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Graham John Brewer and Thayaparan Gajendran



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Evaluating the Impact of Transdisciplinary Problem-based Learning on Student Attitude to Design and the Environment

Graham John Brewer, University of Newcastle, NSW, Australia Thayaparan Gajendran, University of Newcastle, Australia

Abstract: It is widely accepted that transdisciplinary approaches to environmental problem solving provide the best hope for humans to address the issues associated with climate change. The education of professionals in the design and construction/manufacturing sectors should ideally sensitise students to these principles, helping them to recognise the value that other professions bring to the design process, and consequently minimise the environmental impact of their designs. A course on "design and the environment" delivered at the University of Newcastle in Australia embraces these principles, delivering content to mixed cohorts that include design and technology teachers, industrial designers, architects, engineers, and construction managers. It is founded upon problem based learning principles, empowering the students to take ownership of their learning. This extends to the consequences of their designs as they are required to perform a life cycle analysis for their product/building, encouraging them to explore the vexing issues of environmental auditing. Previous evaluation of the course has qualitatively indicated its effectiveness in raising the students' environmental awareness, and this paper confirms this using pre- and post-intervention content analysis of students' documents to measure the effect. The analysis utilises a framework based on the New Ecological Paradigm, and yields interesting results. The paper concludes with a discussion of the implications for course design and the responsibility of the educator in global society.

Keywords: Transdisciplinarity, Tertiary Education, Learning Contracts

Introduction

ESIGNING WITH THE environment in mind has become prevalent over the last 15 years, as producing designs that assist a sustainable future moves beyond the earnest and worthy, becoming as ubiquitous as quality assurance was in the 1990s. Discerning clients increasingly insist upon environmental accountability in their suppliers (Brezet & van Hemel, 1997). As a consequence businesses are now increasingly finding these practices profitable, generating competitive advantage (Stevels, 2001a). This shift presents its own challenges, as 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.

Ultimately the limits of sustainable urban development are defined by the level of creativity displayed by designers (Stevels, 2001b). Educating and training the next generation of designers and educators is central to shaping their thought processes and attitudes. A sustainable future it is therefore dependent upon a generation of "sustainable" designers, for whom

COMMON

GROUND

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eco/green/sustainable thinking is second nature. In order to succeed they have to think creatively in order to produce designs that are both green and profitable (Stevels, 2001b).

Recent thinking suggests that the best sustainable design arises from a multidisciplinary (e.g. Stauffacher, Walter, Lang, Wiek, & Scholz, 2006), or transdisciplinary approach (e.g. Hadorn, Bradley, Pohl, Rist, & Wiesmann, 2006). The importance of multidisciplinarity in the development of sustainability tools and metrics is also highlighted (Levett-Therivel, 2004). This represents a paradigm shift, breaking down the traditional demarcation mentality fostered by the notion of 'professionalism of design' (Walker, 2006):

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. (Walker, 2006)

Whilst it is unusual for universities to reorganise their undergraduate degree programmes in order to embrace multidisciplinary approach to sustainability, it is feasible for students from several disciplines to come together to develop a shared understanding of the links between design decisions and their environmental consequences throughout the life of the asset.

Transdisciplinarity

At the University of Newcastle, Australia the development and delivery of a course entitled "Design and the Environment" is a core component in the Bachelor of Technical Education degree programme, and is being increasingly selected as an elective course by students from other disciplines. Consequently it has to cater for the needs of a multidisciplinary cohort of students. This includes design and technology teachers, industrial designers, architects, engineers, and construction managers. The cohort consists of both full-time on-campus students and part-time distance learners.

The course design is underpinned by a number of key principles, the first of which is that 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. Furthermore 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. Lastly, it is accepted that the norms relating to design evaluation for one discipline (e.g. architecture) can reasonably be expected to differ somewhat from those of another discipline (e.g. textiles) in terms of techniques, availability of tools, and expected rigour.

Most courses demand that all students who take it as an elective are expected to adopt the norms of the group for whom it is 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 presents students in this course with the opportunity to develop a generic, transdisciplinary understanding of sustainable design. Naturally this requires careful course design.

