

## **Educating for urban sustainability: a transdisciplinary approach**

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### **ABSTRACT**

Various approaches to life cycle assessment (LCA) have been developed and are increasingly being adopted in order to quantify the human footprint on the planet in terms of urban development. Very often these techniques are intended for different constituencies and are therefore less than ideal when approached by others not familiar with their focus. Furthermore the most mature LCA tools have been developed for use in the built environment and are not intended for use elsewhere. Unfortunately, a mass of design and production decisions that impact upon sustainability are made outside of this domain, and are poorly served both in terms of a shared understanding of the concepts and dedicated LCA tools: similar patterns can be found in the professional training provided by tertiary education. A novel approach to overcome this deficit is being pioneered by the School of Architecture and Built Environment at the University of Newcastle in Australia, where undergraduate architects, industrial designers, design and technology teachers, facilities managers and construction managers are developing a transdisciplinary understanding of sustainability issues as an integrated part of design through the use of learning contracts. This paper details the resultant holistic, multi-criteria problem-solving course design, and the experiences of staff and students who have previously experienced such an approach, highlighting the beneficial outcomes of developing a transdisciplinary, shared understanding of sustainability in the constructed environment.

**Key words:** life-cycle analysis, design process, transdisciplinary, learning contract.

## INTRODUCTION

The concept of design for the environment has become increasingly important over the last 15 years, moving beyond being simply regarded as a technical activity where the suitability of materials, energy, and life cycle issues were documented. Contributing to a sustainable future is not simply a matter of being earnest and worthy. Rather it has become recognised that designing artifacts that contribute to a more sustainable future is fast becoming as ubiquitous as quality assurance was in the 1990s. In a world where discerning clients insist upon environmental accountability in their suppliers (Brezet and van Hemel, 1997) many businesses are now finding that these practices are profitable, providing them with competitive advantage (Stevens, 2001a). As supply chain concepts move away from the esoteric and assume a role centre stage those charged with manufacturing and constructing the built environment find that "green" supply chain relationships with suppliers, and with customers through "green" marketing have become key elements of their business strategy. However, the limitations on sustainable urban development are defined by the level of creativity displayed by designers (Stevens, 2001b).

The process of education and training is central to shaping the thought processes and attitudes of the next generation of designers and educators. In order to produce a sustainable future it is necessary to produce "sustainable" designers, for whom eco/green/sustainable thinking is second nature, and provides the context within which they exercise their creativity in order to produce profitability (Stevens, 2001b).

Recent thinking suggests that the best sustainable design arises from a multidisciplinary approach (Stauffer, 2006). Levett-Therivel (2004) emphasise the importance of multidisciplinary in the development of sustainability tools and metrics. Stewart Walker (2002) suggests that this represents a paradigm shift, breaking down the traditional silo mentality fostered by the notion of 'professionalism of design', saying,

"By contrast sustainability points towards approaches that are holistic and more inclusive.... the narrowing of our understandings into a specific discipline and within the boundaries of a specific 'profession' is not consistent with the integrative, interdisciplinary or trans-disciplinary, experimental approaches that are needed here."

Whilst it might be somewhat ambitious to expect undergraduate degree programmes to abandon their programme boundaries in order to embrace multidisciplinary approach to sustainability, it is not unreasonable for students from several disciplines to come together in order to learn about the design and the environment, in particular to develop a shared understanding of the links between design decisions and the environmental consequences further down the line.

## PROBLEM CONTEXT

At the University of Newcastle, Australia a number of recent administrative changes and the restructuring of programmes have created a situation where the development and delivery of a course entitled "Design and the Environment" is to be delivered to a multidisciplinary cohort of students. This includes design and technology teachers, industrial designers, architects and construction managers. The cohort consists of both full-time on-campus students and others as distance learners at diverse remote locations. The course is a core component in the Bachelor of Technical Education degree programme, and is being increasingly selected as an elective course by students from the other disciplines mentioned (as well as from elsewhere in the University).

