“2nd Environmental Engineering Academics’ Workshop: Engineering Sustainable Solutions Program - Trial Update”

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Abstract

The Institution of Engineers Australia (Engineers Australia) believes that it is critically important for all engineers, regardless of their discipline, to have an understanding of sustainability issues and opportunities to fulfil this role in society. The Environment College of Engineers Australia (the College) has also been proactively engaged in developing material, through collaboration with The Natural Edge Project (TNEP). In 2003, the College provided a grant to TNEP to develop an Introductory Module as part of a larger initiative called of the TNEP Engineering Sustainable Solutions Program: Critical Literacies Portfolio (ESSP:CLP). This paper provides summary of the trial process that was undertaken in the Australian teaching Semester 1, 2005. Key findings from the trial are presented and review requirements are identified for the Module.

Key Words

Biographical Information on Workshop Presenter

Cheryl Paten is a lecturer in the School of Environmental Engineering, Griffith University (Queensland) where she is working to further embed sustainability principles and practices into the curriculum. Cheryl is engaged in a PhD examining ways to embed emerging sustainability criteria into engineering education. Through formal collaboration with Griffith she is also engaged with the TNEP Secretariat as Education Coordinator. In addition to her PhD studies and lecturing commitments, Cheryl's key current engagement is working with TNEP on the "Engineering Sustainable Solutions Program - Critical Literacies Portfolio" (ESSP-CL), building on from material compiled for the international publication, "The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century". She is on the Advisory Board to the International Journal of Sustainability in Higher Education, and is a Board member of the Engineers Australia Environmental Engineering College. In 2005 Cheryl was awarded Queensland Young Professional Engineer of the Year.

TNEP is an ongoing, not-for-profit partnership hosted by Engineers Australia, driven by a group of young professional engineers and scientists. 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).


1.0 Introduction

1.1 Background

It is increasingly being recognised that the engineering profession will play a significant part in moving society to a more sustainable way of life. In the last decade, environmental engineering has become more prominent as a discipline within the engineering profession; however, environmental engineering education programs at Australian universities have only made some allowance for sustainability theory and its application. The integration of such material into curriculum for other undergraduate engineering disciplines appears even more limited.

The Institution of Engineers Australia (Engineers Australia) believes that it is critically important for all engineers, regardless of their discipline, to have an understanding of sustainability issues and opportunities to fulfil this role in society. In considering accreditation requirements for university engineering courses, Engineers Australia is addressing its responsibility to ensure the inclusion of sustainability education material within undergraduate engineering curricula. The Environment College of Engineers Australia (the College) has also been proactively engaged in developing material, through collaboration with The Natural Edge Project (TNEP). In 2003, the College provided a grant to TNEP to develop an Introductory Module as part of a larger initiative called the TNEP Engineering Sustainable Solutions Program: Critical Literacies Portfolio (ESSP:CLP). A diagram showing how the introductory module fits into the overall program is appended at the end of this paper (Figure 1).

The ESSP is designed to facilitate the effective incorporation of key pieces of information, or ‘critical literacies’, relating to sustainability into engineering curricula and professional development. This introductory module is intended to compliment other student studies as an alert to sustainability principles and activity in the engineering profession. The module is supported (i.e. in its critical academic rigour and structure) by engineering related material in the publication, *The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century*, and its open-source online companion.

1.2 ESSP Development Progress - Context

Having completed the introductory module with a grant from the Environmental College, TNEP recently partnered with UNESCO and Engineers Australia through the Environmental College and Society for Sustainable and Environmental Engineering (SSEE) to develop Level 1 and Level 2 of the Critical Literacies Portfolio of the ESSP. Level 1 and 2 comprise six modules profiling best practice in sustainable engineering solutions, pulling together work from international experts in topics related to the module themes: The Role of Engineers in Sustainability; Engineering for Poverty Eradication; Resource Productivity Improvement; Green Engineering and Chemistry; Whole System Engineering Design; and Design Inspired by Nature. The first draft of Level 1 and 2 of the ESSP is complete and currently in assessment with key reviewers and expert advisors. The final draft will be complete in November 2005 and publication of the ESSP by UNESCO in early 2006.