This course is founded on a generic set of problem definition conditions that can be applied to a wide range of design problems. Firstly, any solution must accommodate, though not necessarily pander to the attitudes and expectations of clients: the 'greenest' designs are ineffectual if they are not adopted by consumers. This raises the issue of the extent to which it is cost-effective or indeed even feasible to conduct an accurate assessment of the life cycle costs – this is determined to a considerable extent by the availability of published data regarding the materials being used. This is a reflection of the maturity of research being conducted in each of the disciplines (G. J. Brewer, Gajendran, Landorf, & Williams, 2007b).

Secondly, the extent to which the designer can satisfy his/herself as to the environmental efficacy of their design is dependent upon the availability and nature of decision support tools to assist them during the design process. This is even more the case when it comes to convincing consumers and expert clients. There is a further complication, namely that the acceptance of their designs and the consequences of their design decisions by the end users might be different from their clients. This is particularly true in regard to constructed assets where the occupants may be tenants rather than those who commissioned the building design (G. J. Brewer et al., 2007b).

The final challenge is posed by the differences in the nature of the artifacts generated by students for assessment, which are likely to be influenced by their prior experiences and professional expectations. For example, product designers might wish to concentrate on producing a full-size model or even a working prototype, whereas those working in the built environment are likely to prefer to generate a documented, graphical model of a building.

In summary this course has been designed to produce environmental generalists who develop a broadly shared understanding of what it means to be an environmentally aware designer, whilst concurrently addressing a range of discipline-specific constraints. The course designers have recognised that forcing the entire cohort to study a compromise range of material and to undertake an assessment that is tailored to no specific group's needs is suboptimal in terms of the new course aims. This is also frustrating and disheartening for the students, who might question its relevance to their intended profession.

Learning Contracts

It is axiomatic to say that assessment drives learning (Hedberg & Corrent-Agostinho, 2000), and this is reflected in the design of this course. Using constructivist theory (Savery & Duffy, 1994) to encourage each student to create his/her own knowledge during complex problemsolving empowers them to take charge of their own learning. This often contrasts with their experiences in other programmes using a traditional structure where the individual courses are based upon content delivery. This casts the course coordinator in the role of 'knowledge director', who thereafter assumes responsibility for the students' learning (Knowles, 1986). The challenge is therefore to devise an easily understood assessment regime that drives student learning and knowledge creation, whilst concurrently telegraphing its professional relevance.

Learning contracts are 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). However their use has tended to be limited to postgraduate courses and self-directed continuous professional development (Williams & Williams, 1999). The obvious multidisciplinarity of this course domain indicates their use to be appropriate. Moreover, their previous use within the school was a success (Williams & Williams, 1999), involving students negotiating their learning goals, the nature of the evidence to be generated by them, and the means and standards by which their work would be assessed.

By following these tenets careful course design and assessment mechanism selection have allowed this course to accommodate a wide range of different students' needs. The use of learning contracts allows them to fulfill the course aims and objectives, and provides a strong motivation for them to engage with the subject matter and take ownership of their learning.

Course Design Overview

This course is intended to make the student a "better", more environmentally conscious professional, to be highly self-directed (Tough, 1979), resulting in deeper and more permanent learning (Brockett & Hiemstra, 1991). By using learning contracts the internal motivations of the learner and the external needs and expectations of society can be mapped and reconciled. This requires the student to select a design problem of their own choosing, establish the professional expectations of their own discipline in relation to assessing the environmental impact of their design solution (they may subsequently come to question the adequacy of their profession's approach to the environment), then conduct a gap analysis between this and their state of understanding upon entry into the course. This forms the basis for their contracted learning.

The student's next action is to document their strategies for fulfilling the learning objectives they have articulated in their learning contract. Importantly these specifications should describe what the student intends 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 appear in the project plan). These are described in terms that are meaningful to the student e.g. content acquisition, learning strategies, skills acquisition, reflective practice and desired exit traits.

