We urgently needed a guide to sustainable development – one of the most widely-used and least-understood concepts in existence. Now we have one. Led by two of the most respected authorities in the field, the team of experts assembled here covers all the expected dimensions – and a few more besides. 'Indispensable' is a word frequently found on book dust covers – here it means what it says.

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Sustainability refuses to be defined, or even stay put in the natural sciences. Rather, it has infected economic justice discourse, infused debates over how power works, wandered into our understanding of consumption and public health, and injected itself into governance dialog. Here is a handbook that documents the power of a rogue idea on how we think: across problems, locally and globally, present and future.

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With the emergence in 2015 of new global Sustainable Development Goals, we reach a new stage in the development of the idea and promise of sustainable development. Over the past 30 years, the concept has come to be anchored in key debates about growth, environment and equity. This Handbook, bringing together an illustrious group of experts, looks at how sustainable development discourses have emerged and changed over that period, and looks forward to new debates now unfolding. It provides an unparalleled, state-of-the-art overview.

Frans Berkhout, King's College London, UK

ROUTLEDGE INTERNATIONAL HANDBOOK OF SUSTAINABLE DEVELOPMENT

Edited by Michael Redclift and Delyse Springett

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Professor Tony McMichael died before this book was published. We dedicate our book to his memory and the cause of enlightened research into sustainable development.

10
SUSTAINABLE DESIGN
Concepts, methods and practices

Martina Maria Keitsch

Introduction

The concept of sustainable development has undergone huge transformations since its first definition by the World Commission on Environment and Development (also known as the Brundtland Commission) as: 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (1987: 46). Since then, sustainable development has required a continually revised understanding of many issues, while missing knowledge has to be identified and innovation must take place when new challenges emerge. In industrial design, sustainable development is strongly coupled with the terms 'sustainable consumption and production' which were introduced by the 2002 Johannesburg World Summit on Sustainable Development:

> Fundamental changes in the way societies produce and consume are indispensable for achieving global sustainable development. All countries should promote sustainable consumption and production patterns, with the developed countries taking the lead and with all countries benefiting from the process ... Governments, relevant international organizations, the private sector and all major groups should play an active role in changing unsustainable consumption and production patterns.
>
> *(2002: 14)*

The frameworks of the Johannesburg World Summit and the Annex 2 of the Rio Declaration 2005 (Universal Design for Sustainable and Inclusive Development) have been adopted by the sustainable design community ever since. According to these frameworks, a working definition of sustainable design might be: 'taking all ecological, social and economic concerns into account in product and service systems, meeting the needs of the present without compromising the ability of future generations to meet their own needs' (Keitsch 2011).

This definition implies considering various technical and functional levels such as minimizing the negative environmental impact by enhancing efficiency and moderating the use of materials, energy, and development space. Measures and tools to relate the design solution to the climate, the region and cultural conditions seem equally important. In order to establish

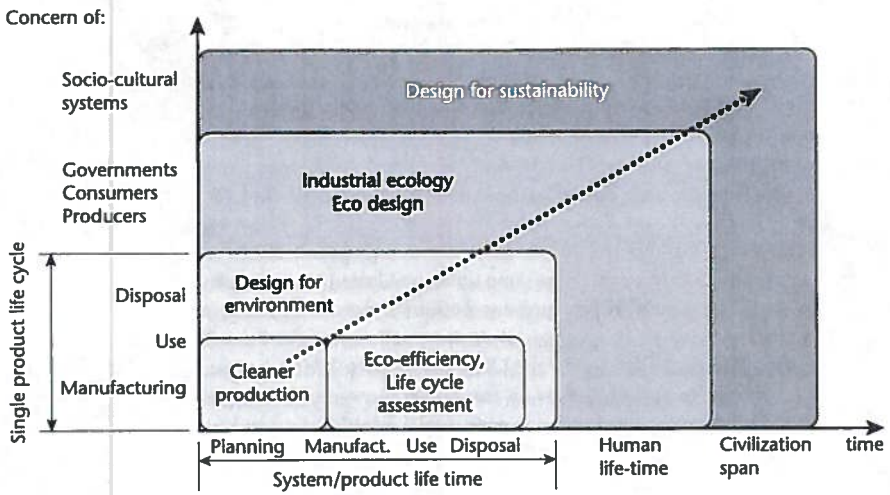

Figure 10.1 Successive changes in industrial design

Source: Keitsch (2011).

harmonious interactions between users and products or services, good form-giving is essential too: 'green' products and services should be well designed, easy to use and beautiful.