TNEP was asked by RMIT’s Professor of Sustainability John Fien to deliver a presentation on the education program development at the Australian Commission for UNESCO Symposium (Melbourne) in July 2005. The secretariat was then invited by Australian Commission Chair Ken Wiltshire to present at the Australian Commission for UNESCO General Meeting in August 2005. Australian Commission members were impressed at the level of leadership taken by Engineers Australia to support the ESSP and its young engineers contributing to the development of the engineering profession.
The ESSP is now accredited as an official program of the UN Decade of Education for Sustainable Development. The Introductory Module was also one of three finalists in the 2005 DEC Allan Strom Eureka Prize for Sustainability Education.

1.3 Introductory Module Trial - Progress

As part of the development process, a number of higher education and vocational learning centres in Australia were invited to undertake a review and/or trial of the introductory module education material over a 12 month period, in Semester 1 of 2005. This trial follows on from the initial pilot trial conducted at Griffith University by TNEP Education Coordinator Cheryl Paten in 2004 and builds on from the trial at the University of Colorado, Boulder as a full Masters course delivered by TNEP Coordinator Charlie Hargroves and TNEP mentor L Hunter Lovins. The development process is summarised in Table 1.

<table>
<thead>
<tr>
<th>Stages of review process</th>
<th>Time-Frame</th>
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<tbody>
<tr>
<td>1. Draft Module Development (internal review by Environment College)</td>
<td>June – Dec 2003</td>
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<tr>
<td>3. Pilot Trial (Griffith University)</td>
<td>April – June 2004</td>
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<tr>
<td>4. 2004 AAEE Workshop + EESD Conference Presentation</td>
<td>Sep – Nov 2004</td>
</tr>
<tr>
<td>5. International universities trial + UNESCO module development</td>
<td>June 05 – June 06</td>
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1.3 Scope of Paper

This paper provides summary of the trial process that was undertaken in the Australian teaching Semester 1, 2005. Key findings from the trial are presented and review requirements are identified for the Module.

1.4 Acknowledgements

The development of this module was made possible by The Institution of Engineers Australia's Environmental Engineering College through provision of a financial grant along with expert peer review and mentoring throughout the process. A special thank you to Martin Dwyer, Tim Macoun, Doug Jones, Terrence Jeyaretnam, Julie Armstrong and the initial review panel Trevor Daniell, Thomas Brinsmead and David Hood, for their continued support in developing further material and training hereon.

The Natural Edge Project would like to thank the lecturers and teachers that have agreed to take part in the academic review and trial: Margaret Rossiter (Australian National University), Elizabeth Taylor (Central Queensland University), Kevin Chennel and Steve Milner (Central TAFE – WA), Sherif Mohamed and Carol-Joy Patrick (Griffith University), Les Dawes and Richard Brown (Queensland University of Technology), Aussie Kanck (TAFE SA), Angus Simpson, Daniel Handley and Holger Maier (University of Adelaide), Stephen Hall (University of Ballarat), Graham Moore (University of Melbourne), Stephen Moore (University of New South Wales), David Radcliffe and Kate O’Brien (University of Queensland), David Dowlng and David Thorpe (University of Southern Queensland), Carolyn Oldham (University of Western Australia), Roger Hadgraft (RMIT), Julia Lamborn (Swinburne University of Technology) and Euan Nichol (Victoria University).
2. Trial Process Overview

The Natural Edge Project, in partnership with Engineers Australia, is collaborating with 16 higher education and vocational institutions in Australia, to trial the Introductory Module of the ESSP:CLP, in Semester 1 and 2, 2005. Key objectives of the voluntary trial are to:

- gauge the usefulness of the format and content of the material developed, in the context of existing engineering programmes;
- receive feedback and review of the material to enable a detailed revision of the material to be undertaken;
- engage with University and TAFE lecturers and teachers across Australia, to form a community of learning around the trial.

Towards the end of each semester, the participants are required to submit a brief report summarising the review and/or trial experience and relevant recommendations or comments, and have students complete a student feedback form. The format of the trial and reporting has been as flexible as possible (ie with regard to the programmes, class sizes, and departments), to engage with as many higher education and vocational institutions as practicable.

Lecturers and teaching staff were given the options of completing one or both of the following:

- a desk-top review of the module;
- a trial of some or all of the module within one or more of their existing courses.