Irrespective of the professional destination of the student the core of their contract will be to produce either a model or a prototype of an artifact that is designed and developed to reflect current environmental issues. 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. In keeping with good design practice the design solution must be supported by documentation that articulates the problem-solving leading to it, including a reflective component that evaluates process selection, decision-making, and the eventual product.

Figure 1 shows a completed learning contract, and is an example used by the class lecturer to illustrate the principles that the students have to incorporate in their own document.

Student name		Student num	ber		
Graham Brewer (bie studer	aj		223456	1	
Assessment item	Rom specification (negotiated)	itom weighting (negotialed, insert value)	Rem 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 Ganti chart.	10%	•		Rubric
Project modeliprototype (18 - 405)	Eam provide la produce a poper of a generic university course delivery system that is canton product actions product actions product the adjusted and the development of a full-schemark course transition, interaction with delivering, and approximate paperies delivery of course adjusted, interaction with delivering and approximate the Course of the adjusted for adjusted and the transition of the demonster and Course of the adjusted for COURS 2000, which will include: "Admits for adjusted the association methods and adjusted for COURS 2000, which will include: "Admits for adjusted the association methods adjusted for E00 questions each "The set adjusted the adjusted to methods adjusted to adjusted as "The set adjusted the adjusted to adjusted to adjusted as "The set adjusted to adjusted to adjusted to adjusted to adjusted as "The set adjusted to	40%			Rubric
Project documentation (10 - 40%)	This will consult of a patients of straumontables and animp the course strategy environment patients and advectors of compliance, advectingment advectors for an environmental evolution for the course will be based on a subject, which are advectors be course to environmental evolution for the course will be based on a subject, which are advectors be course to environment, which are advectors be course to environment, which are advectors and the course to environment, which are advectors be course to environment, which are advectors and the course to environment and evolution and an environment of the course of t	20%			Rubric
Evaluation/reflection (10 20%)	This will consist of a reflective journal undered on a weekly basis that records reflection on action, logistice with reflective accordions. In my control to eline a gyropoide. These will endersource the record reflection is existing, and employed and the restored be finished course relative to the flow specification for the project model/prototype.	10%		0	Rubric
Seminar presentation (20%)	Powepoint slides including notes that outline the key concepts and tools to be included in the course, tagether with an trendman of the concepts weblated in the concentration evaluation. The procentiation will include the (Sent Chart.	20%	· ·	c	Rubric
			Final course grade		
The terms of this Jearnia	g contract have been agreed upon for completion by:				
Completion date	Page 2				
Student name	Graham Brewer (Use student)	Signature		Date	45.40
Course coordinator	Carthana Barran	Signature		Date	120000

Figure 1: Learning Contract

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 (McDonough & Braungart, 2002) to design would be encouraged that reflected its position in the hierarchy of desirable end use of redundant artifacts (Figure 2).



Figure 2: Heirarchy of Desirable end Use

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	Attributes
	origin	
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 Assessment Tools Introduced in 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 each influence group could themselves be subject to relative weightings.

The eventual outcome of the 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.



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 the authors 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).

Evaluation of Approach

The current course design has been informed by previous evaluation, which indicates that students value the flexibility that it offers and the improved learning that it facilitates (G. J. Brewer, Gajendran, Landorf, & Williams, 2008b). Moreover, they recognise the extent to which it challenges them through exposure to life-cycle analysis techniques, and raises their

awareness of their role in our future as designers of artifacts that have an environmental impact (G. J. Brewer et al., 2008b). The following sections report on the design, execution and results of a study that evaluates the impact of students' exposure to the course on their ecological stance and by implication their attitude to other related issues.

New Ecological Paradigm

The New Ecological Paradigm (NEP) was first developed in the mid-nineties as a tool to assess the ecological consciousness of the public (Dunlap & Van Liere, 1978). By the turn of the century it had been updated to reflect changing contexts and world view (Dunlap, Van Liere, Mertig, & Jones, 2000). Consisting of a set of 15 items it was designed to ascertain respondents' stance in relation to five hypothesised facets of an ecological worldview.