The chapter gives an overview of changes in industrial design towards sustainability, indicated in Figure 10.1. It will discuss main concepts, methods and practices in sustainable design from its start with cleaner production strategies in the 1980s, via life-cycle assessment and design for the environment until the turn of the millennium, to current eco-design and design for sustainability approaches.

A new and promising facet in sustainable design concepts is that greater emphasis is today placed on a 'user-centred approach' and on ways to elaborate solutions with involved stakeholders. The chapter concludes with a discussion on future opportunities and challenges for sustainability in industrial design and an overview of how design for sustainability concepts can, besides having ecological advantages, work as catalysts for the advancement of social sustainability – guided by the principle that a design solution is not truly considered sustainable until it is accepted by the users.

The infancy of sustainability approaches in industrial design

The history of sustainable development started at least two decades before Brundtland. By the late 1960s and early 1970s ideas about progress, growth, equity and resources had developed in this new direction (Du Pisani 2006). Environmental concern was triggered by the fear that economic growth might endanger the survival of the human race and the planet, and was expressed by authors such as Glick: 'if we continue our present practices we will face a steady deterioration of the conditions under which we live' (Glick, cited in Dubos et al. 1970: 2). In 1972, the United Nations Conference on the Human Environment recognized that:

> In our time, man's capability to transform his surroundings, if used wisely, can bring to all peoples the benefit of development and the opportunity to enhance the quality of

> life. Wrongly or heedlessly applied, the same power can do incalculable harm to human beings and human environment.

And further, 'To defend and improve the human environment for present and future generations has become an imperative goal for mankind' (Article 3).

However, the association of sustainability with industrial design only began in the mid-1980s, when the US and European manufacturing industry initiated cleaner production strategies (e.g. Frosch and Gallopoulos 1989). Successively, international agreements and national incitements stimulated the design of low energy products and novel ways of recycling or reusing by-products (waste). At the same time, the United Nations Environment Programme began to work on approaches to prevent pollution from occurring in the first place. The resulting strategy, Cleaner Production, is an essential part of the Sustainable Production and Consumption Policy and defined by the UNEP as follows: 'We understand Cleaner Production to be the continuous application of an integrated, preventive strategy applied to processes, products and services in pursuit of economic, social, health, safety and environmental benefits' (UNEP 1999). The strategy adopts, among other things, the precautionary principle, the preventive principle and the integration principle (*Clean Production Action* 2009) and covers areas such as energy efficiency, multilateral environmental agreement targets, and sustainable products.

In industrial design, cleaner production means taking into account the energy and material requirements for manufacturing, the use and the reparability, remanufacturing and recyclability of products. From the early 1990s, industrial designers working with Cleaner Production started to pay attention to the reduction of negative impacts along the life-cycle of a product – from the extraction of raw materials to its ultimate disposal. In 1988, a revised life-cycle methodology emerged, contributing to both exact eco-impact analyses of products and to improved product solutions. The Society of Environmental Toxicology and Chemistry defined life-cycle assessment (LCA) in 1993 as:

> An objective process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment, to assess the impact of those energy and materials uses and releases on the environment, and to evaluate and implement opportunities to affect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extraction and processing of raw materials, manufacturing, transportation and distribution, use/reuse/maintenance, recycling and final disposal.