The following universities completed reviews in Semester 1:

<table>
<thead>
<tr>
<th>Higher Education/ Vocational Institution</th>
<th>State</th>
<th>Focus of Curriculum Trial: Semester 1 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian National University</td>
<td>ACT</td>
<td>Faculty of Engineering &amp; Information Technology</td>
</tr>
<tr>
<td>University of New South Wales</td>
<td>NSW</td>
<td>School of Civil &amp; Environmental Engineering (Faculty of Engineering)</td>
</tr>
<tr>
<td>Griffith University</td>
<td>QLD</td>
<td>School of Environmental Engineering (Faculty of Environmental Sciences)</td>
</tr>
<tr>
<td>University of Queensland</td>
<td>QLD</td>
<td>School of Environmental Engineering (Faculty of Engineering, Physical Sciences and Architecture)</td>
</tr>
<tr>
<td>University of Adelaide</td>
<td>SA</td>
<td>School of Mechanical Engineering (Faculty of Engineering, Computer and Mathematical Sciences)</td>
</tr>
<tr>
<td>University of Ballarat</td>
<td>VIC</td>
<td>School of Science and Engineering</td>
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The following Universities and TAFE colleges are conducting a trial and review in the Semester 2:

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<thead>
<tr>
<th>Higher Education/ Vocational Institution</th>
<th>State</th>
<th>Focus of Curriculum Trial: Semester 1 2005</th>
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</thead>
<tbody>
<tr>
<td>Australian National University</td>
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</tr>
<tr>
<td>Griffith University</td>
<td>QLD</td>
<td>Faculty of Engineering &amp; Information Technology (all schools)</td>
</tr>
<tr>
<td>Queensland University of Technology</td>
<td>QLD</td>
<td>Faculty of Built Environment &amp; Engineering</td>
</tr>
<tr>
<td>University of Southern Queensland</td>
<td>QLD</td>
<td>Faculty of Engineering &amp; Surveying</td>
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</table>
3. Summary of Module Review and Trial Feedback – Semester 1 2005

3.1 General Comments

It appears that, in general, trial participants of the Introductory Module did see the module as a beneficial tool to introduce the concepts of social responsibility, environmental conservation and regenerative development (rather than just minimising impacts) from a whole of system approach, within the context of engineering design and services. All participants used the Introductory Module within the existing curriculum of first-year engineering courses, however interest was expressed in incorporating the material within other year levels and at a Masters level.

Quotes from general feedback on the module include:

- “The CLP 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……. This program is a vital step in ensuring that engineers think about the impact that they command as designers and project managers.” (Melbourne University)

- “The Critical Literacies Portfolio (CLP) is a timely and innovative package that provides much needed educational material for undergraduate engineering courses.” (University of Adelaide)

- “By targeting the next generation of engineers, this program is demonstrating extraordinary vision and long-term commitment.” (Australian National University)

- “Many of the concepts (e.g. Factor 4) required greater time to explain than anticipated. Students appeared to have little prior knowledge on which to build understanding, this required time to be spent on regional and State-wide examples (e.g. brown coal, cheap electricity, aluminium production).” (University of Ballarat)

- “There is a lot of information in these modules which … would be great for [all] engineers to get on board with, but it needs to be presented with very close ties to what they will do, because otherwise it can be dismissed by them as “greeny” stuff. The lectures definitely present the sustainability in a very positive way, as an opportunity rather than a guilt-trip which is fantastic, but I suspect that the ties directly to engineering applications need to be tighter for it to be most effective”. (University of Queensland)

3.2 Comments on Module Content
Trial participants noted the use of content from a diverse set of disciplines (engineering, economics, social science, ecology, biology, and governance) to advocate a whole of system/society approach to the delivery of sustainable engineering solutions. The multidisciplinary nature of the module was found to generate significant interest among students, however because of this, more time was thought to be needed than originally anticipated, to adequately cover each unit within the allocated lecture time.

The use of case studies greatly assisted the understanding of the students, and their confidence in the role of the engineering profession playing a role in sustainable development as the case studies showed examples of solutions that already exist.

An important characteristic of the Introductory Module content to trial participants was the extensive review of literature conducted to ensure the material is rigorous and supported by known publications. Reference also to current media stories demonstrated the relevance of sustainability in engineering, stimulating interest in the content amongst students and trial lecturers alike.

Comments on Module content include:

- “Students admitted to having little or no prior knowledge of the material offered and were genuinely interested in the interrelationships between economic, environmental and social issues, once the key role of the engineer was explained.” (University of Ballarat)

- “The program introduces behaviours, situations, cause-effect outcomes etc. to which the students can relate and develops the discussion from this strong contextual base. The material is engaging and the success-cases are motivating.” (Australian National University)

- “Using a range of case studies, the program demonstrates that sustainability and education of sustainability is not linked to a specific discipline or industry but must be integrated across all disciplines to be successful.” (Melbourne University)

- “The program provides the most up-to-date material from the experts in the field covering diverse and fast evolving technologies. This material is ground breaking in that it covers such a wide range of specialised areas and draws together the critical information to give engineering students a clear picture of the current sustainability landscape.” (University of Adelaide)

### 3.3 Comments on Style/Structure

Comments on the style and structure from Trial Participants were generally positive although there was constructive critique on making the material more ‘accessible’ for lecturers with very limited preparation times. The particular design of each unit (ie Educational Aim, Key Points, Brief Background Information, Key References, Key Words, and Assessment Questions & Activities) was generally regarded by trial participants as a useful format to assist the lecturer in adapting the material to suit their own needs.

