



DEVELOPING e-LEARNING MATERIALS FOR SUSTAINABLE CONSTRUCTION MANAGEMENT

Final Report

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SUMMARY

Teaching of sustainability issues in Construction and Civil Engineering is currently being achieved fragmentally, and lacks broadness and depth in terms of the issues covered. The aim of this project was to develop e-learning materials to effectively equip learners with essential knowledge and skills in assessment of sustainability within the built environment, through the creation of a WIKI ('What I know is') interface.

A series of learning outcomes were devised to act as objectives for developing the teaching materials to be accessible via the WIKI.

The tasks carried out during the project were the development of a knowledge repository of information relating to the field, the development of learning materials based on this information, the conversion of these materials into an electronic web-ready form, the evaluation of the WIKI through consultation with a wider body of experts, and the publication of the WIKI on-line.

The teaching materials were developed under the thematic headings of '*Sustainable Development Indicators*', '*Environmental Management Systems*', '*Environmental Impact Assessment, Strategic Environmental Assessment and Sustainability Appraisal*', '*Life-Cycle Assessment*', '*Sustainable Construction Tools*', and '*Sustainability Accounting and Cost Benefit Analysis*'.

The materials developed have been converted to an HTML format using the TeamsLX WIKI development tool.

Feedback from the wider group of experts has so far been limited, but it is anticipated that more detailed feedback will be forthcoming. The WIKI has been trialled as part of teaching modules delivered by the Division of Civil Engineering at the University of Dundee.

An editable form of the WIKI has been published within the University of Dundee's e-learning facilities. A non-editable, stand-alone form of the WIKI is publicly available on the internet.

By its nature, the WIKI will continue to grow and develop as further contributions and modifications are made to it. A series of plans for future development are provided.

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1 BACKGROUND

Sustainable construction management is a complex subject cutting across many different disciplines. The teaching of sustainability issues in Construction and Civil Engineering is currently being achieved fragmentally, and lacks broadness and depth in terms of the issues covered. In order to meet the needs of employers and professional bodies, the aim of this project was to develop e-learning materials to effectively equip learners with essential knowledge and skills in assessment of sustainability within the Built Environment. This has been carried out through the development of a WIKI ('What I know is') interface dealing with international and UK framework sustainable development indicators, building assessment tools, UK regulation and guidance, and other sustainability assessment systems.

2 OBJECTIVES

The project has been carried out with the underlying philosophy that a strong emphasis should be placed on interaction and participation enhanced by utilizing a computer-based collaborative learning network. The overall aim of the project was, therefore, to develop an electronic learning system created using up-to-date WIKI web technologies. A range of experts can contribute to the modules and, under supervision, the learners can create, edit and modify contributions to a website. It allows them to easily share knowledge with others. Thus, collaboration is encouraged, both between the various branches of engineering and also between engineers and other professions.

The WIKI is intended to be used in combination with lecture and tutorial-based teaching modules with assessed assignments which require interrogation of the WIKI for information and external sources of data. The target learning outcomes from use of the WIKI are:

- Critical understanding of sustainable development principles;
- Critical understanding of international, national and regional sustainable development policies, indicators and targets;
- Critical understanding of green building and the sustainable built environment;
- Knowledge of how to select and apply environmental management systems;
- Knowledge of how to perform life-cycle analysis; and
- Familiarity with current sustainable building assessment tools.

These learning outcomes were used as objectives to guide the development of the teaching materials during the project. The development activities are discussed in the next section.

3 APPROACH TAKEN

The project programme was divided into four tasks described below.

3.1 Task 1 - Development of Knowledge Repository

The first task in the project was to gather together information and data relating to key topics in the field of sustainable construction management, and to develop teaching materials from this information. The key themes covered were:

- Sustainable development indicators;
- Sustainable building assessment tools;
- Environmental impact assessments;
- Social impact assessments.

3.2 Task 2 - e-Content Development

The materials developed in Task 1 were then converted to a web-ready WIKI format.

3.3 Task 3 – Evaluation

A wider group of experts were contacted to provide feedback on the WIKI.

3.4 Task 4 – Publish

The WIKI was published on my.dundee.ac.uk (the e-learning system for the University of Dundee, based around Blackboard). A publicly accessible, non-editable version of the WIKI was also published on the internet.

4 OUTCOMES

4.1 Task 1 – Development of Knowledge Repository

The information gathered and teaching materials developed can be divided into six themes, plus a short section describing and providing access to a previous research project carried out at the University of Dundee. These themes are discussed in more detail below.

