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**“How Do You ‘Teach’ Sustainability to Engineers”?**  
**Introducing the Engineering Sustainable Solutions Program**

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## Abstract

Environmental engineers are increasingly being required to have knowledge about sustainability in their professional careers. Accreditation mechanisms for including sustainability in degree program requirements exist and are gradually being implemented by Engineers Australia. However, true integration of sustainability material into higher and vocational education curricula is still low, particularly outside the environmental engineering degree programs. In addition to environmental engineering, it is crucial for engineering across the specialisations, to be exposed to sustainability concepts and theories.

This paper will demonstrate how sustainability as a 'critical literacy' can be designed for teaching within mainstream engineering education, using a current Australian project as a case study. The project demonstrates that sustainability education for all engineers is not only possible, but that there is international interest in collaborating in such an educational initiative. A pilot trial of the Introductory Module was undertaken in Semester 1 2004 and Version 2 trials are now proceeding with a number of universities and organisations nationally and internationally. Further modules are currently being developed in collaboration with Engineers Australia and UNESCO. The program is a finalist in the 2005 Banksia Awards (Category 11, Environmental Leadership Education and Training).

## Key Words

Critical Literacy, Curriculum, Education Module, Engineers Australia, Engineering Sustainable Solutions Program, Higher Education, Vocational Education, National and International Collaboration, Portfolio, Professional Development, The Natural Edge Project.

## Biographical Information on Presenters of Paper at EES2005

**Cheryl Paten** is an environmental engineer by training, and is employed as a lecturer in the School of Environmental Engineering, Griffith University. She lectures Environmental Management Systems to fourth year engineers and post-graduate students, Mechanics & Materials to first year environmental engineering students, and is currently working to embed sustainability content more explicitly in the environmental engineering degree program. Cheryl's position at Griffith University is in formal collaboration with The Natural Edge Project (TNEP), where she is a Secretariat member.

**Nick Palousis** is The Natural Edge Project's Operations Coordinator, having joined the group in 2003 upon graduating in Mechatronic Engineering and Mathematical and Computer Science at the University of Adelaide. Nick is currently coordinating the development of the Level 1,2 and 3 Modules of the Critical Literacies for Engineers Portfolio (CLEP). He is also exploring the concepts of systems thinking and its application to sustainable business practice in his master's degree (by research) at the University of South Australia.

TNEP is an ongoing, not-for-profit partnership driven by a group of young engineers and scientists based in Australia. The team receives mentoring and support nationally and internationally from a wide range of individuals and organisations, in business, government and in research. The project is focused on assisting nations to develop a natural advantage through a whole of society approach, to achieve sustainable genuine-progress ([www.naturaledgeproject.net](http://www.naturaledgeproject.net)).

# 1 Introduction

## 1.1 Background

Globally and in Australia<sup>1</sup>, Engineering Institutions<sup>2</sup>, Practising Engineers, United Nations (UN) divisions such as UNESCO<sup>3</sup>, non-government organisations<sup>4</sup> and universities<sup>5</sup> are looking to provide professional training/curricula materials and courses to capacity build engineers to create a sustainable future. Many engineering Institutions globally and the World Federation of Engineering Organisations (WFEO) have strong commitments to sustainable development and programs like WFEO-Comtech to provide online educational materials and databases<sup>6</sup>. There exists international consensus of the need for a change in traditional engineering practices to overcome the challenges put forward by sustainability.

The 2002 and 2004 International Conferences on Engineering Education in Sustainable Development (EESD 2002, EESD 2004) emphasised that Engineering education, especially higher education for the training of decision-makers, researchers and teachers, should be oriented towards sustainable development and should foster environmentally aware attitudes, skills and behaviour patterns, as well as a sense of ethical responsibility. The 2004 conference declaration reaffirmed that, "Engineering has responded to the needs of society and without a doubt, today's society requires a new kind of engineers." It also stated:

*"Universities must redirect the teaching-learning process in order to become real change agents who are capable of making significant contributions by creating a new model for society. Responding to change is a fundamental part of a university's role in society. There is evidence that sustainable development has already been incorporated in engineering education in a number of institutions around the world. The United Nations Decade on Education for Sustainable Development (2005-2014) offers a great opportunity to consolidate and replicate this existing good practice across the international higher education community. Universities now have the opportunity to re-orient the traditional functions of teaching and research, by generating alternative ideas and new knowledge. They must also be committed to responding creatively and imaginatively to social problems and in this way educate towards sustainable development."* (Declaration of Barcelona, 29th October 2004)