Trial Participants noted that the style and structure of each module, and in particular the assessment questions and online companion, further encouraged thinking and research beyond the scope of the lecture. The modular design of the module enabled Trial participants to embed whole units within the existing course, across multiple engineering disciplines.

Comments on Module Style/Structure include:

- “What I would find very helpful is 6 pages or so per lecture (absolute maximum of 10), with 6-10 key learning objectives (lecturer to choose main ones), with a variety of graphics, some concise but specific examples with a strong engineering focus [-] and all of the fantastic references which are in the document.” (University of Queensland)
"The framework offered by ESSP will ensure a collective understanding for engineering students of the problems being faced, the approaches that are showing success and the opportunities that exist in sustainable development. While this framework has been designed to achieve certain learning outcomes, it also promotes wider thinking and encourages innovative approaches – something that appeals to the target audience." (Australian National University)

"The CLP breaks new ground by providing a flexible suit of learning support material to allow instructors with a wide range of backgrounds to adapt the material to their own needs. The combination of material to personalise courses, but have the backup of the companion book and website to maintain currency of material are at the cutting edge of sustainability education." (Melbourne University)

"The modular design of the program makes it versatile enough to be applied to all disciplines of engineering education. This reflects the diversity of areas where sustainability principles must be applied and the myriad solutions that may be applied to solve engineering problems in a sustainable fashion." (University of Adelaide)

"The material was used to give structure to ‘big picture’ considerations (e.g. historical development of international agreements and summits) in lectures with previous quantitative tutorial problems similar to calculations in ‘Triple Bottom Line Reporting in Australia’." (University of Ballarat)

3.4 Comments on Implementation/Delivery

Feedback from the Trial Participants suggests a positive response from students and lecturers on the delivery of the Introductory Module material in lectures. Lecturers implemented the material, using parts or the entire module, to suit their own needs and established delivery methods. In most trials interactive class discussion was used to discuss the concepts and case studies covered in the Module.

Based on the material taken from the Introductory Module, some lecturers reported that they are now starting to see students take into consideration the environmental and social factors within their design projects and essays.

Module Implementation/Delivery Comments Include:

- "The idea behind the lectures is very good, producing a resource for lecturers to use. However, I did not find the lectures very usable in the current format. [comments re. fewer learning points, more graphs, less text and more worked examples were provided – see Section 4]" (University of Queensland)

- "Students are considering the issues in their design projects, in their presentations of different engineering disciplines and in their essay topics. The students have highlighted the significance of whole system thinking to a range of 21 engineering disciplines including Software, Geomatics, Materials, Robotics, Risk Management, Telecommunications, and Chemical. The ESSP program appears to have awakened sensitivity to the importance and relevance of sustainability issues for engineers. The students essay topics are diverse and not overtly directed to sustainability issues. (Australian National University)

- “… for each topic, triple-bottom-line considerations were evident in almost every essay.” (Australian National University)

- “From an instructional design point of view, there is also clear evidence of research into sound educational techniques to enable the academic delivering the program to personalise the program without losing key educational objectives embedded in the program.” (Melbourne University)

- “Class discussion was also used to debate possible units for life cycle analysis with an example of building construction alternatives with greenhouse gas emissions as a unit of measurement given as directed reading.” (University of Ballarat)
Suggested additions included:

- Discuss the quotation “Science is necessary, technology not always”.
- “Given the modern pace of technological innovation and the capacity for long-term testing in regard to human health, producers’ responsibilities for technological disasters should be time-limited.” Discuss.
- “Law enforcement technology threatens individual privacy.” Discuss

4. Opportunities for Review & Revision

Based on the feedback from the Semester 1 trial, the following observations are made about opportunities for review and revision of the Module.