In its latest incarnation the NEP questionnaire addresses five areas including: the reality of limits to growth, anti-anthropocentrism, the fragility of nature's balance, rejection of exemptionalism, and the possibility of an eco-crisis. It is structured so that agreement with the eight odd-numbered items indicates a pro-ecological view, and disagreement with the seven even-numbered ones also indicates a pro-ecological worldview.

Dunlap et al (2000) point to a study by Kempton, Boster, and Hartley (1995) as confirmation of the validity of the NEP, whose profile of American attitudes in relation to ecological issues mirrors their own. In particular they note the similarity of the three main findings in both studies (table 2).

NEP (Dunlap et al, 2000)	Kempton et al (1995)
Limits to growth	Nature is a limited resource upon which hu- mans rely
Balance of nature	Nature is balanced, highly interdependent and complex, and therefore susceptible to human interference
Human domination over nature	Materialism and lack of contact with nature have led our society to devalue nature

Table 2: NEP Validity: Alignment with Kempton et al. (1995)

Ultimately the NEP measures a primitive set of beliefs that may be reflected in a range of other attitudes and behaviours. Whilst social psychologists (Dunlap et al., 2000) caution against a strong link between the NEP and behaviour it is likely that:

...a pro-ecological orientation or "seeing the world ecologically," reflected by a high score on the NEP Scale, should lead to pro-environmental beliefs and attitudes on a wide range of issues. (Dunlap et al., 2000)

In the context of the current research it is considered to be an appropriate tool upon which to base investigation of attitudes and attitudinal change over time.

Content Analysis

Krippendorff (2004) identifies three distinguishing characteristics of contemporary content analysis: that it is fundamentally empirically grounded, exploratory in process, and predictive or inferential in intent; that it transcends traditional notions of symbols, contents, and intents; and that it has been forced to develop a methodology of its own, one that enables researchers to plan, execute, communicate, reproduce, and critically evaluate an analysis independent of the desirability of its results

Content analysis is a research method that can be used to determine whether a particular concept or idea is overtly presented, or implicitly implied, within a text-based document or sets of documents. It particularly lends itself to quantifying the extent to which particular ideas or concepts are present, and as such may be used in a longitudinal study to ascertain the extent to which particular ideas may become more or less prevalent over time. In the context of the current study Berelson (1971) indicates the usefulness of the technique both in determining the attitudinal and behavioural responses of a particular student cohort to a teaching intervention, and to potentially identify their intentions in relation to the focal topic upon graduation. This approach to content analysis is known as conceptual analysis.

At its most fundamental level conceptual analysis (sometimes also confusingly known as thematic analysis) involves tagging (or coding) text and tallying the occurrences of each code within a document or document set. This generally involves the systematic application of a previously developed "code dictionary" in a stepped process (Carley, 1993). The more precise the dictionary is in its identification of concepts and their proxies, the easier it is for the research to retain focus on relevant text. The corollary is that a qualitative approach to coding allows new, important material to fall within the scope of the study. Such an approach would be familiar to qualitative researchers in their generation of thematic codes, for instance when analysing interview transcripts. However they have to be more vigilant and diligent when applying this approach as the scope for inaccuracy and bias significantly increases, which must be negated through careful protocol design (Morse & Richards, 2002).

Another decision to be made at the design stage is whether to code for the existence of a concept, or the frequency with which it occurs. In the context of the current study it was decided that frequency had to be included as this had the potential to indicate the extent to which a particular concept or set of concepts had impacted upon the attitudes and behaviour of the students.

Having decided upon the purpose of the study, the range of concepts it is intended to probe, and the depth of enquiry it is intended to achieve it is then necessary to develop a comprehensive coding dictionary.

Coding Dictionary

The mechanism developed to assess the effect on attitude derived as a result of exposure to course content has been titled the "NEP Dictionary" (figure 3). This tool is designed to facilitate both manual qualitative, and semi-automated quantitative content analysis using the search function in Adobe Acrobat by providing words and word stems that have been coded as representative of personal attitudinal attributes identified in the NEP. The words and concepts in the dictionary are derived from a thematic analysis of the teaching materials used in the course, with their coding for inclusion being based on the NEP concept descriptions.