Nationally, Engineers Australia has recognised for more than 20 years, that the engineering profession has a significant opportunity and moreover an obligation, to move society to a more sustainable way of life. Tenet 6 of the Australian Engineering Code of Ethics statement states that, "Members shall, where relevant, take reasonable steps to inform themselves, their clients and employers, of the social, environmental, economic and other possible consequences which may arise from their actions" (Engineers Australia, 2000). Engineers Australia's 2004 National President, Mr Doug Jones, is clear about the need to move forward on education for engineers in sustainability, "*It is up to engineers to consider sustainability in every project they design and construct & every product that is made. Sustainability is now a fundamental responsibility that all engineers must carry every day.*" (Jones, 2004). 2005 President Andrew Downing has restructured the mission statement, "*to promote, catalyse and partner in delivering the principles, practice and culture of sustainability to the engineering profession and the broader community.*"

## 1.2 Scope of the Paper

This paper describes a current Australian initiative that is designing a series of educational modules, to help embed sustainability as a 'critical literacy' into mainstream engineering education. The significance of the case study is discussed with respect to collaboration between TNEP and key organisations including Engineers Australia, the Society of Sustainability and Environmental Engineering, and UNESCO. The case study is then discussed

<sup>1</sup> Federation of Engineering Institutions of South-East Asia and the Pacific (FEISEAP). Institution of Engineers, Australia, publications [http://www.ieaust.org.au/library/institution\\_pubs.html](http://www.ieaust.org.au/library/institution_pubs.html).

<sup>2</sup> Google: The Engineer of the 21st Century Inquiry - Change Challenges for Sustainability.

<sup>3</sup> Google: UNESCO Global Higher Education for Sustainability Partnerships (GHESP)

<sup>4</sup> <http://www.acfonline.org.au/na/asp/pages/default.asp>

<sup>5</sup> University Leaders for a Sustainable Future ([www.ulsf.org](http://www.ulsf.org))

<sup>6</sup> The Australasian Virtual Engineering Library - [www.avel.edu.au](http://www.avel.edu.au)

in relation to engaging institutions nationally and internationally and initial feedback is provided from the trial of Introductory Module. Finally, comments are provided on the possible next steps for the Portfolio and larger Engineering Sustainable Solutions Program.

The first phase of this project was presented at two academic forums in 2004: the Australasian Association of Engineering Education Conference as a workshop (Toowoomba, 29 September 2004), and then as a paper presentation at the Engineering Sustainable Solutions Conference (Spain, 28 October 2004).

This paper presents a summary of the first phase and then describes the second significant phase of the project, where more modules are being prepared and where universities around the country are now asking 'does this introductory module help engineering students to really grasp sustainability?'. Phase 2 also involves collaboration at an international level, with UNESCO support and international university participation in trialing the material. Finally, the paper will comment on the possibility of widening the program to engineering professionals in continuing professional development (CPD).

### 1.3 The Natural Edge Project

The Natural Edge Project (TNEP) is an ongoing, not-for-profit partnership driven by a group of young engineers and scientists based in Australia. Hosted by Engineers Australia, the team receives mentoring and support nationally and internationally from a wide range of individuals and organisations, in business, government and in research. TNEP is focused on assisting nations to develop a natural advantage through a whole of society approach, to achieve sustainable genuine-progress<sup>7</sup>.

## 2 A Description of the Critical Literacies for Engineers Portfolio

Recognising the vital role the engineering profession will play in implementing sustainable development, TNEP are developing a suite of peer reviewed and trialed learning modules, known as the "Engineering Sustainable Solutions Program: Critical Literacies for Engineers Portfolio" or CLEP (Figure 1 below). The intent is that the program will provide critical information required for the engineering profession to deliver sustainable solutions, from entry level material through to detailed and more complex content. The material introduces the significant concepts related to sustainability, current efforts and future directions in engineering practice for sustainable development.

The CLEP provides a multi-disciplinary approach to devising innovative solutions to sustainability challenges such as greenhouse gas reduction, waste management and water conservation. The aim of the project is to enable key pieces of information, or so-called 'critical literacy' items relating to sustainability, to be incorporated as effectively as possible into the broadest range of engineering curricula. The project is intended to compliment other student studies as an alert to sustainability principles and activity in the engineering profession.

### 2.1 Portfolio Structure

The development of the portfolio follows a two-year development of TNEP's publication, *The Natural Advantage of Nations* (Hargroves and Smith, 2005). CLEP covers six engineering topics relevant to sustainability: Profitable Greenhouse Solutions; Greening of Industry; Greening the Built Environment; Sustainable Urban Transport; Water: Nature's Gold; and Zero Waste: Value Loops.

The portfolio begins with an 'Introductory Level' comprising two modules: Introduction, and Supporting Case Studies. These provide context to the challenges facing the engineering profession in deriving sustainable solutions. The Introductory Module I.1 (Introduction to Sustainable Engineering) was completed in 2004 with support from the Engineers Australia Environmental Engineering College. Module I.2 (Supporting Introductory Case Studies for Thematic Units) is currently on hold.