In concert with incorporating environmental concerns into service solutions, Design for Environment (DfE) evolved out of product life cycle assessment in the early 1990s (United States Environmental Protection Agency). DfE developers apply LCA to all potential environmental implications of a product or a service being designed, energy and materials used; manufacture and packaging; transportation; consumer use; reuse or recycling and disposal. DfE tools enable consideration of these implications at every step of the production process from chemical design, process engineering, procurement practices, and end-product specification to post-use disposal. The DfE approach also enables designers to consider traditional design issues of cost, quality, manufacturing process, and efficiency as part of the same decision system. In an applied context, Design for Environment has, for example, been part of the Xerox industrial design since 1990, when the company started a five-year effort to create waste-free factories including

90 per cent minimum reduction in solid waste to landfills, air emissions, hazardous waste, and process wastewater discharges (Azar et al. 1995). The company's interest in DfE in the 1990s evolved in parallel with an increased consumer demand for 'green' design, i.e. the fabrication of environmental-friendly products (Unger and Eppinger 2011) and both created a 'second wave' of sustainable design (Bhamra and Lofthouse 2007) expressed in concepts as eco-design and industrial ecology (IE).

The second wave: eco-design and industrial ecology

In its initial phase, DfE and the emerging eco-design concept comprised mainly quantitative and empirical methods within a defined problem solving setting. Improvement strategies concentrated on a life-cycle optimization of material and energy flows within a system of production and consumption. In the DfE branch, as well as in early industrial ecology, normative questions such as whether developers and designers need a certain ethical attitude towards the environment or the consumer were not considered relevant (Opoku and Keitsch 2006). However, towards the millennium shift, many designers and developers started to realize that eco-design solutions may easily be lost by inappropriate production and consumption activities at other levels. To some extent, eco-design contributed, for example, to persuade consumers to sustain unfair economic wealth. These insights contributed to an attempt to define designers' tasks in terms of their contribution to sustainable societies (Madge 1997). Ehrenfeld summarizes this attempt as twofold: to realize eco-technical principles such as low material-energy intensity and high regenerative demands through products and service solutions and to respond to users' and societies' needs: 'The key to sustainability will be a balance between devices and a modified consumption ... and products and services that can transparently restore the human capability for caring and coping in all dimensions of life' (2008: 123, 124). In 2009, the eco-design concept eventually reached top-level political consciousness and the European Parliament established a framework for eco-design requirements for energy-related products:

> 'Ecodesign' means the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle ... The ecodesign of products is a crucial factor in the Community strategy on Integrated Product Policy. As a preventive approach, designed to optimize the environmental performance of products, while maintaining their functional qualities, it provides genuine new opportunities for manufacturers, consumers and society as a whole.
>
> *(Ecodesign Directive 2009/125/EC Article 2, 23 and Article 5)*

The EU eco-design framework defines conditions and criteria for all energy-related products in the residential, tertiary, and industrial sectors and implementing measures are being developed to define the product requirements for each product group.

Today, eco-design can be broadly characterized by two branches: a technology-oriented branch, and a society-oriented branch (Keitsch 2012a). The technology-oriented branch is, among others, developing tools to allow quick estimations on how to minimize the impact on the environment, e.g. the EcoDesign strategy wheel (Delft Design Guide) or Eco-it, a DfE and eco-design software. The society-oriented eco-design branch appears partly in Ehrenfeld's sense (e.g. Manzini 2003) and partly as an ethical call for design responsibility, aiming to raise designers' awareness and commitment to change society for the better, as, for example, in Papanek's work:

> There are professions more harmful than industrial design, but only a very few ... by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breathe, designers have become a dangerous breed ... In this age of mass production when everything must be planned and designed, design has become the most powerful tool with which man shapes his tools and environments (and, by extension, society and himself). This demands high social and moral responsibility from the designer.
>
> *(Papanek 1991: ix)*

The concept of industrial ecology (IE) is traditionally closely linked to DfE and eco-design. Some authors claim that eco-design provides the setting for IE (Dale 2001) while others see IE as background for design over the life-cycle of products and processes within the framework of sustainable development (e.g. Indigo Development, see also Figure 10.2). The main objective of IE is to tackle environmental challenges attached to production, consumption and recycling processes of industrial products. The field is explained as the multidisciplinary study of industrial systems and economic activities, and their links to natural systems (Graedel and Allenby 2010). Conceptually, IE perceives units, processes and industries as interacting systems rather than isolated components: 'This systems-oriented vision accepts the premise that industrial design and manufacturing processes are not performed in isolation from their surroundings, but rather are influenced by them and, in turn, have influence on them' (Graedel and Allenby 1995: xix, 9).