The triggers for the development of a new course were:

- A change in the staffing of the course that introduced a built environment perspective to the delivery of sustainability concepts.
- The increasing numbers of students from other disciplines taking the course as an elective, indicating the desirability of transdisciplinarity.
- The need to deliver the programme to remote distance learning students.

The course redesign was underpinned by a number of key principles that were articulated thus:

- The role of the designer should be pivotal in shaping not only the instant appeal or otherwise of an artefact but also the long-term costs and consequences of owning and operating it, both for the owner/user and for the wider community.
- It should be possible for members of a discipline to identify appropriate boundaries to design problems associated with their discipline. This should include the nature of the environmental impacts, their assessment, and the generation of design alternatives that will minimise them.
- The accepted norms for one discipline can reasonably be expected to differ somewhat from those of another discipline.

This last point threw up a challenge to the course designers. In the past it had been the case that all students who took the course as an elective would be expected to adopt the norms of the group for whom it was a core element of their programme, in this case the design and technology teachers, with their emphasis on product/manufacturing design. However the increasing acceptance of holistic approaches to problem-solving within science and society suggested that the development of a generic, transdisciplinary understanding of sustainable design would be desirable.

Issues associated with developing a generic template of sustainable design for the

multiple disciplines within the cohort included:

- The attitudes and expectations of clients for their services,
- The availability and nature of decision support tools to assist them during the design process, and
- The acceptance by the end users (who might be different from their clients) of their designs and the consequences of their design decisions.

One of the first issues the staff and students would face would be the extent to which it is cost-effective or indeed even feasible to conduct an accurate assessment of the life cycle costs -- this would depend to a considerable extent upon the availability of published data regarding the materials being used. This in turn would reflect the relative maturity of research being conducted in each of the disciplines.

Another issue would be differences in the nature of the artifacts generated by the students for assessment, again being influenced by the prior experiences and expectations of the various student groups within the cohort. Product designers might wish to concentrate on producing a full-size model or even a working prototype, whereas those working in the built environment would tend to prefer to generate a documented, graphical model of a building.

In summary, the new course would have to produce environmental generalists who shared a common understanding of what it means to be an environmentally aware designer, whilst continuing to address the range of discipline-specific constraints. It was quickly recognised that forcing the entire cohort to study a compromise range of material and to undertake an assessment that was tailored to no specific group's needs would be sub-optimal in terms of the new course aims, and both frustrating and disheartening for the students, who might question the relevance of much that they were studying.

### **ASSESSMENT DRIVING LEARNING: THE CASE FOR LEARNING CONTRACTS**

It has become axiomatic to say that assessment drives learning (Hedberg and Corrent-Agostinho, 2000), and this is reflected in the design of undergraduate programmes in the School of Architecture and Built Environment at the University of Newcastle in Australia, where Problem Based Learning is widely used across the disciplines of architecture, construction management and industrial design. Whilst each programme uses unique assessment strategies they all embrace constructivist theory, encouraging each student to create their own knowledge as they solve complex problems (Savery and Duffy, 1994), thus empowering the students to take charge of their own learning.

However, students from other Faculties are more often used to a traditional programme structure where the individual courses are based upon content delivery,

placing the course lecturer in the position of “knowledge director”, thereby assuming responsibility for the students’ learning (Knowles, 1986). In a course where the majority of the students are used to this model of delivery and yet the deliverers are firmly constructivist the challenge becomes one of finding an assessment mechanism that drives student learning and knowledge creation, whilst concurrently telegraphing its professional relevance.

It was realised that by using careful course design, particularly in relation to assessment mechanisms, it would be possible to accommodate a wide range of different students needs, fulfil the course aims and objectives, and provide a strong motivation for the students to engage with the subject matter and take ownership of their learning.

