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Educating for urban sustainability: a transdisciplinary approach

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An understanding of sustainability issues should be a key component of degree programmes. It is widely regarded as being a central attribute to professional practice and responsible global citizenship, arguably more so for the training of teachers since they potentially influence their students. This issue was brought to the fore when responsibility for delivering the ‘design and the environment’ course was transferred to the building discipline at the University of Newcastle in Australia as a result of restructuring. The attractiveness of the subject as an elective, the need to make it accessible to distance learning students and the desirability of applying transdisciplinary approaches to solving environmental problems presented the course designers with both challenges and opportunities, particularly in devising an assessment context within which students from multiple disciplines could be exposed to, and learn from each other’s professional environmental evaluation norms. This paper describes an innovative holistic, multi-criteria problem-solving course design that allows a diverse mix of undergraduates to develop a transdisciplinary understanding of sustainability issues through the use of learning contracts. It reports the experiences of staff and students involved with the course, highlighting the beneficial outcomes.

1. 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 lifecycle issues are documented. Contributing to a sustainable future is not just a matter of being earnest and worthy. It has become recognised that designing artefacts that contribute to a more sustainable future is becoming as ubiquitous as quality assurance was in the 1990s. In a world where discerning clients insist upon environmental accountability from their suppliers,¹ many businesses are now finding that such practices are profitable, providing them with competitive advantage.² Those charged with manufacturing and constructing the built environment find that ‘green’ relationships with suppliers and 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.³

University degree programmes should be instrumental in 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.³ Recent thinking suggests that the best sustainable design arises from a multidisciplinary approach.⁴ Levett-Therivel⁵ emphasise the importance of multidisciplinary in the development of sustainability tools and metrics. Walker⁶ 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 course boundaries in order to embrace a multidisciplinary approach to sustainability, it is not unreasonable for students from several disciplines to come together in order to learn about design and the environment, in particular to develop a shared understanding of the links between design decisions and their environmental consequences.

2. PROBLEM CONTEXT

At the University of Newcastle, Australia, a combination of restructuring, programme rationalisation and transfer of responsibility for delivery of courses has provided the opportunity to develop and deliver a ten-credit course entitled ‘design and the environment’ to a multidisciplinary cohort of students. This consists of both full-time on-campus students and others such as distance learners at diverse remote locations. The course is a core component in the bachelor of education (design and technology) degree, and is being increasingly selected as an elective course by students from other disciplines, particularly industrial designers, architects, engineers and construction

managers. The programme notionally contributes 130 h to students' respective programmes and is required to develop both students' workshop skills and understanding of the environmental impact of designed artefacts.

The course redesign was underpinned by a number of key principles.

- (a) 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 the wider community.
- (b) 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 environmental impacts, their assessment and the generation of design alternatives that will minimise them.
- (c) The accepted norms for one discipline can reasonably be expected to differ somewhat from those of another discipline. However, design decisions taken in one discipline ought to be informed by knowledge obtained from beyond the designer's own 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 this would be the design and technology teachers, with 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

- (a) the attitudes and expectations of clients for their services
- (b) the availability and nature of decision support tools to assist them during the design process and
- (c) the acceptance by end users of their designs and consequences of their design decisions—these might differ from those of the designers' clients (e.g. perceptions of tenants compared to property developers).

One of the first issues the staff and students faced was the extent to which it is cost-effective or indeed even feasible to conduct an accurate assessment of lifecycle costs, which depend variously upon the availability of published data regarding the materials and techniques being used and the size of the production run. This in turn would reflect the relative maturity of research being conducted in each of the disciplines.

Another issue was differences in the nature of the artefacts generated by 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 broadly 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 materials and manufacturing methods, and to undertake an assessment that was tailored to no specific group's needs, would be sub-optimal in terms of the espoused course aims, and both frustrating and disheartening for the students who might question the relevance of much that they were studying. A novel approach was required.

3. ASSESSMENT DRIVING LEARNING: THE CASE FOR LEARNING CONTRACTS

It has become axiomatic to say that assessment drives learning⁷ and this is reflected in the design of undergraduate programmes in the school of architecture and built environment at the University of Newcastle, 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 expand their own knowledge as they solve complex problems,⁸ thus empowering students to take charge of their own learning.

However, students from other faculties are more often used to a traditional programme structure in which individual courses are based upon content delivery, placing the course lecturer in the position of 'knowledge director' thereby assuming responsibility for the students' learning.⁹ In a course where the majority of 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 student needs, fulfil the course aims and objectives and provide a strong motivation for 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.⁹ 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.¹⁰

The school of architecture and built environment 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.¹⁰ The learning contracts were based upon the principles set out by Knowles⁹ and involved students negotiating

- (a) their learning goals
- (b) the nature of the evidence to be generated by them
- (c) the means and standards by which their work would be assessed.