The philosophy of IE is based on the assumption of interdependence between human-made and non-human-made systems and the matching of selected principles of natural ecological

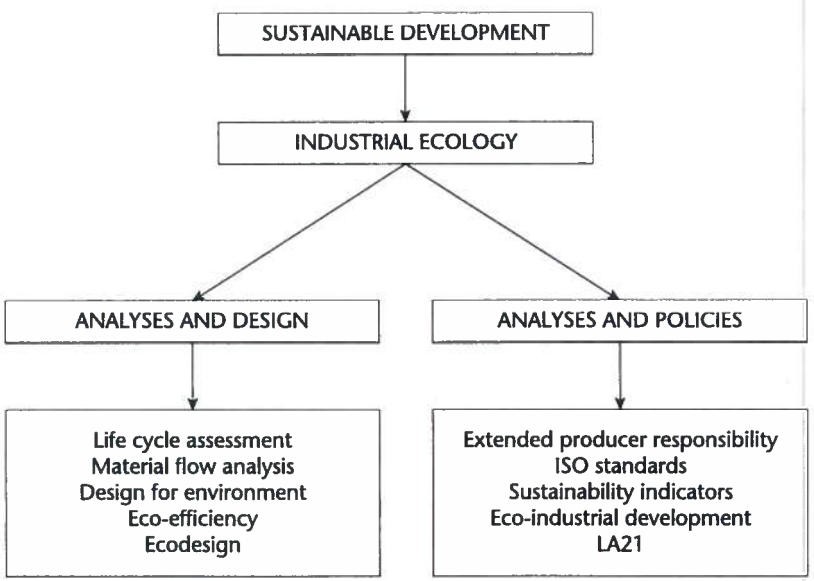

Figure 10.2 Locating eco-design in industrial ecology

Source: Keitsch (2012c).

systems to industrial contexts. Due to this assumption, the IE concept also achieved the status of being a multidisciplinary field bridging the gap between the natural sciences, social sciences and the humanities, even if this might not have been the intention of its founders:

> Industrial Ecology is the objective, multidisciplinary study of industrial end economic systems and their linkages with fundamental natural systems. It incorporates, among other things, research involving energy supply and use, new materials, new technologies and technological systems, basic sciences, economics, law, management, and social sciences. Although still in the development stage, it provides the theoretical scientific basis upon which understanding, and reasoned improvement, of current practices can be based. Oversimplifying somewhat it can be thought of as 'the science of sustainability.' It is important to emphasize that industrial ecology is an objective field of study based on existing and technological disciplines, not a form of industrial policy or planning system.
>
> *(Allenby, cited in Opoku and Keitsch 2006)*

Consequently, approaches to activate research on the socio-political implications of IE are still feeble. Socio-political issues in IE appear, for example, by relating energy and material flows to the social settings in which they occur (Boons and Howard-Grenville 2009) and by thematizing stakeholder participation (Ehrenfeld 2008). The latter includes questioning and interpretations of production and consumption values and creates a continuous broadening of scope beyond the rather simplistic notions of environmental technology and cleaner production in the previous decade (Madge 1997). Mostly, the technological importance of IE is, however, still emphasized while the concept shares several characteristics with the technology branch of eco-design.

A status quo appraisal of sustainable design

The sustainable design concepts presented in this chapter mirror to a certain degree the development of the sustainable development concept in general. Systematically, current sustainability approaches in industrial design can be illustrated by different implementations levels (Figure 10.3).

Didactically, Figure 10.3 is translated into three questions, which students in the design curriculum should relate to (Keitsch and Bjørnstad 2010):

1 Does the solution contribute environmentally to a sustainable development?
2 Does the solution promote new products and services?
3 Does the solution contribute to new sustainable consumption practices?