Learning contracts have long been recognised as a mechanism by which students can be empowered to take command of their own learning, negotiating a range of matters including topics to be covered, criteria for assessment, and the nature of their assessment product (Knowles, 1986). Yet the strong didactic teaching tradition within professional education has dampened their adoption despite the obvious multidisciplinary of the technological domain. Consequently the use of Learning Contracts in the context of professional education has tended to be limited to postgraduate courses and self-directed Continuous Professional Development (Williams and Williams, 1999).

This School had considerable experience of using learning contracts in design courses. Their introduction was in response to student feedback, and their use met with an enthusiastic response (Williams and Williams, 1999). The learning contracts were based upon the principles set out by Knowles (1986) and involved students negotiating:

- Their learning goals
- The nature of the evidence to be generated by them
- The means and standards by which their work would be assessed

Such a mechanism was proposed for the course “Design and the Environment”.

### **EVALUATION OF PROPOSED CHANGES**

The course redesign was informed by student evaluation of other design courses that utilised learning contracts (Williams and Williams, 1999), and of the predecessor course, which had trialed a transdisciplinary approach to the environmental evaluation of artefacts.

#### **The use of learning contracts. (Williams and Williams, 1999)**

The qualitative feedback collected from students at the conclusion of their contracts

was analysed and the major themes summarised thus:

#### *Flexibility*

The majority of students commented positively about the flexibility this methodology provides them in organizing their subject content and learning activities. Students eventually, although not always initially, appreciate the control this provides in developing their course work in collaboration with the lecturer rather than having specified tasks given to them.

#### *Learning Needs*

Students perceive this methodology as meeting their learning needs, being able to reflect on their learning experiences and identify what learning has taken place, as well as being able to identify the skills and knowledge they have acquired.

#### *Confidence to Explore New Areas*

The majority of students commented on the confidence they gained in confronting new technological areas. Because they are setting the learning agenda, they seem to be less intimidated about moving into new content and skills areas. The contract negotiation period allows them to organize the approach of the study into this new or unfamiliar content.

#### *Awareness of Learning Accomplishments*

An important aspect of student-centred learning is that the student is provided opportunity to reflect on the learning experience. The learning contract provides opportunity for this reflection to occur with students developing their own objectives and participating in the development of the assessment criteria. Students are clearly able to identify their learning accomplishments.

#### *Preferred Methodology*

An evaluation of students after 3 years in the programme indicated that many students could clearly identify that the learning contracts were the preferred learning methodology experienced during their course.

### **Transdisciplinary environmental evaluation**

A combination of qualitative and quantitative feedback collected from the student evaluation of course/teaching was analysed and the major findings/themes presented thus:

#### *Life cycle analysis*

Qualitative feedback indicated that life cycle analysis was recognised as both relevant and underrepresented in the students prior experience. There was clear indication that many students felt that future cohorts should be given greater freedom in both project selection and approaches to life cycle analysis, supported by

appropriate resources.

#### *Environmental impact of design decisions*

There was overwhelming qualitative and quantitative evidence that the students valued this approach to design for the environment. On a Likert scale where 1) indicated strong disagreement and 5) indicated strong agreement with the statement "this course has increased my understanding of the environmental impact of product design decisions" the class responded with a mean value of 4.4 (S. D. 0.493).

### **COURSE DESIGN**

An unspoken objective for this course was the desire to make the student a "better", more environmentally conscious professional, an attribute which the students might not necessarily have regarded as being of great importance. The course designers recognised that when students learned something of their own volition (as opposed to rehearsing something and repeating it) they tended to be highly self-directed (Tough, 1979), and because they experienced the consequences of exercising their own initiative their learning tended to be deeper and more permanent (Brockett and Hiemstra, 1991). Whilst it would be considered perfectly normal and acceptable for an individual to develop their own learning in respect of personal interests in an ad hoc fashion, the needs and expectations of awarding and accrediting bodies would always be taken into account where the purpose of learning was to improve the individual's competence to perform a job or in a profession. It was established that learning contracts provided a mechanism by which internal motivations of the learner and the external needs and expectations of society could be reconciled.