Such a mechanism was proposed for the design and the environment course.

4. COURSE DESIGN

An unspoken objective for the course was the desire to make the student a 'better', more environmentally conscious, professional, an attribute that 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-directed¹¹ and, because they experienced the

consequences of exercising their own initiative, learning tended to be deeper and more permanent.¹² 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 an individual's competence to perform a job or in a profession. 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

IDEA2461 Design and the Environment: Learning Contract					
Student name		Student number			
Graham Brewer (the student)		123456			
Assessment item	Item specification (negotiated)	Item weighting (negotiated, insert value)	Item rubric grade (x/100)	Final item grade (cols 3x4)	Item rubric
Project plan (5 - 10%)	List of key activities and milestones required to complete the project together with time estimates for each and completion deadlines. These will be presented in a Gantt chart.	10%	0	0	Rubric
Project model/prototype (10 - 40%)	I am going to produce a model of a generic university course delivery system that is carbon neutral. It will be based on the development of a Blackboard course template. The objective will be to enable paperless delivery of course materials, interaction with students, and assessment. This will be cross referenced with University policies to check for consistency and absence of conflicting requirements. In addition to the template a sample course will be developed for IDEA2461, which will include: * Artwork for attractive course appearance * Two self marking 20 question multiple choice tests, with banks of 60 questions each * Two Turnitin assignments	40%	0	0	Rubric
Project documentation (10 - 40%)	This will consist of a portfolio of documentation detailing the course structure, relevant policies and evidence of compliance, development sketches for artwork, etc. The environmental evaluation for the course will be based on savings in materials (e.g. paper, printing, etc) as compared to the costs (computers, electricity, student printing costs, etc). This will reflect the life cycle costs associated with computer ownership, and power generation, as offset by savings in student travelling to campus (assuming distance learning delivery). The balance of any carbon deficit associated with the course will be costed in terms of carbon credits purchased from accredited sources.	20%	0	0	Rubric
Evaluation/reflection (10 - 20%)	This will consist of a reflective journal updated on a weekly basis that records reflection on action, together with reflective annotations in my portfolio where appropriate. These will endeavour to record reflection in action. Post completion reflection will evaluate the finished course relative to the item specification for the project model/prototype.	10%	0	0	Rubric
Seminar presentation (20%)	Powerpoint slides including notes that outline the key concepts and tools to be included in the course, together with an overview of the concepts included in the environmental evaluation. The presentation will include my Gantt chart.	20%	0	0	Rubric
			Final course grade	0	
The terms of this learning contract have been agreed upon for completion by:					
Completion date	5-Nov-07				
Student name	Graham Brewer (the student)	Signature	Date	12-Aug-07	
Course coordinator	Graham Brewer	Signature	Date	12-Aug-07	

Fig. 1. Learning contract

performance they wished 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 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, for example content acquisition, skills, and exit traits.

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 artefact 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 academic staff.

In order to accommodate a 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 an architecture student wishing 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, students would now be in a position to document their learning goals using a learning contracts *pro forma* (Fig. 1). This would typically be completed by the end of week four of the course. It should be noted that the example shown in Fig. 1 was developed by the lecturer and shown to students in order to illustrate the principles and practicalities involved: this example was then developed in real time to demonstrate the problems that would occur and ways in which to overcome them.

As the design developed over time it was deemed appropriate that 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 (week 5), at which both their peers and 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'¹³ approach to design would

be encouraged that reflected its position in the hierarchy of desirable end-use of redundant artefacts (Fig. 2¹⁴).

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 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 lifecycle costing would be emphasised as desirable components in their documentation.

The wide variety of students' backgrounds and consequent diversity in projects required that students should be exposed to a wide range of contemporary issues within the course activity programme (see Table 1), which included a transdisciplinary tranche of approaches to environmental impact analysis (see Table 2). Their selection of an appropriate approach thereafter would be based on a mixture of understanding, suitability and pragmatism.

