousness?

These are big questions that lend themselves to extensive consideration. So, rather than seek to answer all of them, we will focus on one: viewing the existence of multiple metaphors for sustainability as an opportunity to enrich tertiary teaching. In the following section we offer an argument in favour of presenting sustainability to our undergraduate engineers using not one but a multiplicity of metaphors. There are many aspects of the following argument that apply equally to teaching sustainability at undergraduate level across the breadth of academic disciplines.
Why use a multiplicity of metaphors?

Metaphors have the advantage of making new concepts accessible through the use of pre-existing understanding. There are, however, disadvantages to their use. One of these is that a metaphor can only offer a partial representation of a new phenomenon (Lakoff & Johnson, 1980; Franklin, 1999). As a partial representation, the salient features of the metaphor may be misconstrued or misunderstood. This can happen because the metaphor:

- is usually an abbreviated version of the phenomenon and, as a consequence, some of the less important (from the metaphor user’s perspective) aspects of the phenomenon are selectively excluded;
- may distort some aspects of the new phenomenon either through over-extension of the metaphor (for example, when the ‘human body as a machine’ metaphor is over-extended it suggests a high degree of repair-ability and constant uniform function, and denies spiritual and psychological dimensions of performance) or through disproportionate emphasis on some aspects of a phenomenon and de-emphasis of others (for example, verbal disagreement viewed through the metaphor of ‘a battle to be won’ de-emphasises the use of empathy and compromise); and
- may contain implicit assumptions that will be projected onto the new phenomenon (for example, the metaphor ‘time is money’ rests on the assumption that time is a valuable commodity. Lakoff and Johnson (1980) point out that this assumption is not ubiquitous across cultures but rather, a legacy of industrialisation).

In the study under discussion we identified and explored four of the sustainability metaphors used by our engineering academics. It is apparent that while each metaphor delivers a considered and insightful perspective on sustainability, not one of these metaphors offers an uncontestable, definitive or ideal sustainability schema. We believe this is because there is no such thing as an ideal schema of sustainability; rather sustainability is a complex, abstract phenomenon that needs to be viewed from a multitude of different perspectives (Mitchell & Baillie, 1998) and with regard to the specific context in which it is being applied. Our primary argument in the face of these findings is that exposing our students to a variety of mental models of sustainability could give these future engineers the flexibility to respond appropriately to a wide array of professional contexts or problems calling for consideration of sustainability. In other words, we believe sustainable engineering might well be taught using a multiplicity of metaphors.

Some of the advantages of understanding a phenomenon through the use of more than one metaphor were recognised and formalised by physicist and philosopher Nils Bohr (1958). Bohr’s Complementarity Principle remains one of the fundamental principles of quantum physics and was based on the coexistence of two empirically valid but incompatible models describing the nature of electrons. Electrons have consistently been demonstrated to behave as discrete entities (particles) in one experimental context, and as continuous entities (waves) in another experimental context. Bohr held that these two models (or metaphors) for electron function were not only
valid, but both were necessary to generate a complete understanding of electron function ‘in the sense that each one of them expresses important aspects of the phenomena of light’ (translation by Walach & Römer, 2000, p. 223). Bohr later extended the principle of complementarity to describe a broad range of situations in which pairs of incompatible concepts were used to describe one fact or event (Walach & Römer, 2000). The principle of complementarity and our earlier discussion of the shortcomings of metaphors would suggest that using a range of metaphors for teaching sustainability would allow our engineering academics and their students greater insights into the nature of sustainability than would the use of a single metaphor. Each metaphor would express important aspects of the phenomenon of sustainability.

Implementing a multi-metaphor approach in sustainability teaching and learning could start with a process of making participating academics’ mental models of sustainability explicit. This first step would consist of recognising, describing and exploring the similarities and differences between the ways that participating academics conceived of sustainability. In this process, a divergence of conceptions would be viewed as a strength which provides multiple perspectives for explaining, understanding and applying sustainability. Next, the resulting array of metaphors, schemas or conceptions could be incorporated into teaching and learning activities to be trialled in the classroom. An important part of taking a multi-metaphor approach would be communicating its rationale and benefits to students who might otherwise experience diverse conceptions of sustainability as a source of confusion.

We believe that an explicit multi-metaphor approach to teaching sustainability would capitalise on the diversity of existing metaphors within the academe. This approach could result in curricula that reflect the richness and depth that a variety of perspectives can bring to understanding a novel, complex, abstract concept like sustainability. Furthermore, acquaintance with an array of mental models for sustainability could equip our students with the skills, knowledge and flexibility to enact sustainability in whatever complex, diverse or uncertain problems their future professional lives present.

Acknowledgements

We extend our sincere thanks to the academics who generously shared their views on sustainability for this study.

Notes on contributors

Anna L. Carew is a Lecturer in Educational Development at the University of Wollongong, Australia. She works with academics to improve the quality of teaching within the university generally, and in the discipline of engineering, particularly. Her research focus is transdisciplinarity; teaching, learning and researching across the disciplines to solve consequential social and environmental problems. Prior to commencing at Wollongong, Anna completed her doctorate in engineering
education at the University of Sydney, and worked as a researcher and consultant with the Institute for Sustainable Futures, Sydney, Australia.

Cynthia A. Mitchell is a principal research fellow and Director of Postgraduate Studies at the Institute for Sustainable Futures, University of Technology, Sydney, Australia. Her work at the Institute focuses on sustainable urban form and buildings, learning and education for sustainability, sustainable energy provision and sustainable water service provision. Cynthia was previously a Senior Lecturer in the Department of Chemical Engineering at the University of Sydney and President of the Australasian Association of Engineering Education.

References