The starting point for developing a learning contract would be to refer to the specifications or competences that had to be exhibited by an excellent practitioner or professional. These would have previously been articulated by the professions, and interpreted/contextualised by the learning institution, usually in the form of a course outline, which itself had been aligned with the graduate skills profile for the programme to which the course contributed. Each student would then be required to conduct a learning needs analysis, identifying the extent of their prior knowledge in the field, knowledge gaps, and a clear understanding of the level of performance they would want to attain in respect of those competences upon completion of the course.

Armed with this knowledge the student would then be in a position to document their strategies for reaching their learning objectives in a learning contract. These would relate to the issues previously identified as falling short of optimal. The specifications would describe what the student intended to *learn by the end of the course* (as evinced in assessable outcomes), as opposed to the activities they intended to *do during the course* (which would appear in the Project Plan). They would be described in terms that were meaningful to the student e.g. content acquisition, skills,

exit traits, etc.

It was recognised that the course cohort in any given year would be multidisciplinary, and that the most desirable outcome for the students would be to develop a transdisciplinary understanding of designing for the environment. This would require an assessment regime that was very adaptable. In keeping with the previous course the assessment item would be either a model or a prototype of an artifact that had been designed and developed from first principles to reflect current environmental issues. However, in a departure from the old course, the project context would be chosen by the student rather than the staff.

In order to accommodate the wide variety of student projects the definition of a model needed to be extended to include graphical and virtual models where their use could be justified in terms of time and resource constraints. An example of this would be where an architecture student might want to design a building that incorporated certain green/sustainable concepts -- this would require drawings or virtual models that described the building in sufficient detail to conduct some sort of environmental/energy/lifecycle audit.

Again, in keeping with good design practice, it was decided that the design solution would have to be supported by documentation that articulated the problem-solving processes leading to it, including a reflective component that evaluated process selection, decision-making, and the eventual product.

Having been exposed to the requirements of the course, and having received an intensive overview of the key concepts to be assessed, the students would now be in a position to document their learning goals using a learning contracts pro forma (Figure 1). This would typically be completed by the end of week two of the course.

As the design developed over time it was deemed appropriate that the students be given the opportunity to obtain interim feedback on their progress towards an eventual solution. To this end the students would produce a progress report that they would present at a seminar, at which both their peers and the lecturing staff would be able to critique their approach. In particular this presentation would provide an opportunity to highlight the integrated nature of the design process and environmental thinking in terms of energy consumption, resource depletion, and waste management issues. A "cradle to cradle" approach to design would be encouraged that reflected its position in the hierarchy of desirable end use of redundant artifacts (Figure 2).



IDEA2461 Design and the environment.					
Student name			Student number		
<i>Insert name</i>			<i>Insert number</i>		
Assessment item	Item specification (negotiated)	Item weighting (negotiated, insert value)	Item rubric grade (x/100)	Final item grade (cols 3x4)	Item rubric
Project plan	<i>Insert description(s)</i>	5 – 10%			<a href="#">Hyperlink</a>
Project model/prototype	<i>Insert description(s)</i>	10 – 40%			<a href="#">Hyperlink</a>
Project documentation	<i>Insert description(s)</i>	10 – 40%			<a href="#">Hyperlink</a>
Evaluation/reflection	<i>Insert description(s)</i>	10 – 20%			<a href="#">Hyperlink</a>
Seminar presentation	<i>Insert description(s)</i>	20%			<a href="#">Hyperlink</a>
			Final course grade	<i>Insert grade</i>	
<b>The terms of this learning contract have been agreed upon for completion by:</b>					
Completion date	<i>Insert date</i>				
Student name	<i>Insert name</i>	Signature		Date	<i>Insert date</i>
Course coordinator	<i>Insert name</i>	Signature		Date	<i>Insert date</i>