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<sup>7</sup> [www.naturaledgeproject.net](http://www.naturaledgeproject.net)

The Introductory Level is then followed by Level 1 to Level 3, the first two of which are being compiled in collaboration with the United Nations Education, Science and Cultural Organisation (UNESCO), and Engineers Australia. Level 1 builds on the context provided in the introductory module to focus on the implications for engineering in developed and developing countries, as well as theory and background information relating to sustainable engineering methodologies. 'Level 2' introduces the technological aspects of engineering for sustainability, providing technical content and case studies of successful engineering methodology to respond to 'sustainability challenge' themes: Profitable Greenhouse Solutions, Greening of Industry, Greening the Built Environment, Sustainable Urban Transport, Water: Nature's Gold and Zero Waste: Value Loops. Level 3 will provide example calculations for translating a number of key sustainability concepts into engineering design.

The development of the portfolio will proceed module by module. Each module is based on a theme as follows: The Role of Engineers in Sustainability; Engineering for Poverty Eradication; Resource Productivity Improvement; Green Engineering and Chemistry; Whole Systems Engineering Design; and Design Inspired by Nature. Within each module, the following six topics (ie Profitable Greenhouse Solutions; Greening of Industry; Greening the Built Environment; Sustainable Urban Transport; Water: Nature's Gold; and Zero Waste: Value Loops) will be discussed to provide context to the module theme.

Each of the 36 units will be developed in close collaboration with relevant contributors – experienced professionals and academics. Like the Introductory Module, each of the units will be self-contained and modular to provide the portfolio with the greatest level of flexibility possible for integration with existing engineering courses; for example one or more individual units can be integrated within an existing engineering course. Alternatively, a whole module (e.g. Green Engineering, Whole System Design) or topic (e.g. Sustainable Energy, Greening Industry) can be delivered as a separate undergraduate course or intensive workshop.

The Natural Edge Project (TNEP) Secretariat is inviting international experts to contribute material to each unit of the portfolio. The portfolio will bring together the work and knowledge of these experts into an integrated series of baseline 'lectures' to assist students/trainees in delivering sustainable engineering solutions. Each contributor will provide the TNEP Secretariat with base content (e.g. relevant papers, reports, publication references) relevant to a particular unit. The Secretariat will facilitate the compilation, review and editing processes of this material into a suitable unit format, which will be further examined by a peer review committee consisting of invited international experts. Expert Advisors will be assigned to a Module monitor and advise the content and layout – such experts include Bernard Amadei (Engineers Without Borders USA), Hunter Lovins (Natural Capitalism Inc.), Amory Lovins (Rocky Mountain Institute), Paul Anastas (Green Chemistry Institute), and Janine Benyus (Biomimicry Guild).

## **2.2 Typical Module Layout**

The Portfolio is comprised of a number of 'modules' as described above, each containing six individual 'technical units' (represented by circles). A diagram showing the module layout for the Introductory Module (representative of a typical module within the portfolio), is presented in Figure 2. Each module consists of three key resources, which are described under the following subheadings:

### **2.2.1 Trainers Guide**

The Trainers Guide provides background information on the module and its functionality, to ensure that the trainer can make the most of the tools available. The guide is complimented by a base set of example presentation slides for each unit, which could also be used to produce handouts or as a basis for discussion in a workshop environment.

### **2.2.2 Study Guide**

The study guide provides the trainer with a set of information to teach from, for each of the six 'technical units'. The layout of the units within the module is shown graphically below in Figure 2. Within each part, there are several sub-headings ('parts') to direct the flow of the content.