4.1.1 Sustainable Development Indicators

The sustainable development indicators theme places emphasis on the United Nations Commission on Sustainable Development (CSD) sustainability indicators. This approach has been taken on the grounds that the UK and many other countries have adopted sustainability indicators which closely follow the CSD indicators. Links are also provided to information relating to the UK's current

sustainability status, the Sustainability Dashboard computer program, plus other systems of indicators.

4.1.2 Environmental Management Systems

The coverage of environmental management systems (EMS) places emphasis on the ISO 14000 series of standards, since this is the most widely-used environmental management framework. The basic approach to devising an EMS complying to ISO 14000 is described and the key standards in the series are described. Links are also provided to sites providing details of other EMSs including EMAS, The Natural Step and Natural Capitalism. Links are not provided to the standards themselves, as subscription is required. Most UK higher education organizations will have access to these resources via online library services.

4.2 Environmental Impact Assessment, Strategic Environmental Assessment and Sustainability Appraisal

This theme examines three related approaches to assessing likely environmental impact. Environmental impact assessment (EIA) is traditionally applied to construction projects during both construction and operation. A detailed examination of the processes required to carry out an EIA are included. This includes a discussion of specific approaches to establishing environmental baselines, projecting baselines forward, and predicting impacts. This includes links to sources of data and all related UK legislation.

Strategic environmental assessment and sustainability appraisal are adaptations to the basic EIA process by the UK government to assess the impact of government policies/plans/programmes and spatial planning strategies. Thus, these methodologies are outlined with reference to the basic EIA methodology, with links to UK government guidance documents.

4.2.1 Life-Cycle Assessment (LCA)

The coverage of LCA is structured to reflect the normal procedures as defined in the ISO 14040 and 14044 standards. Each stage of the LCA process is described in detail, with links to data sources, where appropriate. In addition, background information on the following environmental issues is included:

- Abiotic Depletion/Depletion of Abiotic Resources
- Fossil Fuel Depletion
- Land Use
- Global Warming/Climate Change
- Ozone Depletion Potential
- Human Toxicity
- Ecotoxicity
- Photochemical Ozone Creation Potential
- Acidification

- Eutrophication

4.2.2 Sustainable Construction Tools

The material on sustainable construction tools includes tools developed in both the UK and North America. These are:

- BREEAM (Building Research Establishment, UK);
 - BEES (National Institute of Science and Technology, USA);
 - SBTool (International Initiative for a Sustainable Built Environment, Canada);
- and
- LEED (US Green Building Council).

4.2.3 Sustainability Accounting and Cost-Benefit Analysis

Sustainability financial accounting (SFA), full cost accounting (FCA) and cost-benefit analysis (CBA) are all discussed in this section. Links are provided to methodology documents dealing with SFA and FCA.

4.2.4 Metrics, Models and Toolkits for Whole Life Sustainable Urban Development, an EPSRC-funded project

This was an EPSRC-funded project conducted by the Construction Management Research Unit at the University of Dundee, dealing with a number of issues relating to the subjects covered by the knowledge repository. Thus a link is provided to access the findings and key documents of this project.

4.3 Task 2 - e-Content Development

The conversion of the materials collated during Task 1 was carried out via the University of Dundee's e-learning system, which is based on a Blackboard platform. Information was entered via the HTML editor interface of the TeamsLX WIKI development tool. The WIKI currently consists of 107 pages (including the home page). Pages addressing the learning outcomes of the project are listed in Table 1. The general hierarchy of the pages is indicated, although it should be stressed that as a result of the inter-linked nature of the WIKI, these are very approximate.

Much of the activities relating to sustainability assessment and environmental management relate to the sourcing and use of environmental, social and economic data. For this reason the WIKI also acts as a launch pad to various websites which provide access to data on a range of aspects of environmental impact. For instance, the discussion of air quality baseline evaluation under the environmental impact assessment section provides links to the Carbon Trust, the Air Pollution Information System, the Air Quality Archive, the Environment and Heritage Service (Northern Ireland), the National Atmospheric Emissions Inventory, NETCEN, the Scottish Environmental Protection Agency, and the Scottish Executive.

Table 1. Pages and Approximate Hierarchies in the WIKI.