Figure 1. Learning Contract

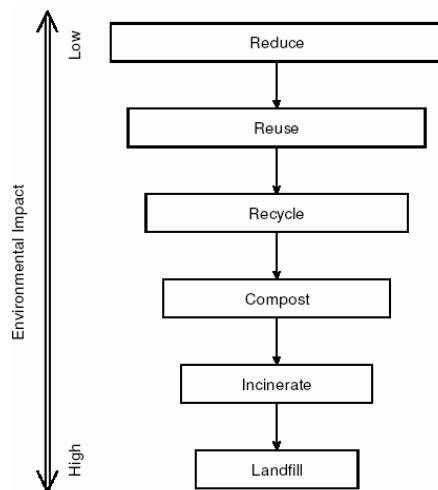


Figure 2: Hierarchy of waste disposal (Peng, Scorpio and Kibert 1997)

The course designers recognised that environmental auditing of designs could take many forms, some of which would be more rigorous than others. It was decided that the students should be encouraged to explore ways in which to give public legitimacy to their design decisions. The use of published data and, wherever possible, reference to existing design tools would be encouraged and rewarded. In particular the issues of embodied energy and life cycle costing would be emphasised as desirable components in their documentation.

The inevitable consequence of this decision was that the students should be exposed to a transdisciplinary tranche of approaches to environmental impact analysis (see Table 1). Their selection of an appropriate approach thereafter would be based on a mixture of understanding, suitability and pragmatism.

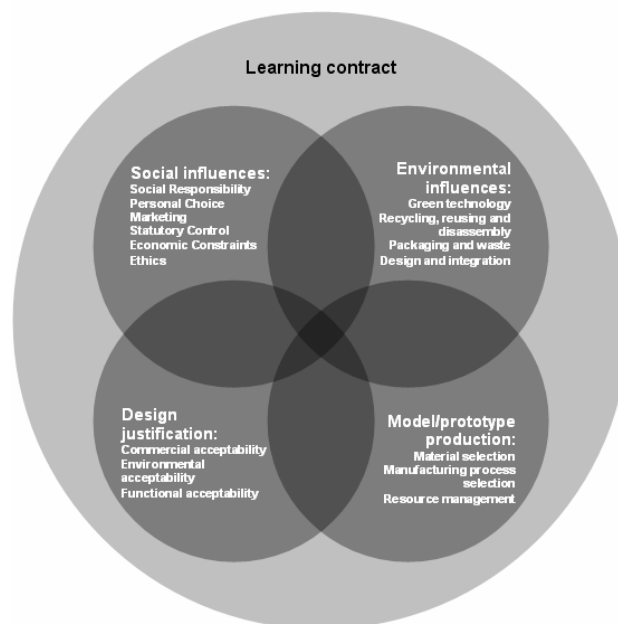
Analysis tool	Country of origin	Attributes
Environmental Priorities Strategy	Sweden	Environmental load indices applied to processes and materials. Generates results in environmental load units/societal costs
BUWAL critical flow model	Switzerland	Relates material and process emissions to maximum allowable emission per unit area impacted by the product. Tends to concentrate on airborne pollutants.
Eco-Indicator 95 model	Holland	Software-based. Calculates pollution values by material and process. These individual values are then adjusted for effect using a correlation factor and combined to give a single figure for the impact of the process chain.
Material grouping LCA	Australia	Analysis based upon simplified groups of materials commonly used in manufactured products, known as life cycle inventory, based upon known published data for each of the materials groups.. Sacrifices detail for usability
LEED	USA	Rating system for built assets based upon design attributes, on-site tests and verification of "as built" attributes, conducted by certified raters. Provides a simple, multi-tier rating as to a building's sustainability.
BREEAM	UK	Environmental rating system for built assets based upon management, energy use, health and well-being, pollution, transport, land use, ecology, materials, and water consumption.
BASIX	NSW, Australia	Simplified online energy and water rating system for dwellings, based upon manual input of design features.