Meeting these questions in a design assignment, the most frequent student solutions relate to the micro implementation level, i.e. to analyze and improve the material and energy used in products. Students tend to dive here into the details of the main product. The material focus results, for example, in recycle solutions to reduce the amount of garbage. The students reuse/redesign materials often to less functional but witty objects. Example 1 in Figure 10.4 is a good illustration of redesign of thrown-away furniture, where the students use existing materials to make new objects. Some students also rethink the user's hunger for renewal. Instead of proposing new products with small changes, they focus on the history the objects have been a part of. That means living with the same objects but looking at them in a new light. Not through repair or redesign, just through storytelling. This reflective approach is illustrated in

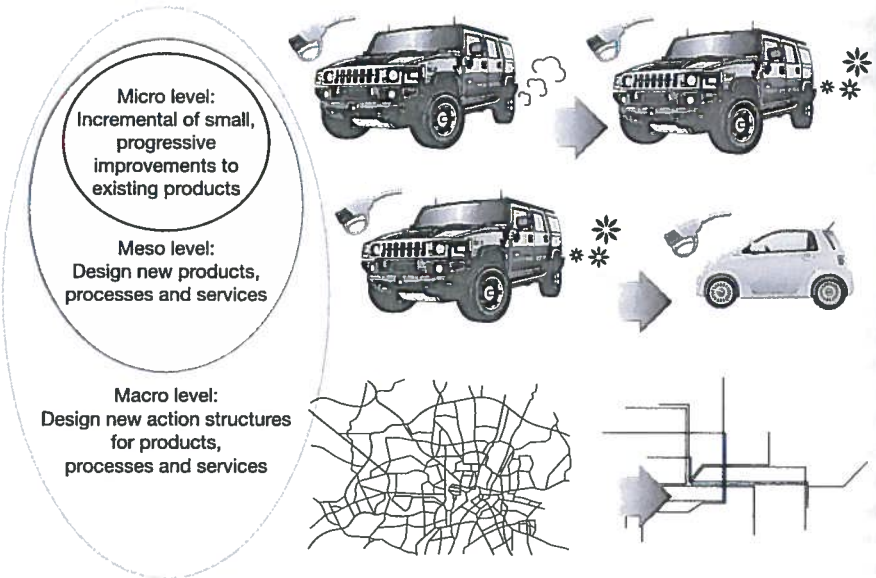

Figure 10.3 Three different implementation levels for sustainability in industrial design

Source: Keitsch (2011).

example 2 in Figure 10.4. A few students focus on a macro level in the form of new action structures or change of consumption practices. Example 3 in Figure 10.4 shows Niteo, a solar lamp and a charging station for small electrical devices. Niteo converts chemical energy, available in a bio-convertible substrate, directly into electricity. The main considerations of this solution were the aesthetic appearance and the cultural integrability of the product, i.e. its capability of being integrated in a specified cultural context thereby contributing to overall sustainability. Additionally, the student drafted how the distribution was planned and that the local craftsman, here from Nepal, gives the exterior form and expression.

Historically, in the first phase of sustainable design, after Brundtland, solutions concentrated primarily on ecological strategies and improvements and conservation of natural surroundings. Nature was regarded and employed as the most important source for inspiration and ecology

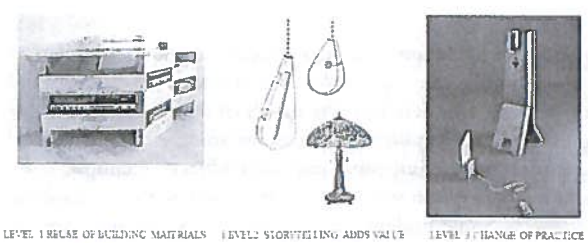

Figure 10.4 Examples, Master's student course

Source: Keitsch (2011).

and engineering provided descriptive, scientific approaches. However, the following decades made it clear that these disciplines have no normative basis to offer for decision-making. The ethical thinking needed to figure out sustainable solutions (Jonas 1984) cannot be learned from nature. It must be developed in parallel with the human self-realization. Authors claimed further that sustainable principles, indicators and strategies should be grounded in a holistic philosophy that includes both non-material aspects of the human–nature relationship and material requirements (Naess 1989). In this context, social sustainability, which promotes social interaction and cultural enrichment, received a lot of attention at the end of the millennium:

> Social Sustainability . . . is related to how we make choices that affect other humans in our 'global community' – the Earth. It covers the broadest aspects of business operations and the effect that they have on employees, suppliers, investors, local and global communities and customers. Social sustainability is also related to more basic needs of happiness, safety, freedom, dignity and affection.
>
> *(Green Team, weblog)*

Like environmental sustainability, social sustainability strives to take future generations into consideration, and to live with the awareness that human actions make an impact on others and the world at large.