Analysis Protocol

The data for this study is contained in the learning contracts submitted by the students for the course. Key elements in both are the link between theory and practice, context and solution, and intention and outcome. In the case of intention and outcome this is equally applicable to the ideation and learning processes, with the latter being expressed in terms of learning outcomes and their link to learning activities.

Two contracts are submitted, the first being in draft form at the end of week 4, with the second being finalised in week 10. The draft learning contract is submitted after exposure to an intensive three-week period of core knowledge sessions, covering issues such as embodied energy and life cycle analysis. Thereafter each week consists of a session that is focused on a particular industry sector and its associated environmental problems, supported by appropriate tutorial activities.

Concepts to code	Example proxy concept codes (for automated quantitative coding using Acrobat)	Example coded words (used in manual qualitative coding)
the reality of limits to growth	food shortage, water short- age, shortage of space, pop- ulation control	overcrowding, overpopula- tion, shortage, famine, drought, contraception, sus- tainable, development
anti-anthropocentrism	humans as animals, humans as part of nature, animal rights, systems thinking, systems boundaries	animal rights, human animal, human ape, fauna, rights, re- spect, equality, eco-system
the fragility of nature's balance	global warming, ozone de- pletion, chaos theory, com- plexity, tipping point	balance, eco-system, imbal- ance, trigger, harmony
rejection of exemptionalism	scientific power, scientific solutions,	technology, scientific, inter- vention, control, elements
the possibility of an eco-crisis	climate change, rising sea level, pollution, drought, freak weather events	flood, drought, flash flood, desertification,

Table 3: NEP	Dictionary	(examples))
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The two learning contracts may be thought of as containing snapshots of the individual students thinking in relation to their chosen design problem at approximately the one third and two thirds points in the course, with the learning and knowledge implications this brings. Content analysis of the two sets of learning contracts will therefore deliver insight into the thinking of the group. This is achieved in the following way:

- 1. Each learning contract is converted into a PDF file, and stored in one of two folders, each one relating to either the draft or final contract stage.
- 2. Each folder is searched in turn for instances of the coded words (column 2, table 3) and the results tabulated according to folder.
- 3. A random sample (every fifth learning contract) is coded manually using the proxy concept codes, and the results compared to those obtained using the automated search function.
- 4. The results are then summarised in a spreadsheet.

Results

The class of 2008 consisted of 44 students, composed of 35 design and technology student teachers, 4 distance learning construction managers, 2 industrial designers, an architect and 2 international exchange engineers.

43 draft Learning Contracts were submitted for feedback in week 4 of the course. A further 38 contracts were received in week 10 after they had been revised by the students to reflect their learning and experiences during the intervening 6 weeks. The draft learning contracts from students who had dropped out of the course were therefore excluded from the study. Analysis of the remaining 38 pairs of learning contracts, using the protocol described in the previous section yielded the results that are summarised in table 4.

It should be remembered that the coding figures represent the total number of times that a particular concept is mentioned within the total body of learning contracts for that particular event. It does not discriminate the number of times that a particular student mentions a particular concept. This holds true for both qualitative and quantitative component of the protocol.

	Draft Learn	ing Contract	Final Learning Contract		
Concepts to code	Qualitative evidence - Proxy concept codes	Quantitative evidence - Coded words	Qualitative evidence - Proxy concept codes	Quantitative evidence - Coded words	
the reality of limits to growth	16	15	20	16	
anti-anthropocentrism	6	6	10	11	
the fragility of nature's balance	21	16	21	17	
rejection of exemptionalism	5	3	13	16	
the possibility of an eco-crisis	30	29	47	60	

Table 4:	Coding	and	Analysis	Results
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Discussion and Conclusions

In general it is apparent that the students entered the course sensitised to the concepts of excessive growth and consumption upsetting the balance of nature, leading to the likelihood of an eco-crisis. It is also apparent that they engaged less with the concepts of anthropo-centrism and exemptionalism.