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 (Fig. 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 each student was designing their own learning experience, including the criteria against which their work was to be assessed. Fig. 3 describes a situation where all of the influences are given equal

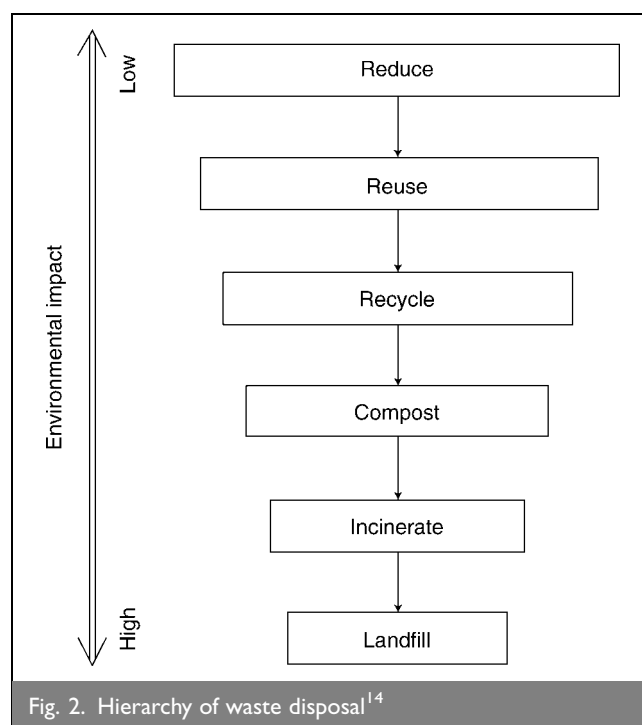


Fig. 2. Hierarchy of waste disposal¹⁴

Week	Sessions	Outputs
1	Course introduction Objectives Learning contracts Introductory project planning (3 hour session)	Planning
2	Design process Role of the designer in society Decision-making process (3 hour session)	
3	Lifecycle concepts Embodied energy Lifecycle analysis and tools (3 hour session)	Draft learning contract for approval Presentation of ideas
4	Design for disassembly (1 hour session/ 2 hour design studio)	
5	Cars Transport (1 hour session/ 2 hour design studio)	
6	Domestic buildings and water use (1 hour session/ 2 hour design studio)	
7	Electrical goods Consumer electronics (1 hour session/ 2 hour design studio)	Design and manufacture
8	Domestic buildings and energy consumption Passive solar design (1 hour session/ 2 hour design studio)	
9	Textiles Packaging (1 hour session/ 2 hour design studio)	Final learning contract for approval
10	Carbon neutrality and offsetting Kyoto Case study: carbon neutral university course (1 hour session/ 2 hour design studio)	
11	3 hour design studio	
12	Course review (1 hour session/ 2 hour design studio)	Design and manufacture
13	3 hour design studio	
14		Final submission

Table 1. Course activity programme

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 a 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 each influence group could themselves be subject to relative weightings.