Participation in society is an overall goal of social sustainability and can be viewed from perspectives such as social integration, personalization and appropriateness (Vavik and Keitsch 2010). This means, for example, treating all groups with dignity and respect; incorporating opportunities for choice and the expression of individual preferences; and respecting and reinforcing cultural values and the social and environmental context of any project. Today, many people experience information and communication technologies as barriers to participation. One reason for that may be that political bodies relate participation as a strategy of empowering less to individual conditions than to social processes. One social sustainability design approach to meet these challenges is the 'Dialogue Café'. The idea behind Dialogue Café is to facilitate communication between people from all walks of life, across the world, to address social, environmental and economic issues ranging from youth literacy and job skills needed for the twenty-first century to urban development. The cafés bring ordinary people together to share common interests and concerns. They are linked by life-size, high-definition video screens, the sound allowing people from different cities and cultures to talk and meet despite being located on different sides of the world. The Dialogue Café concept gives people the opportunity to be directly involved in creating solutions in their communities – solutions that need not be isolated and can be shared. A broad dialogue of a diverse group of people can exponentially expand our collective ability to solve problems and innovate as a global community. The cafés are bottom-up movements that complement the tradition of addressing sustainability issues from the top.

Reflecting these new perspectives, sustainable design approaches of the new millennium and its first decade attempted a transition towards socio-cultural sustainability and stakeholder participation including what Knight calls a 'broadening of scope in theory and practice' (2009: 4). McLennan expresses this transition programmatically: 'Sustainable design starts with the understanding that the purpose of our design is to create physical artefacts that benefit people' (2004: 5).

Currently, user involvement in sustainable design is motivated by two factors: a general increase on a user-focus in the design community (Lee et al. 2008) and the concept of 'people-centred sustainable development', introduced in 1995 by the Copenhagen Declaration on Social Development:

> We commit ourselves to promoting and attaining the goals of universal and equitable access to quality education, the highest attainable standard of physical and mental health, and the access of all to primary health care, making particular efforts to rectify inequalities relating to social conditions and without distinction as to race, national origin, gender, age or disability.

It is important to note here that the interpretation of 'user' has changed significantly in the design community over the last decades and that this change influences methods and results of user involvement for sustainable design as well. While the early 1970s and 1980s highlighted physical needs (e.g. Dreyfuss 1967; 2003) and introduced ergonomics as an important consideration for design, the early 1990s, with Krippendorff (1989), for example, started to focus increasingly on social and symbolic needs, extending the concern of designers to cognitive and emotional constraints and social interactions when using a product.

Recent concepts in sustainable design can broadly be categorized within three areas. The first one, sustainability and user involvement, is best represented by Ezio Manzini and his 'Sustainable everyday life' concept. Manzini's research focuses on foresight, creativity and interaction: 'Indeed, we cannot act in a forward-looking way if we are unable to imagine a state in which we could potentially live in a different and more attractive way than now' (Manzini and Jégou 2003: 13). Methodologically, Manzini combines a natural science and engineering-oriented approach (technology sphere) with social constructivism (society sphere). His 2006 article, 'Design, ethics and sustainability', also emphasizes the role of the designer in society:

> Conceiving and proposing products, services and lifestyles, designers play an important role and consequently have an equally important responsibility in generating social expectations in terms of wellbeing ... Of course designers have no means of imposing, for good or bad, their point of view on others. But they do have the tools to operate on the quality of things, and their acceptability, and therefore on the attraction of the scenarios of wellbeing they help to generate.
>
> *(ibid.: 2)*

Practically, Manzini presents guidelines in the form of two fundamental principles for designers: low material-energy intensity and high regenerative potential. These principles are very much in line with the eco-technical part of sustainable development. However, he connects these principles with personal and social well-being: 'The concept of well-being is the most basic set of visions and ideas that legitimate socially and ethically the same existence of the production and consumption system' (Manzini 2003: 1). Building scenarios for sustainable well-being is (again) a social task for designers: 'Goal: we have to conceive scenarios of wellbeing in which the overall quality of the context of life has to be considered, in which the physical and social common goods are regenerated and where contemplative time has its place' (ibid.: 7).