Sustainable Development Indicators	Sustainable Construction Tools	Environmental Impact Assessment, Strategic Environmental Assessment and Sustainability Appraisal		
	<i>BREEAM</i>	<i>Environmental Impact Assessment (EIA)</i>		
	BREEAM Buildings BREEAM Developments BREEAM Invest BREEAM LCA BREEAM Smartwaste BREEAM Specification	EIA - Air Quality and Climate EIA - Air Quality Baseline Data Sources EIA - Archaeological Baseline Data Sources EIA - Archaeological, Material and Cultural Assets EIA - Baseline Studies EIA - Checklists EIA - Descriptive Checklists EIA - Ecology	EIA - Economic Impacts EIA - Impact Prediction EIA - Landscape EIA - Magnitude Matrices EIA - Mitigation Recommendations EIA - Monitoring EIA - Monitoring Recommendations EIA - New Approach to Appraisal (NATA) EIA - Questionnaire Checklists	EIA - Receptors EIA - Scoping EIA - Significance EIA - Simple Matrices EIA - Social Impacts EIA - Socio-Economic Impacts EIA - Soils, Geology and Geomorphology EIA - Time-Dependent Matrices EIA - Noise EIA - Presentation of Findings EIA - Transport EIA - Water EIA - Threshold of Concern Checklists
	<i>BEES</i>	<i>Strategic Environmental Assessment (SEA)</i>		
		SEA - Screening SEA - Stage A	SEA - Stage B SEA - Stage C SEA - Consulting Bodies	SEA - Stage D SEA - Stage E
	<i>LEED</i>	<i>Sustainability Appraisal (SA)</i>		
	<i>SBTool</i>	<i>Integrated Impacts Assessment</i>		
Environmental Management Systems	Sustainability Accounting and Cost Benefit Analysis	Life-Cycle Assessment		
<i>ISO 14000 Series</i>		<i>LCA - Accessibility</i> <i>LCA - Allocation</i> <i>LCA - Allocation Procedures</i> <i>LCA - Assumptions</i> <i>LCA - Calculating Data</i> <i>LCA - Categorisation</i> <i>LCA - Characterisation</i> <i>LCA - Classification</i> <i>LCA - Collecting Data</i> <i>LCA - Completeness Check</i> <i>LCA - Conclusions, Limitations and</i>	<i>LCA - Data Requirements</i> <i>LCA - Evaluation</i> <i>LCA - Goal and Scope Definition</i> <i>LCA - Identification of significant issues</i> <i>LCA - Impact Assessment</i> <i>LCA - Intended Application</i> <i>LCA - Interpretation of Results</i> <i>LCA -</i>	<i>LCA - Limitations</i> <i>LCA - Normalisation</i> <i>LCA - Relevance</i> <i>LCA - Reliability</i> <i>LCA - Sensitivity check</i> <i>LCA - The Functional Unit</i> <i>LCA - The System Boundary</i> <i>LCA - Type and Format of</i>

		<i>Recommendations</i> <i>LCA - Consistency Check</i> <i>LCA - Critical Review</i> <i>LCA - Data Quality Requirements</i>	<i>Interpretation to be Used</i> <i>LCA - Inventory Analysis</i> <i>LCA - LCIA Methodology and Types of Impacts</i>	<i>Report</i> <i>LCA - Type of Critical Review</i> <i>LCA - Value Choices and Optional Elements</i> <i>LCA - Weighting</i>
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Table 1. (continued) Pages and approximate hierarchies in the WIKI.

Sustainable Development	Abiotic Depletion / Climate Change	Acidification	Eutrophication	Global Warming
Land Use	Ozone Depletion	Photochemical Ozone Creation	Toxicity	Local Development Documents
Regional Spatial Strategies	Metrics, Models and Toolkits for Whole Life Sustainable Urban Development			

4.4Task 3 - Evaluation

Feedback from the wider group of experts has so far been limited, partly due to work commitments of this group. However, expressions of willingness to provide feedback have been received and it is anticipated that more detailed feedback will begin arriving in July and August of this year.

The WIKI has been trialled as part of teaching modules delivered by the Division of Civil Engineering at the University of Dundee, namely the MSc modules CE50019 – Concrete: Sustainable Use and Environmental Impact Assessment, CE50004 – Sustainable Construction, and CE52002 – Health, Safety and Environmental Management. Specifically, the WIKI has been used to complement lectures on both environmental impact assessment (EIA) and life-cycle assessment (LCA) and to act as a procedural guide and data-locating gateway for carrying out EIA and LCAs as coursework assignments. Based on student feedback and trends in assignment submission content, modifications have been made to the WIKI.