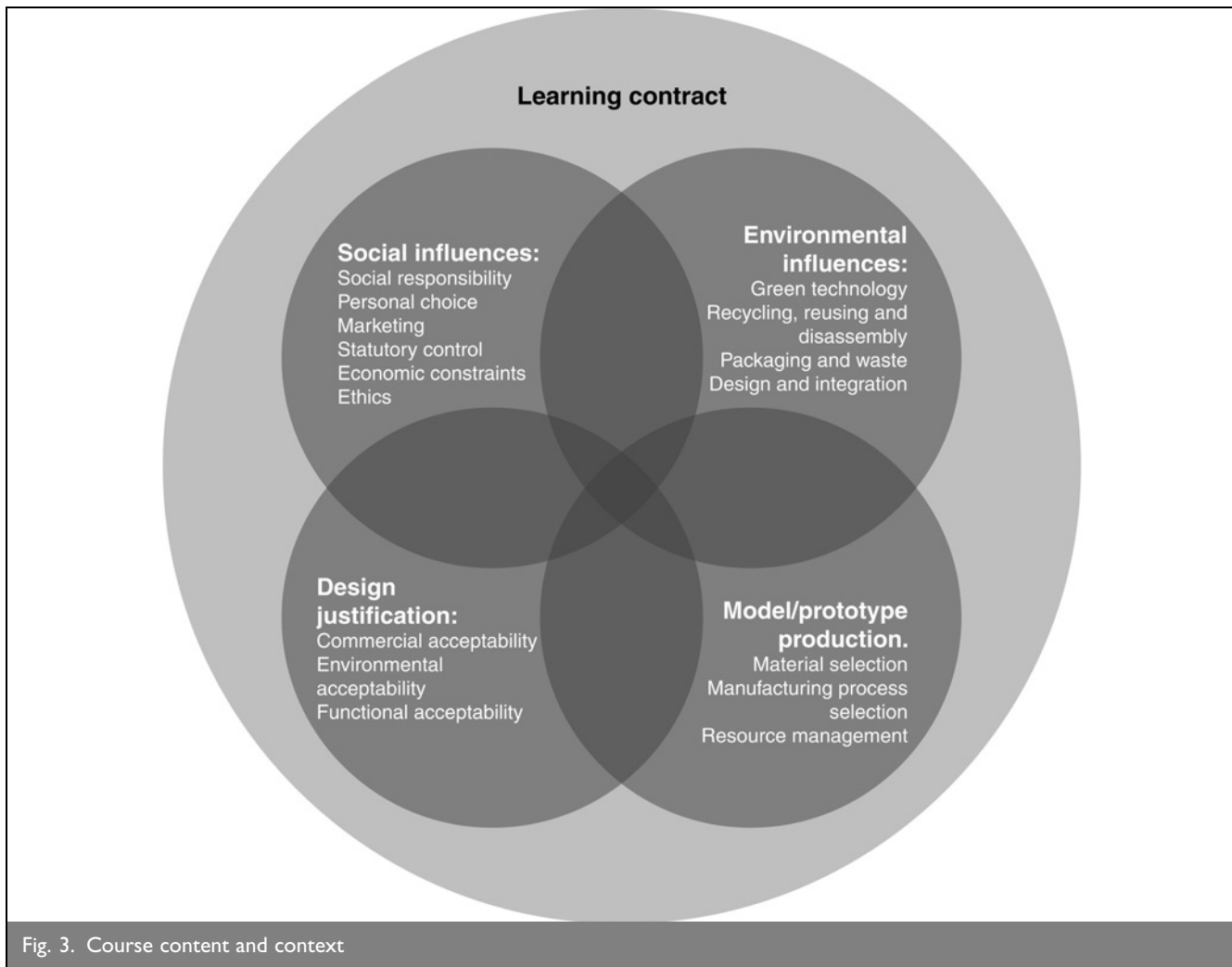
The eventual outcome of a student's learning experience—agreed upon with the lecturer and enshrined in their individual learning contract—would look more complex and 'messy', reflecting the inherent complexity and 'messiness' of real-world problem-

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.

Once the student had documented what (s)he intended to achieve, it would 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

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 on simplified groups of materials commonly used in manufactured products; known as lifecycle inventory, based on known published data for each of the materials groups. Sacrifices detail for usability
Leed	USA	Rating system for built assets based on design attributes, on-site tests and verification of 'as built' attributes, conducted by certified raters. Provides a simple, multi-tier rating of a building's sustainability
Breeam	UK	Environmental rating system for built assets based on management, energy use, health and wellbeing, pollution, transport, land use, ecology, materials and water consumption
Basix	NSW, Australia	Simplified online energy and water rating system for dwellings, based on manual input of design features

Table 2. Environmental impact tools presented in the course



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, negotiations concerning individual learning contracts would be conducted with the course coordinator. However, it was felt that presentations in a group situation could provide powerful feedback for individuals, and therefore it was decided that a group seminar would be undertaken in the early weeks of the course. Group feedback would help students understand whether their strategies to achieve learning objectives were clear, understandable and achievable. It would also help to surface alternative strategies and techniques, both in terms of the learning contract and the assessment product.⁹

5. EVALUATION

The primary evaluation of any course should consider the quality of student learning as evinced by assessment submissions. In this regard, the cohort's work displayed both rigour and innovation across a widely diverse range of contexts (see Fig. 4). Projects were as varied as concrete reinforcement stools, particulate-capturing exhaust systems for motorbikes, recycled cardboard furniture, software to monitor and control domestic power and water consumption, grey water reuse systems, green buildings and various textile-based products. The overwhelming majority were supported by detailed audits of current environmental

issues associated with the chosen design problem, together with an assessment of lifecycle impacts. These were predominantly conducted using Eco-IT 1999 software.

Quantitative and qualitative feedback on the students' experiences of the course was obtained using two mechanisms: student evaluation of courses questionnaire (SEC), which is mandatory for all courses, and student evaluation of teaching questionnaire (SET), which is voluntarily used by staff wishing to obtain detailed feedback on their performance. Whilst the former is standardised, the latter can be customised to address specific issues of interest and can include free responses to open-ended questions. All quantitative responses are given on a five-point Likert scale where 1 = strongly disagree and 5 = strongly agree. In this SET, open-response questions asked for three best points, two worst points and one area for improvement in the course. Evaluation of the course also included unsolicited feedback obtained in tutorials and student emails. A total of 38 students were enrolled in the course, all of whom were given the SEC. 14 students were distance learning enrolees who were not given the SET. Sixteen on-campus and three distance learning students completed questionnaires. The results are summarised in Table 3, which also contains the last set of SEC results for the old course.