Table 1. Environmental impact tools presented in the course.

The course content was conceived using a systemic perspective of the design process. This formed the basis for both content selection and course structure. This approach was driven by the idea that the designer was subject to a variety of influences that often competed with each other for attention and predominance, and that (s)he was constantly making decisions that balanced one with another. When drawn as a Venn diagram (figure 3) it was possible to see that the eventual solution to the design problem lay in a decision space at the intersection of all the influence domains (shaded black). These influences were made explicit in the course outline, and reflected in the course objectives.

However the novelty of this course lay in the fact that the student was designing their own learning experience, including the criteria against which their work was to be assessed. Figure 3 describes a situation where all of the influences are given equal prominence, however the fact that they are set in the context of a learning contract environment indicates that they in turn are influenced by the learning experience. In practical terms this meant that the student was at liberty to choose to assign different weightings to each influence, and to articulate them in their learning contract. Furthermore, the range of issues contained within it each influence group could themselves be subject to relative weightings.

The eventual outcome of the students learning experience, agreed upon with the lecturer, and enshrined in their individual learning contract would look more complex and "messy", reflecting the inherent complexity and "messiness" of real world problem-solving. Above all, each student's solution would be unique, representing their understanding of the issues and the relative importance of each to the generation of a holistic design solution. This would eventually be reflected in the mix of assessment items and weightings nominated by the student in their learning contract.



**Figure 3: course content and context.**

Once the student had documented what (s)he intended to achieve it would now be possible for them to propose strategies to make this happen. Due consideration

would need to be given to resourcing these objectives, in terms of human and material resources, tools and techniques, as well as time. The use of project planning techniques, such as Gantt charts and method statements were recognised to be both helpful and appropriate. These would include performance specifications that allowed both the student and the assessor to gauge the extent to which the evidence presented met with the agreed performance specifications.

Naturally, the negotiations concerning the individual learning contract would be conducted with the course coordinator. However it was felt that presentations in a group situation could provide powerful feedback for the individual, and therefore it was decided that a group seminar would be undertaken in the early weeks of the course. Group feedback would help the students understand whether their strategies to achieve learning objectives were clear, understandable, and achievable. It would also help surface alternative strategies and techniques, both in terms of the learning contract and the assessment product (Knowles, 1986).

## **CONCLUSION**

This paper has established that urban sustainability is derived from the drive towards achieving optimal outcomes in terms of a complex mix of resource use, waste and pollution, and social factors/services, which are traditionally designed and controlled by a diverse range of professional disciplines. It has argued that it is desirable for a common understanding of sustainability issues to be developed during professional training in a multidisciplinary context such as an undergraduate course that delivers design for the environment concepts. It has shown that the understanding thus gained is transdisciplinary, exposing students to the challenges faced by professionals operating in other disciplines that impact upon the urban/constructed environment. This exposure sensitises them to the integrated nature of urban sustainability, thus better equipping them to produce better solutions in concert with their colleagues.

Having established the desirability of multidisciplinary classes as the venue for environmental sustainability education the paper has then explored both the curriculum and assessment challenges inherent in such an approach. In particular it has focused on the need to expose the students to a range of concepts and tools that might be utilised by each of the disciplines represented in the cohort. By doing this the students get to recognise the similarities and differences in approach, the difficulties that arise when making design decisions and auditing design outcomes, and the need to be flexible and open-minded when making decisions in the boundedly rational context provided by design projects.

Given that 'assessment drives learning', the paper argues that the acquisition and integration of complex skills to solve 'messy' real world problems requires a flexible

assessment regime, arguing that learning contracts are the most suitable mechanism. Evidence is provided that previous design cohorts have benefited from the use of learning contracts and the development of transdisciplinary understanding, in separate situations. This is then used to argue that it is logical to bring both concepts together in order to provide an appropriate learning environment for a diverse student group. The outcome of this course design is to be used in semester two 2007.

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