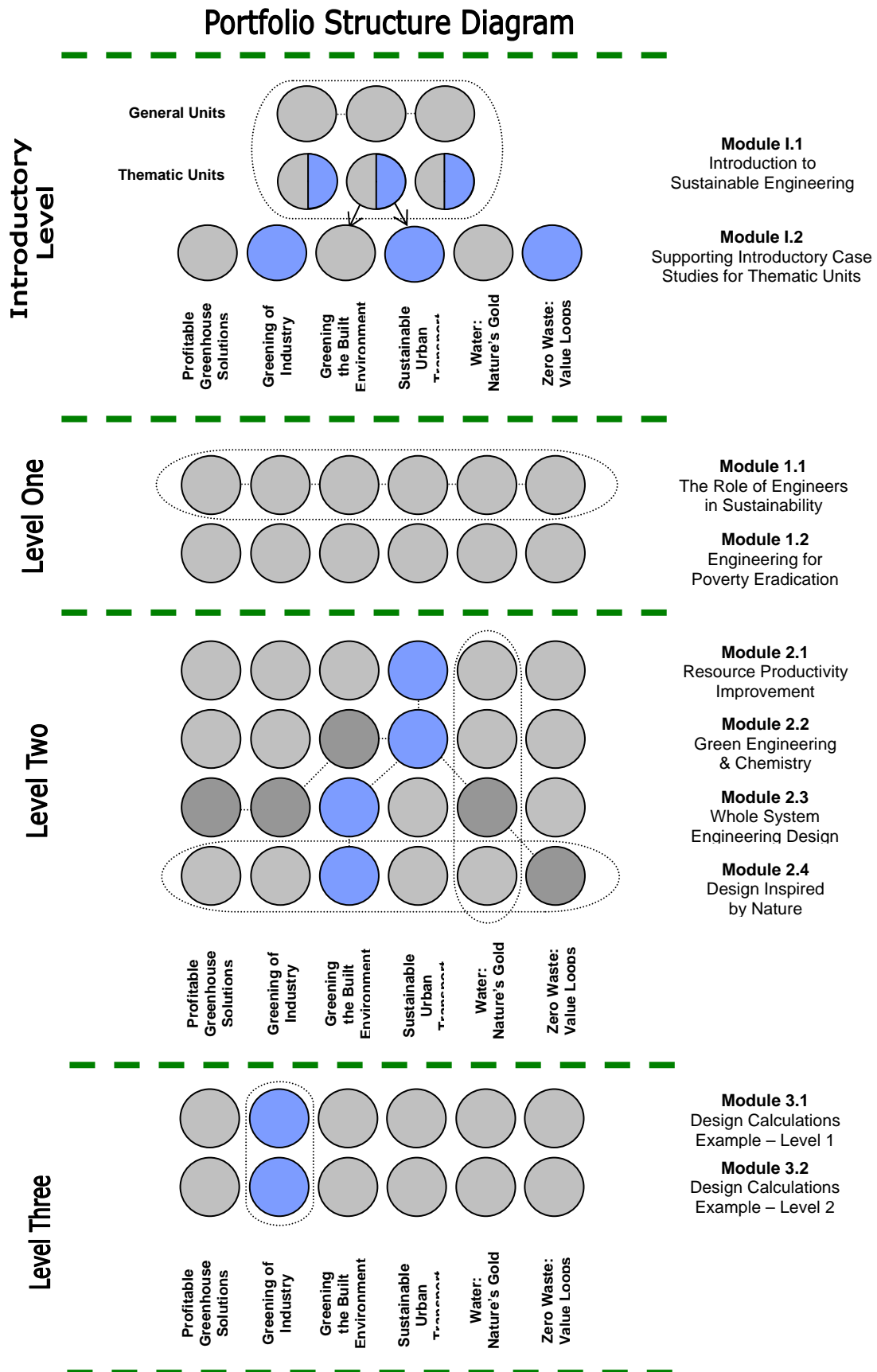
### **2.2.3 Online Companion Website**

In the preparation of any education program, and in particular an introductory course, it is a

challenge to cover all possible questions or uncertainties that may arise or be asked during delivery of the material. In response to this challenge, the program is designed so that it is supported (ie in its critical academic rigour and structure) by an online companion website<sup>8</sup>. Concepts and information presented in each module are also covered in more detail in the book and online additional reading lists. If and when trainers or students seek additional information or justification of content presented in the module, they can search the online site for assistance, and/or read the chapter of the publication that corresponds to the associated unit. This provides a 'one-stop shop' type of environment that is as flexible as possible toward teaching and learning.

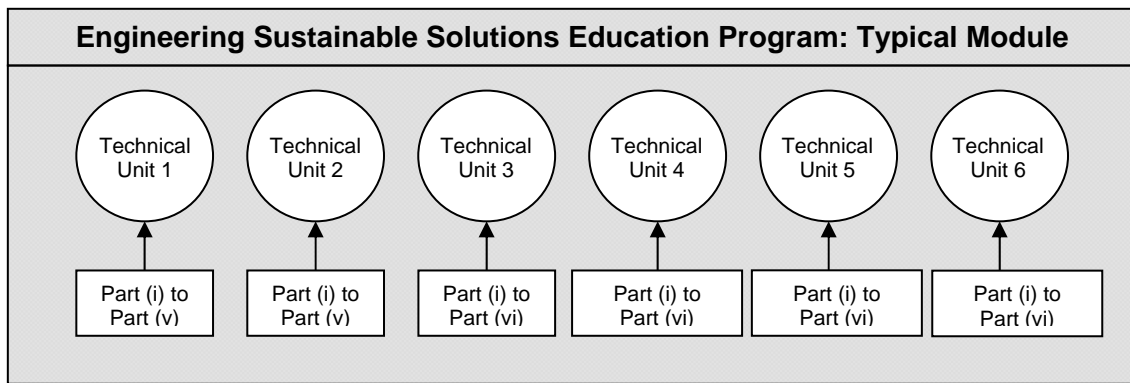
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<sup>8</sup> [www.thenaturaladvantage.info](http://www.thenaturaladvantage.info)



**Figure 1:** Diagram showing the layout for the Engineering Sustainable Solutions Program - Critical Literacies for Engineers Portfolio (ESSP:CLEP).