By the time that the students were preparing to exit the course it was evident that they were, as a group, discussing all of the NEP concepts with greater frequency. From an environmental perspective this can be considered a positive outcome, indicating the development of pro-environmental attitudes and intentions in relation to their course deliverables (Dunlap et al, 2000).

The improvement in the pro-environmental profile of the class attitude was confirmed in the final tutorial session during group discussion, when students were discussing their position upon a notional continuum whose polar extremes were represented by two globes, within one of which there was a figure of the human, whilst figure remained outside the globe in the other -- these were taken to represent the eco-centric and anthropocentric extremes. None of the 18 students present at that session described themselves as holding attitudes lying within the anthropocentric side of the continuum. Many regarded their position as heavily towards the eco-centric, and all indicated that their attitudes were in a state of flux, tending to move in that direction.

From a methodological perspective this study offers many lessons.

- Firstly, the accuracy of the results is dependent in the first instance upon the development of an appropriate dictionary, whose contents accurately capture the essence of the concepts under consideration.
- Secondly, it is necessary to recognise that automated qualitative content analysis is extremely unlikely to capture all instances of the concepts under consideration. This can be explained in terms of shortcomings in the dictionary, and idiosyncratic linguistics used in the texts under investigation. Franzosi (1989) indicates that 75-80% accuracy is a valid outcome.
- Thirdly it is also necessary to accept that automated content analysis may well pick up erroneous examples of text taken out of context e.g. eco-crisis will be coded irrespective of the writer's intention ("there is an eco-crisis" as opposed to "the consequences of an eco-crisis have been hyped up"). It was for this reason that the decision was taken to conduct manual qualitative coding in parallel with the quantitative study.

Ultimately the objective must be to capture the essence of the writers intention and meaning, by using whatever means are both possible and feasible. This may require forgoing the powerful simplicity of reduction in favour of complex and tenuous analysis (Chatman, 1978).

From the perspective of teaching practice this study appears to have confirmed earlier assertions (Brewer et al, 2007, 2008) based on anecdotal evidence that indicated the course as having a beneficial impact upon students in regard to their environmental awareness, and their post-graduation intentions in regard to professional practice. However it is the authors' intention to administer a modified version of the NEP survey instrument to next year's class on two occasions -- upon commencement and pre-exit -- in order to obtain concrete evidence of the effectiveness of the teaching intervention.

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About the Authors

Dr. Graham John Brewer

I am the Head of Discipline of Building at the University of Newcastle in Australia, where I have input into the construction management, architecture, and education (design and technology) programmes. My research interests include ICT (benchmarking, critical success factors were used in project teams, innovation and attitude), urban sustainability (ageing in place/residential aged care, designed to disassembly, urban design and health), and teaching and learning (problem-based learning, metacognitive development and reflective practice, learning contracts, education and sustainability). I have written six books dealing with the challenges associated with the use of ICT in project teams operating in the built environment. I have received a teaching award, and have recently submitted my PhD, which is in the field of innovation adoption.

Thayaparan Gajendran

The focus of Gajendran's research is on cultural analysis relating to technological innovations, education in the built environment and sustainability. Gajendran employs multiple methodological perspectives including quantitative, qualitative and mixed methods, using case study strategies, Delphi, ethnographic interviews and questionnaire surveys. His contributions, particularly from a methodological point of view, extend to constructing attitudinal, value and cultural analysis frameworks to decipher the complex underlying triggers to human Behaviour. He has published number of industry best practice guides, conferences and journals papers. Gajendran is the coordinator of construction economics, estimating and tendering and facilities management course and is the program convener for the construction management program at the University of Newcastle. He is a member of the faculty of engineering and built environment methodological peer review committee. He was the chair of the engineering and built environment human research ethics committee in 2005-2006. He is also an associate of australian institute of quantity surveyors. Prior to his appointment as an academic he worked in the industry as a quantity surveyor and project consultant for it solutions.