Industrial Design and Engineering Transition
to Radical Innovation for Sustainability in Tertiary Education:

*Concept Design Strategies based on a New Zealand Study*

A thesis presented in partial fulfilment of the
requirements for the degree of

Master of Philosophy

in

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Abstract

A UN Decade of Education for Sustainable Development (UNDESD) is currently in progress from 2005 – 2014. The importance of Sustainable Development (SD) and Sustainable Product Design (SPD) has been recognized by the professional bodies for industrial design and engineering, and promoted within tertiary education. A consensus gained from a literature review revealed that radical innovation is now necessary to achieve Factor 4 (i.e. reducing resource use to a quarter of the total), or Factors 10-20 (reducing resource use to a 10th – 20th of levels in the present production/consumption model) in upholding global environmental and social integrity. Design and engineering are seen as “core catalysts of change” towards radical innovation for sustainability, and therefore essential that industrial designers and engineers be appropriately educated. The motivation and main aim of this research was therefore to develop an educational framework for mainstream industrial design and engineering in SD/SPD at tertiary level. This should be based on the key concepts of SD/SPD towards radical innovation, successful international examples of industrial design and engineering curricula, as well as any pertinent information derived locally from the New Zealand design and engineering scenario. The latter was derived via a survey of industrial/product design, mechanical/mechatronics engineering students in their final year of undergraduate study in New Zealand.

These research strands were synthesized and further refined, using a 4-year undergraduate degree structure (combined years 1-2 for a 3-year design degree programme). The Conceptual Educational Framework and Guidelines are intended as an aid and underlying structure towards embedding radical innovation for sustainability in Industrial Design and Engineering curricula. Together, they provide a draft, a roadmap of essential and important concepts, to combine with discipline-specific core content of Industrial Design and Engineering undergraduate degrees.

The NZ survey results proved similar to international studies: an overall discrepancy between the high ratings of the importance of sustainability and low values in actual knowledge, with definitions of ecodesign (eco-efficiency through reduction and/or minimization of harmful environmental impacts), rather than eco-effective, beneficial sustainable design (comprising environmental, economic and social considerations). The key recommendations are documented within four concepts: 1. Emphasis on the Social Element of SD/SPD, 2. Transition towards Systems Thinking via PSS (Product-Service Systems), 3. Complementary Sustainable Design Strategies and 4. Transition towards Strategic Design. These concepts advocate emphasis on the social element of SD/SPD through context and creativity; systems thinking via PSS; eco-effectiveness and Cradle-to-Cradle design principles (C2C), followed by eco-efficiency for optimization; and all governed by strategic design. The design intent of the Conceptual Educational Framework and Guidelines is to maximize beneficial, eco-effective systems, sustainable behaviour, equity, quality of life, and connecting design, technology and human behaviour.
Acknowledgements

I would like to sincerely thank all those who have helped me in their various ways towards completion of this Master’s thesis, a goal that I set myself as an industrial designer towards ecological and sustainable design literacy. By clarifying for myself, I hope that I have also been able to clarify for others the complex factors that contribute towards radical innovation for Sustainable Product Design, and how concepts relate to each other.

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- The NZ final year student survey received a ‘Low Risk’ status from the Massey University Ethics Committee

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Glossary of Terms

ABET  Accreditation Board for Engineering and Technology (US)
APEC  Asia-Pacific Economic Cooperation
ASEE  American Society of Engineering Educators
BDes  Bachelor of Design
BDVA  Bachelor of Design and Visual Arts
BE  Bachelor of Engineering
C2C  Cradle-to-Cradle
COP  Conference of the Parties
CSR  Corporate Social Responsibility
CUAP  Committee for University Academic Programmes (in New Zealand)
DEEDS  Design Education & Sustainability (part of the EU Leonardo programme)
DF  Degrees of Freedom
DINZ  Designers Institute of New Zealand
ECTS  European Credit Transfer Accumulation System
EE  Environmental Education
EESD  Engineering Education for Sustainable Development
EMS  Environmental Management Systems
EMUDE  Emerging Demand for Sustainable Solutions (EU programme)
EPP  Environmental Product Policy
ESCD  Engineering and Sustainable Community Development
ESD  Education for Sustainable Development
EU  European Union
FCCC  UN Framework Convention on Climate Change (or UNFCCC)
GNP  Gross National Product
HEE  Humanitarian Engineering Ethics
ICSID  The International Council of Societies of Industrial Design
OECD  Organisation for Economic Cooperation and Development
IP  Intellectual Property
IPCC  The Intergovernmental Panel on Climate Change
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>IPENZ</td>
<td>The Institution of Professional Engineers New Zealand</td>
</tr>
<tr>
<td>IUCN</td>
<td>The World Conservation Union</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
</tr>
<tr>
<td>NIS</td>
<td>National Innovation Systems</td>
</tr>
<tr>
<td>NPD</td>
<td>New Product Development</td>
</tr>
<tr>
<td>NZQA</td>
<td>New Zealand Qualifications Authority</td>
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<tr>
<td>OAS</td>
<td>Organization of American States</td>
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<tr>
<td>PBL</td>
<td>Problem-Based Learning</td>
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<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PD</td>
<td>Product Development</td>
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<td>PDP</td>
<td>Product Development Process</td>
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<td>PSS</td>
<td>Product-Service Systems</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<td>SADC</td>
<td>South African Development Community</td>
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<tr>
<td>SCD</td>
<td>Sustainable Community Development</td>
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<td>SD</td>
<td>Sustainable Development</td>
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<td>SME</td>
<td>Small to Medium-Sized Enterprise</td>
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<td>SPD</td>
<td>Sustainable Product Design</td>
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<tr>
<td>STS</td>
<td>Science, Technology and Society</td>
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<td>SusProNet</td>
<td>Sustainable Product Development Network</td>
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<tr>
<td>TEO</td>
<td>Tertiary Education Organization</td>
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<tr>
<td>UN</td>
<td>United Nations</td>
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<tr>
<td>UNCED</td>
<td>United Nations Conference on Environment and Development</td>
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<tr>
<td>UNDESd</td>
<td>United Nations Decade of Education for Sustainable Development</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
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<tr>
<td>UNFCCC</td>
<td>UN Framework Convention on Climate Change (or FCCC)</td>
</tr>
<tr>
<td>VITA</td>
<td>Volunteers in Technical Assistance</td>
</tr>
<tr>
<td>WCED</td>
<td>The World Commission on Environment and Development</td>
</tr>
<tr>
<td>WWF</td>
<td>World Wide Fund for Nature (formerly the World Wildlife Fund)</td>
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