**Figure 2:** Module layout, showing the use of units and parts to guide the trainer and students through the material presented.

### 2.3 Typical Unit Layout

Each unit (equivalent to one lecture) is designed to both compliment the other units and also to stand alone if needed to enhance an existing program. The material has been designed in this way to provide the teacher with the greatest level of flexibility possible for integration with existing engineering courses; for example one or more individual units can be integrated within an existing engineering course. Alternatively, a whole module (e.g. Green Engineering, Whole System Design) or topic (e.g. Sustainable Energy, Greening Industry) can be delivered as a separate course or intensive workshop.

Each unit provides a lecture 'Overview', 'Key Points' to highlight the important facts of the unit (and hence learning outcomes of each lesson), 'Brief Background Information' to provide supporting material for the key points, 'References and Publications' supporting the material presented in each session, and 'Key Words and Resources' to assist students/trainees with online or catalogue searches of information relating to the topics covered. The unit then provides assessment questions and group activity suggestions to allow the teacher to assess the level to which students have comprehended the key topics. The units may be delivered in either a full day workshop, in a series of one hour lessons or over a given period as part of a larger course or program.

### 2.4 Key Reference Documents

Books like *Natural Capitalism: The Next Industrial Revolution* (Lovins *et al*, 1999), the case studies on the Australian Conservation Foundation (ACF)'s *Natural Advantage: Blueprint for a Sustainable Australia* (ACF, 2000) and the *Western Australian State Sustainability Strategy* (Department of the Premier and Cabinet, 2003) show that right now we can achieve genuine sustainable progress. Content collated for the module portfolio also contains references to key recommendations by significant government and institutional reports, forums and councils. These include:

- The World Federation of Engineering Organisation's sustainability related reports.
- Institution of Engineers Australia's relevant taskforce reports on sustainable energy (Engineers Australia, 2001a, 2001b), sustainable transport (Engineers Australia, 1999), and sustainable engineering practice (Engineers Australia, 1997).
- The Australian Government's National Environmental Education Council and Environmental Education National Action Plan.
- The South Australian Environment Industry Cluster Development (Department of Industry, Science and Resources, Emerging Industries Section, 2001).
- Recommendations from significant national and regional forums like the CSIRO FutureCorp forum.

### 2.5 The Importance of Case Studies

The CLEP uses case studies, personal stories and anecdotes throughout the module to illustrate where engineers have delivered remarkable solutions to sustainability challenges.

They are important as they show what has already been achieved and therefore, in principle, what can be replicated, or indeed improved upon. Case studies and stories avoid the need for lengthy discussion about whether particular sustainability goals are achievable, proving that steps have already been taken by someone, somewhere. They also help to avoid 'reinventing the wheel'.

### 3 Collaboration as a Leverage Point

#### 3.1 Content Collaboration

The CLEP is innovative in that it has involved collaboration on content and on implementation. The initiative takes a whole of system approach to the delivery of sustainability education in engineering universities and professional development, by inviting the input of a range of experts from a variety of fields other than that of the traditional engineering disciplines, but which directly influence the success of implementing sustainable development through engineering. Engineers must consider the integrated social, environmental and economic issues that, while increasing the breadth of the engineering challenge problem, are vital to achieving practical results.