4.1 Training Manual Amendments

- Clarification of how this module fits into the Portfolio (update this section in the Training Manual). This will address comments by some lecturers who are seeking more worked examples, as worked examples are provided in subsequent modules (under development).
- Acknowledgement in the Training Manual that a better understanding of systems is a learning outcome of the Introductory Module.
- Clarification regarding Teacher requirements with respect to the likely number of hours for preparation, based on the extent of their knowledge base. This section in the Training Manual should also provide information on the need to include time for review before preparing lectures/workshops. A justification of the word length (ie 25-45 pages to support an individual lecture) should also be provided, reminding the lecturer that the ‘back end’ is background information – most of the material is within the first 6 pages.
- Enhance information within the Training Manual on the merits of Problem Based Learning, and how trainers can make use of the ‘Activities’ sections to guide discussion. Also note that this part of each unit can be used to relate the material back to the students’ engineering disciplines.
- Include a section in the Training Manual on teaching large classes. Include tips on using quality graphs and images, promoting discussion, breaking up the lecture etc.

4.2 Unit Amendments

- Clarification of Key learning points within each unit, to enhance ‘accessibility’ for lecturers with minimum preparation time and/or limited lecture/workshop time with students. In order to assist lecturers delivering each unit within an hour timeslot, the key learning points for each part within each unit can be reviewed to select four to five core learning points for the whole unit. Each of the parts within the Unit can then form ‘supplementary learning points’. These can also be double-checked to make sure that they are in a logical sequence.
- Graphics Assistance: While copyright restrictions prevent the inclusion of graphs, the units will be revised to have a ‘Graphics Assistance’ heading in each part, linking to quality websites and pages that provide images, cartoons and graphs.
- Links to other modules: In order to facilitate lecturers explain some mechanisms in more detail, each part of each unit can provide links to other modules (currently under development).
5. Conclusions

At the conclusion of the Semester One trial process, the following general conclusions were made:

- The Introductory Module is pitched at the right level to build students’ awareness of the role of the engineering profession in delivering more sustainable engineering solutions, specifically those that take into account social and environmental impacts and their effect on the economic performance of the product or service. It is noted that just under half of the trial participants are within environmental engineering schools, while the rest are from a variety of engineering disciplines.

- There is perhaps an expectation by lecturers in the engineering schools that as the material is in modular format, it is immediately transferable to the classroom. While the module does bridge a significant gap in providing peer-reviewed material based on emerging consensus, this does not mean that the lectures or workshops will self-assemble. Although preparation time is significantly reduced because the material has already been sourced, reviewed and the content is in order, time will be required, dependent on the teacher’s background (ie prior learning and training).

- The Module provides a sufficient mix of content and case studies across the disciplines (both engineering and non-engineering) to generate and maintain student interest while effectively delivering the message that a whole of society approach is in fact required to deliver sustainable solutions.

- The Module appears flexible enough to be used with all engineering disciplines and using a variety of teaching styles (eg for small versus large class sizes, workshop style versus whiteboard learning).

- The structure and style of each unit appears effective in providing lecturers with the flexibility to utilise the material to suit their needs, thereby acting as a curriculum-enhancing tool as well as a course substitute. Due to the length of some units and the problems associated with exceeding lecture time, trial participants will need to decide which key points to combine or remove from lecture delivery.

- Depending on the level of prior learning in this area (ie knowledge base), there may be time required for self learning (using the material) before teachers can then embark on preparing and delivering lectures.

6. What Happens Next?

So, what happens next? it appears that the national ESSP partnership is moving in the right direction with regard to seeking strategies to embed sustainability critical literacy skills into engineering degrees. Amendments to the module (as recognised in this paper) are awaiting additional input from the Semester 2 2005 trial.

The second semester trial will continue to develop relationships with other universities to obtain further trial and review feedback. If your vocational or higher learning institution is not involved in the trial but would like to be, please contact me on cheryl@naturaledgeproject.net for more information. Thank you to all current participants - we look forward to feedback.
Figure 1. Diagram showing the relationship between the Introductory Module (Module I.1) and the rest of the Engineering Sustainable Solutions Program: Critical Literacies Portfolio.
6. References


5. The Natural Edge Project (TNEP) is an ongoing, not-for-profit partnership hosted by Engineers Australia, driven by a group of young professional engineers and scientists. 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).

6. Refer to www.naturaledgeproject.net/ESSP.aspx for further information


9. The Prize was awarded to a very worthy entry, the Victorian Sustainable Schools Pilot, developed and delivered by the CERES Community Environment Park and the Gould League (a joint initiative of the Federal Department of the Environment and Heritage and the Victorian Government).