4.5Task 4 - Publish

The editable form of the WIKI is held in the University of Dundee’s e-learning facilities, and is accessible with login and password that can be supplied to persons wishing to become contributors. Each page of the WIKI can be accessed for editing, and comments can be left on each page for contributors. The WIKI development environment used in this case also has a discussion board facility and a repository for relevant documents. A screenshot from the Blackboard-based WIKI is shown in Figure 1.

The platform permits the export of the WIKI in a non-editable, stand-alone html form. This version of the WIKI is available publicly at <http://www.personal.dundee.ac.uk/~tddyer/wiki.htm>. The WIKI will also be made available from an easier to remember URL in the near future. This page also gives contact information to people wishing to become contributors to the WIKI. A screenshot from the stand-alone HTML WIKI is shown in Figure 2. The editable WIKI is converted to a stand-alone form and uploaded on a weekly basis.

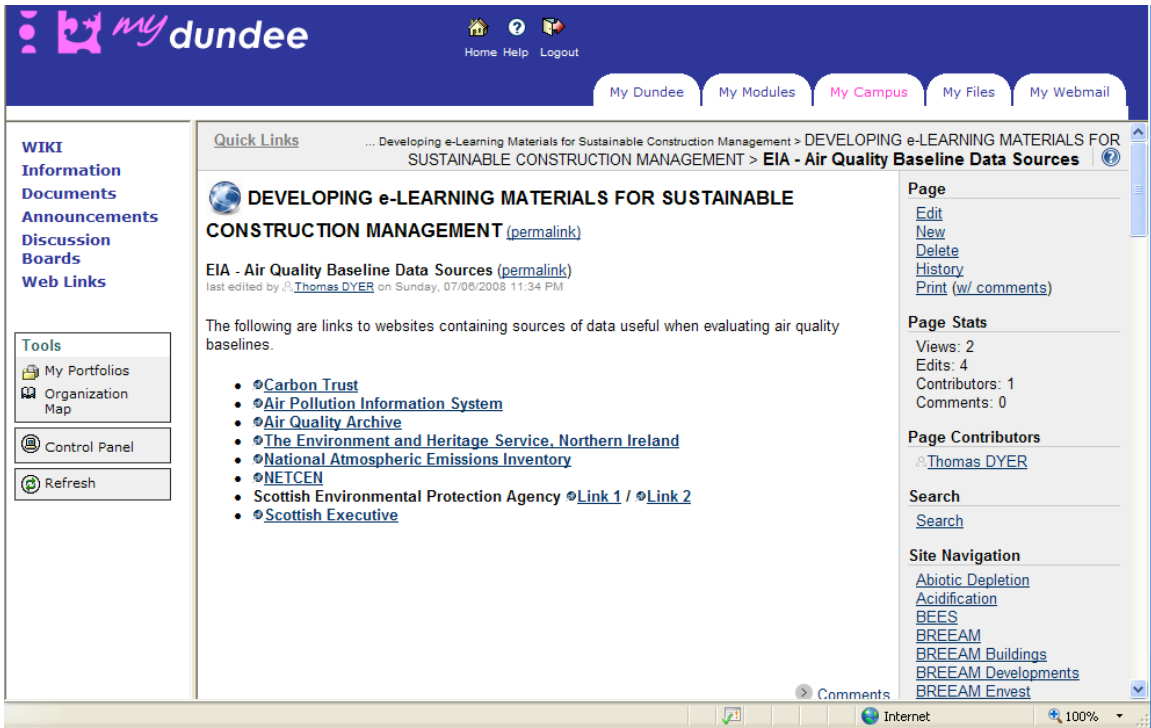


Figure 1. Screenshot from the Blackboard-based WIKI.

Sustainable Development Indicators

Measuring a society's progress towards [sustainable development](#) clearly presents problems in terms of what should be measured. With this in mind, The United Nations Commission on Sustainable Development (CSD) has, since the mid-1990s, published a series of sustainability indicators which can be used by countries to develop their own national indicators tailored to their own specific circumstances. These CSD indicators were first published in 1996, with revised versions in 2001 and 2007.

The indicators include 'Core' indicators which cover issues that are relevant for sustainable development in most countries, and can be calculated from data which is likely to be readily available to the governments of most countries. 'Other' indicators cover possible other ways in which performance can be measured.

Whilst there is some overlap between the different indicator themes, the themes with a primarily social aspect are 'Economic development', 'Global economic partnership' and 'Consumption and production patterns'. The themes which deal with environmental issues are 'Natural hazards', 'Atmosphere', 'Land', 'Oceans, seas and coasts', 'Freshwater', 'Biodiversity'. Economic aspects of sustainability are dealt with through the 'Governance', 'Poverty', 'Demographics', 'Health', and 'Education' themes. These themes are detailed below in terms of their subthemes and indicators.