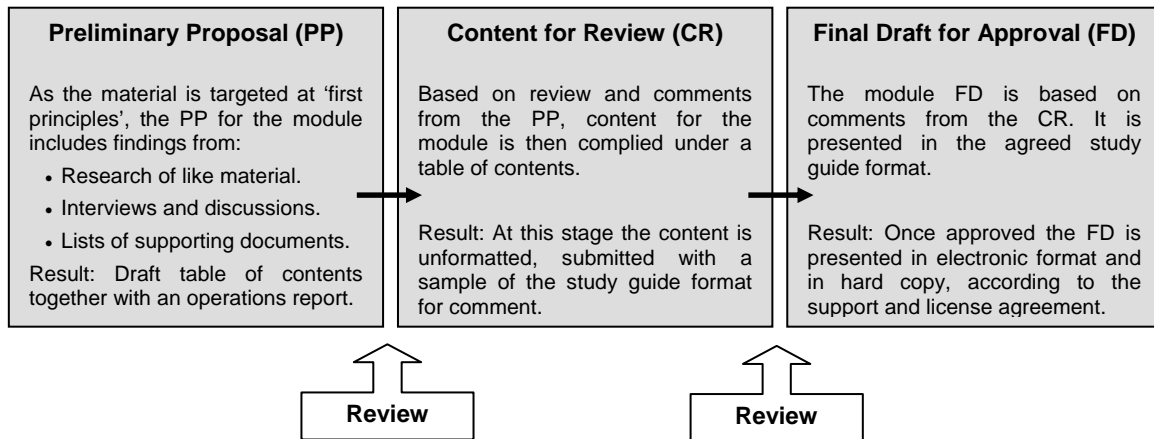
The objectives of the CLEP have encouraged the involvement and collaboration of the world's leading experts in sustainability-related fields: Hunter Lovins, Paul Anastas, Amory Lovins and Janine Benyus – it is intended that with this level of supervision, the material included will be feasible and display global best practice. As for the Introductory Module, it is intended that the content of these subsequent modules will then be further peer reviewed by TNEP's network of professionals, academics and public servants, before being submitted for trial to universities.

The portfolio brings together the latest work of international experts from a range of disciplines into a succinct and academically rigorous set of lessons to assist in the delivery of education on engineering sustainable solutions. Theory from economics, business, ecology, social science and policy and are interwoven within the technical engineering concepts and case studies explicitly relevant to engineers in order to achieve significant steps forward in implementing sustainable development in Australia and internationally.

#### 3.2 National Engineering Collaboration

It is clear that if sustainability is to be included into university curriculum, the relevant professional body for the particular discipline needs to be one of the driving forces. The World Federation of Engineering Organisations (WFEO) recognises this on their website [4] and in their online publication (Committee on Technology, Engineers and Sustainable Development, 2002). The development of such documentation and material sits well within EA's objectives and indeed helps the institution to continue to provide service to its members and the community. As the EA 2004 National President Doug Jones states, "*We need to respond to the overarching responsibility for engineers in the application of our engineering education, training and experience to provide excellent sustainable engineering solutions for the benefit of our employees, clients and the community*" (Jones, 2004).

In January 2004, the College of Environmental Engineers, on behalf of EA, provided a grant to TNEP for the development of an 'Introductory Module'. This was the first step in developing TNEP's larger "Engineering Sustainable Solutions Program - Critical Literacies for Engineers Portfolio" (ESSP-CL) which is currently underway. The development process is summarised in Figure 3 – this process ensured that the Institution was involved in the development and hence direction of the content.



**Figure 3.** A summary of the steps involved in the module development process. The aims of the process are to engage with other organisations and to find the best material possible for inclusion.

### 3.3 International Collaboration

TNEP has ensured the CLEP will provide rigorous peer reviewed material by inviting the input and support of the United Nations Education, Science and Cultural Organisation (UNESCO), who are the lead organisation for the UN Decade Campaign for Education in Sustainable Development; and Engineers Australia, the peak professional body for engineers in Australia and one of the most respected in the world in providing professional development and accreditation services to its members. The involvement of these organisations is critical to achieving sustainable engineering solutions in Australia and internationally. UNESCO has confirmed the publishing of the CLEP and dissemination into developing countries, while Engineers Australia is committed to raising awareness about the concepts, aims and content of CLEP among all Australian engineering education institutions.

## 4 Engaging Universities: Trialling Material (Introductory Module)

Given that this type of large scale sustainability content development for engineering degrees does not appear to have been undertaken before, it is imperative that the initiative proceeds with caution to ensure that the content and style of material developed is suitable for mainstream engineering degrees. The following paragraphs describe the trials undertaken to date on the Introductory Module. Results from these trials will be used to improve the module and will also be fed directly into the design process for the subsequent levels (Level 1 to Level 3) currently being developed.

### 4.1 Pilot Phase – Griffith University Trial

TNEP Education Coordinator Cheryl Paten taught four of the six Introductory Module units as a pilot trial to Griffith University first year students in the School of Environmental Engineering during the first Australian teaching semester in May 2004. For most respondents the lecture material was new and there was enough content. All respondents felt that their understanding of sustainability had improved as a result of the lectures.

As a result of the trialling of the units, the following conclusions were made:

- The format and level of content provided within the units is pitched at the right level for first year environmental engineering students. Verbal feedback from the students and graduate of the environmental engineering course also visiting the lectures, indicated that the material could also be suitable for any general 'first year engineering' course.
- Students absorbed the concepts and material provided extremely quickly. From a position where most had not heard of the Brundtland report, by the end of the fourth lecture, discussions were informed, challenging and engaging as students drew on their own experience to form their own understanding of sustainability.
- The course lecturer considered it beneficial to include the material at this point in the course

material. Students observed on a number of occasions that this information would assist them in their current and possibly future design assignments. They also commented a number of times that they felt inspired and energised by the material presented.

