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**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

Product Development

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Abstract

A UN Decade of Education for Sustainable Development (UNDES) 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.

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Glossary of Terms

<i>ABET</i>	<i>Accreditation Board for Engineering and Technology (US)</i>
<i>APEC</i>	<i>Asia-Pacific Economic Cooperation</i>
<i>ASEE</i>	<i>American Society of Engineering Educators</i>
<i>BDes</i>	<i>Bachelor of Design</i>
<i>BDVA</i>	<i>Bachelor of Design and Visual Arts</i>
<i>BE</i>	<i>Bachelor of Engineering</i>
<i>C2C</i>	<i>Cradle-to-Cradle</i>
<i>COP</i>	<i>Conference of the Parties</i>
<i>CSR</i>	<i>Corporate Social Responsibility</i>
<i>CUAP</i>	<i>Committee for University Academic Programmes (in New Zealand)</i>
<i>DEEDS</i>	<i>Design Education & Sustainability (part of the EU Leonardo programme)</i>
<i>DF</i>	<i>Degrees of Freedom</i>
<i>DINZ</i>	<i>Designers Institute of New Zealand</i>
<i>ECTS</i>	<i>European Credit Transfer Accumulation System</i>
<i>EE</i>	<i>Environmental Education</i>
<i>EESD</i>	<i>Engineering Education for Sustainable Development</i>
<i>EMS</i>	<i>Environmental Management Systems</i>
<i>EMUDE</i>	<i>Emerging Demand for Sustainable Solutions (EU programme)</i>
<i>EPP</i>	<i>Environmental Product Policy</i>
<i>ESCD</i>	<i>Engineering and Sustainable Community Development</i>
<i>ESD</i>	<i>Education for Sustainable Development</i>
<i>EU</i>	<i>European Union</i>
<i>FCCC</i>	<i>UN Framework Convention on Climate Change (or UNFCCC)</i>
<i>GNP</i>	<i>Gross National Product</i>
<i>HEE</i>	<i>Humanitarian Engineering Ethics</i>
<i>ICSID</i>	<i>The International Council of Societies of Industrial Design</i>
<i>OECD</i>	<i>Organisation for Economic Cooperation and Development</i>
<i>IP</i>	<i>Intellectual Property</i>
<i>IPCC</i>	<i>The Intergovernmental Panel on Climate Change</i>

<i>IPENZ</i>	<i>The Institution of Professional Engineers New Zealand</i>
<i>IUCN</i>	<i>The World Conservation Union</i>
<i>NGO</i>	<i>Non-Governmental Organization</i>
<i>NIS</i>	<i>National Innovation Systems</i>
<i>NPD</i>	<i>New Product Development</i>
<i>NZQA</i>	<i>New Zealand Qualifications Authority</i>
<i>OAS</i>	<i>Organization of American States</i>
<i>PBL</i>	<i>Problem-Based Learning</i>
<i>PC</i>	<i>Personal Computer</i>
<i>PD</i>	<i>Product Development</i>
<i>PDP</i>	<i>Product Development Process</i>
<i>PSS</i>	<i>Product-Service Systems</i>
<i>R&D</i>	<i>Research and Development</i>
<i>SADC</i>	<i>South African Development Community</i>
<i>SCD</i>	<i>Sustainable Community Development</i>
<i>SD</i>	<i>Sustainable Development</i>
<i>SME</i>	<i>Small to Medium-Sized Enterprise</i>
<i>SPD</i>	<i>Sustainable Product Design</i>
<i>STS</i>	<i>Science, Technology and Society</i>
<i>SusProNet</i>	<i>Sustainable Product Development Network (part of the EU Fifth Framework Programme)</i>
<i>TEO</i>	<i>Tertiary Education Organization</i>
<i>UN</i>	<i>United Nations</i>
<i>UNCED</i>	<i>United Nations Conference on Environment and Development (The Earth Summit)</i>
<i>UNDESD</i>	<i>United Nations Decade of Education for Sustainable Development</i>
<i>UNEP</i>	<i>United Nations Environment Programme</i>
<i>UNESCO</i>	<i>United Nations Educational, Scientific and Cultural Organization</i>
<i>UNFCCC</i>	<i>UN Framework Convention on Climate Change (or FCCC)</i>
<i>VITA</i>	<i>Volunteers in Technical Assistance</i>
<i>WCED</i>	<i>The World Commission on Environment and Development</i>
<i>WWF</i>	<i>World Wide Fund for Nature (formerly the World Wildlife Fund)</i>