The results in Table 3 indicate a consistently high regard for the conduct and outcomes of the course and the mechanisms employed by it. More importantly, the specific SET questions regarding the impact of the course on students' environmental



Fig. 4. Student projects: urban cycle station, exhaust system, power and water control and monitoring software, and cardboard furniture

awareness and most particularly the impact it had on their intentions with regard to professional practice returned highly favourable results. Comparison with SEC results of the previous course was particularly encouraging, justifying the course redesign. It should be noted that while the response rate from external students was disappointing, thus limiting its usefulness, it was not unusually low relative to other distance learning courses.

There were many positive comments with regard to the diversity of topics considered during the course.

Oh yes, keep these lectures coming—they're why I took this course—to be exposed to wider issues outside my experience (industrial design student, on the usefulness of broad-ranging topics).

I didn't realise what there was to it. . . I mean you hear about Kyoto and it's familiar, but what does it really mean? The stuff on the impact of restaurants and food well I mean. . . I will be teaching that to my kids (food technology teacher, relating course content to future teaching practice).

Never mind that, my flatmates are wondering who keeps switching the lights off all the time! (architecture student, commenting on behaviour change as a result of the course content).

This course has really opened my eyes (SET comment).

And in terms of the learning contracts

It was strange at first but then you get the hang of it. It forces you to think about what you are trying to do (technology teacher).

Yes once you understand your way around it, it is quite simple and it lets you know where you are going and what you've got to do (food technology teacher).

I think the freedom is the thing I like most about this. Normally we get told what we are going to do and it's all the same (industrial design student).

In terms of impact on future professional practice

I am thinking about my own teaching and how to include this! (SET comment).

Question (source)	Mean (cohort)	SD	Mean (old course, no distance learning)
As a result of studying this course, I have improved my knowledge of the topics/material covered (SEC)	4.5 (on-campus) 4.0 (distance)	0.632 0.0	3.47
The substance of this course was intellectually challenging (SEC)	4.8 (on-campus) 4.0 (distance)	0.447 1.0	3.24
The following components used in this course were well organised, providing an effective learning experience: (SEC)			
Lectures	4.6 (on-campus) 4.0 (distance)	0.629 0.0	
Tutorials	4.3 (on-campus) 4.0 (distance)	0.837 0.0	3.41 (across all components)
Online support (Blackboard)	4.6 (on-campus) 4.7 (distance)	0.756 0.557	
Overall I am satisfied with the quality of this course (SEC)	4.4 (on-campus) 3.7 (distance)	0.814 0.557	3.35
This course has increased my understanding of the environmental impact of product design decisions (SET)	4.6	0.484	—
This course has exposed me to a wide range of environmental sustainability issues (SET)	4.7	0.464	—
This course will impact upon the way in which I conduct my professional practice (SET)	4.3	0.583	—

Table 3. Summary of SEC and SET results

Finally, some unsolicited emails from students

I am looking into getting a patent for my product—I'll let you know how I get on, thanks for the awesome course.

I enjoyed the course immensely and really think it should have been a core subject for Industrial Design as I think there wasn't enough emphasis on sustainability until our final year. Thanks again.

6. CONCLUSION

The design of constructed and manufactured artefacts must balance an often conflicting and complex mix of resource use, waste and pollution and social factors/service issues. It has been argued that it is desirable for a shared 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 been shown that the understanding thus gained is transdisciplinary and exposes students to the challenges faced by professionals in other disciplines that impact upon the urban/constructed environment. This exposure sensitises students to the holistic nature of design for urban sustainability, hopefully better equipping them to produce more appropriate solutions in concert with their colleagues in their professional life upon graduation.

Having established the desirability of multidisciplinary classes as the venue for environmental sustainability education, this paper explored both curriculum and assessment challenges inherent in such an approach. In particular, it has focused on the need to expose students to a range of concepts and tools that might be utilised by each of the disciplines represented in the cohort. By doing this, students recognise 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 bounded rational context provided by design projects.

Given that 'assessment drives learning', this paper argues that the acquisition and integration of complex skills to solve 'messy' real-world problems require a flexible assessment regime, arguing that learning contracts are the most suitable mechanism. Evidence has shown that the approach has resulted in better student satisfaction than the previous course, and that the cohort has benefited from the use of learning contracts and the development of transdisciplinary understanding, resulting in a positive impact upon professional intentions.

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