The trial was deemed successful by students and university academics, and further supported the need for engineering curriculum reform/adjustment for the delivery of effective solutions. Feedback from the pilot trial was used to make amendments to finalise Version 1 of the Introductory Module. The trainers guide was modified to include a note to encourage the teacher/ facilitator to include less information on power-point material and discuss concepts and terms with the students. The trainers guide also recommended that students be provided with some handouts or notes to improve their retention of information and ability to engage with the material being presented. The guide recommended that teachers should allow 10 to 15 minutes of a lecture for discussion and questions, to ensure that the students don't feel overwhelmed by volume of material.

## 4.2 Phase 2 National Trial

The Introductory Module is currently being trialled with various engineering schools and departments in 14 universities nationally. Formal reporting on the trial is due by the completion of Semester 1, more thorough examination of data and feedback will be possible. However verbal feedback to date has been very positive. This could be in part due to an early comprehensive review by one of the universities in December 2004, which provided valuable information on improving layout and content. Subsequently a revised version was sent to all participating universities. Issues to consider when assessing the initial feedback from universities includes the method used in soliciting verbal feedback which was not anonymous. It will be important for the participating universities to feel safe in providing both positive and negative criticisms in the final report.

Examples of early comments provided include:

- "The modular design of the program makes it versatile enough to be applied to all disciplines of engineering education."
- "By setting out with a clear grasp of the significant challenge before them, and by defining the paradigm shifts needed to bring about behavioural change in the delivery of engineering works, the developers have assembled resources and presented material in such a way that others will inevitably take up the challenge."
- "The CLEP is innovative in that it is trying to ingrain a philosophy of sustainability into engineering students at the very beginning of their course, thus carrying that philosophy into all future learning."
- "There are clear efforts to build international links for delivery of the program and to promote cooperation and collaboration among professionals in Australian engineering education."
- "For many of the first year engineers, this is their first engagement with the idea that as designers of the future they will have opportunities to impact significantly in the area of sustainability. The anecdotal evidence is that they have embraced the challenge wholeheartedly. The topics raised through the ESSP (delivered as a series of 6 lectures) have spread (without prompting or design) throughout other aspects of the course. Students are considering the issues in their design projects, in their presentations of different engineering disciplines and in their essay topics."
- "The ESSP has confirmed for me, as a teacher, that engaging students in the self-learning process by sparking their curiosity for career opportunities and possibilities has a snow-balling effect. It would be harder now to disengage these students from considering sustainability issues, than it was to engage them through the ESSP."

The program is a finalist in the 2005 Banksia Awards (Category 11, Environmental Leadership Education and Training).

## 4.3 Phase 3: International Trials

Internationally, the introductory module is currently being trialed by the University of Zaragoza's Mechanical Engineering Department. It is also being delivered by TNEP member Charlie Hargroves with Hunter Lovins at the University of Colorado, Boulder.

The Introductory Module will also be used to assist the reconstruction effort in the affected Tsunami disaster region, by Engineers Without Borders (EWB-USA), to help engineers local to the region reconstruct the affected areas using sustainable engineering practices. EWB-USA were recently selected as the lead agency for the US professional engineering response to disaster relief in the affected region. It is also being considered by the National Regional Governments for Sustainable Development (NRG4SD) network.

## 5 ESSP & Sustainability Education – The Next Steps

The national trial of the Introductory Module is nearing completion and reporting will be undertaken in July 2005. The international trial is due for completion at the end of the year.

With the support of UNESCO and EA through the Environmental Engineering Society (EES) and Environmental College (ES), The Natural Edge Project is currently developing Level 1 & 2 content and associated training material of the ESSP. It is anticipated the draft content will be complete for publishing by October 2005. UNESCO will be publishing the ESSP – Introductory Level, Level 1 and 2 – for dissemination internationally, and with a particular focus on developing countries. Engineers Australia, in partnership with The Natural Edge Project, will be delivering training of the ESSP to its members over the period of 2006 – 2008.

The trial and evaluation process for Level 1 to Level 2 is a 12 month process intended for commencement in August 2005, whereby the modules will be included within existing courses and taught by university lecturers (as for the Introductory Module trial). During the trial and on completion, feedback will be gathered from lecturers and students to determine how effective the program was to them in delivering the knowledge required (and interest generated) to undertake a longer-term integration within the course structure. It is envisaged that the content compilation for Level 3 will commence around July 2006, pending the development schedule for Levels 1 and 2. Should the reader wish to be involved in trialling or reviewing existing material or participating in the review of future modules, please contact the authors.