THEME	SUBTHEME	CORE INDICATOR	OTHER INDICATOR
POVERTY	Income Poverty	Proportion of population living below national poverty line	Proportion of population below \$1 a day
	Income Inequality	Ratio of share in national income of highest to lowest quintile	
	Sanitation	Proportion of population using improved sanitation facilities	
	Drinking Water	Proportion of population using an improved water source	
	Access to Energy	Share of households without electricity or other modern energy services	Percentage of population using solid fuels for cooking
	Living Conditions	Proportion of urban population living in	

Figure 2. Screenshot from the stand-alone html WIKI.

The WIKI has been publicized at the "Sustainability and the Curriculum: Progress and Potential" workshop at the University of Bradford, 10-11 July, 2007 and at the "Building Education and Research" Conference, February 2008, Kandalama, Sri Lanka. It will also receive publicity at "Concrete: Construction's Sustainable Option" at the University of Dundee, 8-10 July 2008.

It is likely to be publicized at "Waste 2008", Stratford-upon-Avon, 16-17 September 2008, depending on work commitments. One aim of publicizing the WIKI is to develop a body of regular contributors, such that continuous development can be maintained throughout the WIKI's active life.

5 FUTURE DEVELOPMENT

By definition, a WIKI will continue to change beyond the completion of this project. The nature of a WIKI means that it is a constantly developing body of work whose extension and expansion is controlled by the community of contributors. However, certain major objectives have been set for the enhancement of its function. And these are discussed below.

5.1 Further Evaluation

As discussed in Section 4.3. The majority of evaluation sought on the WIKI is still outstanding. Thus, a near future aim is to call in this feedback and to act on any comments or recommendations.

5.2 Extension of Data Sources

The quantities of data available, particularly in terms of emissions factors and 'state of the environment' information useful for establishing environmental baselines are immense, and it is conceded that the WIKI currently only scratches the surface. For this reason, sourcing of data will be an ongoing process.

5.3 Expansion of Social Elements

Most of the social aspects of environmental impact dealt with by the WIKI currently place emphasis on socio-economic aspects of impact, with only minor discussion of aspects such as quality of life and happiness. Thus, the expansion of this aspect of the WIKI is a priority.

5.4 Visual Materials

The WIKI interface is currently text-based, with diagrams used where these assist in understanding. However, there is a strong argument for enhancing its visual appearance through the use of photographic material. Inclusion of such materials has been flagged as an important part of the WIKI's further development.

5.5 Accessibility

One major aim for the future development of the WIKI is to ensure accessibility to people with disabilities and for people using mobile devices. This further development is likely to be carried out in collaboration with the University of Dundee's Information and Communication Services.

6 CONCLUSIONS

The overall aim of this project was to develop electronic teaching materials relating to environmental management in the built environment. A series of outcomes which were felt to be key requirements of learning in this field were drawn up, and used as aims to direct the project activities.

The project has successfully collated information relating to environmental management issues in the built environment. This information has been used in the development of teaching materials for higher education modules under the thematic titles '*Sustainable Development Indicators*', '*Environmental Management Systems*', '*Environmental Impact Assessment, Strategic Environmental Assessment and Sustainability Appraisal*', '*Life-Cycle Assessment*', '*Sustainable Construction Tools*', and '*Sustainability Accounting and Cost Benefit Analysis*'.

The teaching materials have been incorporated into a computer-based WIKI system. The WIKI has been published online, both in an editable form with

password access within the University of Dundee's e-learning facilities, and as a non-editable publicly accessible site.

The nature of WIKIs means that development is an ongoing process. Plans for further development for the short- and long-term future of the WIKI have been drawn up, some of which are currently in progress. Key to this ongoing development process is the establishment of a body of regular contributors.

Initial student evaluation of the WIKI has been extremely useful, and the WIKI will be employed again within the University of Dundee in the next academic year to assist in teaching the modules discussed in Section 4.3. It will also be used in the teaching of a new Construction Management module which is currently under development. To achieve wider national (and possibly international) usage of the WIKI, as well as expand the contributor base, it is recognized that wider publicity is required. Some activities to achieve this have already been carried out, but additional plans are being developed including an article in an appropriate periodical. Possible additional routes to improving awareness of the WIKI are also currently being discussed.

END