It should be noted by the reader that the content of these education modules has been designed to remain in the course curriculum for at least a decade (ie covering the Decade of Education for Sustainable Development). The supporting online companion ([www.thenaturaladvantage.info](http://www.thenaturaladvantage.info)) is regularly updated, ensuring the most up to date supporting material is – and can continue to be - supplied to users of the material.

Aside from the development of ESSP initiative, Engineers Australia – through the Environmental Engineering College is also driving the development of sustainability education material with a range of institutions for continued professional development, including Murdoch University.

## 6 Conclusions

At the beginning of the UN Decade Campaign for Education in Sustainable Development in 2005, engineering education in Australia is gradually evolving to provide engineering graduates with sustainability critical literacy skills. The authors believe that initiatives such as the *Engineering Sustainable Solutions Program: Critical Literacies for Engineers Portfolio* play an important part in accelerating the reform from 'traditional' engineering to more holistic, contextually sensitive engineering that will move society towards a more sustainable lifestyle.

This paper has provided an example of one initiative under development, part of which is being trialled nationally and internationally to gauge further opportunities for improvement. It is hoped that through the leverage points described, the program will become widely used among engineering education institutions in Australia and overseas.

Early feedback from universities participating in the trial of the Introductory Module indicates that the flexibility of the program will facilitate curricula changes for introducing sustainable development as a mainstream component of any engineering degree course. This will be more formally evaluated at the conclusion of this and subsequent trials of other modules as they are developed.

## 7 Acknowledgements

The authors would like to thank Engineers Australia for their continued support of TNEP and its initiatives, in particular Doug Jones, Martin Dwyer and Julie Armstrong. The College of Environmental Engineering within Engineers Australia is thanked for their support of the education module initiative and with the time dedicated to reviewing the material and providing feedback, in particular Tim Macoun, David Hood and Terence Jeyaretnam.

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## 8 References

American Society of Civil Engineers (2004) Sustainable Engineering Practice: An Introduction. Sponsored by the ASCE Committee on Sustainability of Technical Activities Committee. Published by ASCE, Virginia.

EESD (2002) Engineering Education for Sustainable Development: Results of the EESD conference, Delft, October 24th- 25th 2002.

Government of Western Australia (2003) Hope for the Future: The Western Australian State Sustainability Strategy. Department of the Premier and Cabinet, Perth.

Hargroves, K., Smith, M. (2005) The Natural Advantage of Nations: Business Opportunities, Innovation, and Governance in the 21st Century, Earthscan, London.

Hawken. P., Lovins, A., and Lovins, H. (1999) Natural Capitalism: The Next Industrial Revolution. Earthscan, London.

Institution of Engineers Australia (2001a) Towards a Sustainable Energy Future: Setting the Directions and Framework for Change. Sustainable Energy Taskforce Report.

Institution of Engineers Australia (2001b) Sustainable Energy Innovation in the Commercial Buildings Sector. Sustainable Energy Building And Construction Taskforce Report.

Institution of Engineers Australia (2000) Code of Ethics document. Approved by the Congress of The Institution of Engineers, Australia and adopted by The Association of Consulting Engineers, Australia and The Association of Professional Engineers, Scientists and Managers, Australia.

Institution of Engineers Australia (1999) Sustainable Transport: Responding To the Challenges. Sustainable Energy Transport Taskforce Report.

Institution of Engineers Australia (1997) Towards Sustainable Engineering Practice: Task Force on Sustainable Development.

Jones, D (2004) "From the President" columns featured monthly in The Magazine of Engineers Australia, Engineers Media, Sydney.

Krockenberger, M., Kinrade, P., and Thorman, R. (2000) Natural Advantage: Blueprint for a Sustainable Australia. Report produced for the Australian Conservation Foundation.

Paten, C., Palousis, N., Hargroves, C and Smith, M. (2004) "Engineering Sustainable Solutions Program - Critical Literacies for Engineers Portfolio: Putting Sustainability as a 'Critical Literacy' into Mainstream Engineering Curricula", International Journal of Sustainability in Higher Education, in press.

Pope, J., and Morrison Saunders, A. (2005) Sustainability Assessment Training Module: Professional Development. Murdoch University, Western Australia.

Ridley, T., and Ir. Lee Yee-Chong, D. (2002) Engineering and Technology for Sustainable Development, 2002 World Summit for Sustainable Development, Johannesburg.

World Federation of Engineering Organisations' Committee on Technology (2002) Engineers and Sustainable Development. A report that accompanied the production of a CD and Folder package by the World Federation of Engineering Organisations. France. [www.wfeo-comtech.org](http://www.wfeo-comtech.org).