The idea of creative communities, where stakeholders interact locally in daily life is the most significant feature of Manzini's concept:

> There is, in my view, a new model of organizing society and the production and consumption and whatever. When I use the words small, open, local and connected, this is my way of telling the story ... For me, dealing with the needed sustainable changes that are mainly cultural and behavior change, the pivotal moment has been when I moved from saying 'What can I do to help people change behavior?' toward the discovery that a lot of people (even if they aren't yet so visible) had already changed, and in a good way, their behaviors. And that therefore, the right question is: 'What can I do to trigger and support these new ways of thinking and doing? How can I use my design knowledge and tools to empower these grass-roots social innovations?'
>
> *(Manzini 2011)*

Manzini's work summarizes some of the most recent ideas in sustainable design with an activist agenda for designers and stakeholders (Fuad-Luke 2009) and the attitude that sustainable design will not only meet the triple bottom line of ecological, economic and social sustainability, but contribute simultaneously to human well-being and civic stability (ibid.: 25). Here, interaction with stakeholders and mutual responsibility is the focus of the design work, instead of proclaiming a solipsistic individual ethos and a 'genius' design philosophy.

The second area in recent sustainable design concepts attempts to integrate elements of social practice theory into design research and practice, which are seen as a supplement to earlier 'social engineering' views that attempt to 'control or change behaviour' through physical, technological and cognitive interventions (Keitsch 2012b). In social practice, theory 'practice' is exemplified through single activities such as cooking, travelling, working, and so on (Reckwitz 2002). A practice is regarded as a significant unit for inquiries – in opposition to, for example, structuration theories which focus on general elements of social interactions. In aiming at empowering, educating and motivating consumers towards sustainable activities, novel design concepts (e.g. Gronow and Warde 2001; Shove 2003; Patterson 2006) take especially everyday practices into consideration. Everyday practices are seen as repetitive, routine and mundane activities and closely connected to common socio-cultural understandings about 'right' and 'wrong' ways of doing things (Gram-Hanssen 2008) and an analysis of everyday practices relating to socio-cultural identity development is significant for sustainable design in terms of product and service development.

The third area in sustainable design concepts is biocentric approaches, which have come forward in context with Arne Naess' 'gestalt' concept (1989). For Naess, the joy, when aesthetically experiencing nature's 'gestalt', triggers empathy with other living beings. The fact that every organism is part of a whole becomes realizable through experiencing the gestalt. Naess' gestalt ontology supports a moderate, aesthetically motivated biocentrism, based on the awareness for everyday experiences and different ways of communication about sustainable ways of living. As Goldsmith points out:

> There is a tendency in design that comes from a desire to appear objective and 'scientific' to try and quantify each aspect of design, from square footage of area, to kW of cooling. Extending even to our own field of sustainable design we take the science of ecology and use it to define the ecosystems we build in with terms like solar inputs and types of waste outputs. This is all in an effort to make the art of design seem more legitimate in a world that values quantification above appreciating the gestalt of a design's function. In Naess' essay, 'The Place of Joy in a World of Fact', he condemns this view and asks us not to try and reduce our experience to a simple knowledge of the basic physical realities of our surrounding world, but to appreciate them for their experiential reality of sounds, sights, smells, and feelings.
>
> *(2009: 4)*

Obviously, the aesthetic implications of Naess' gestalt ontology appeal to creative and innovative methods within the design process and therefore contain interesting material for the future development of sustainable design concepts, but are, in their current state, sketches rather than

fully developed concepts since their methodological consequences and applications have not yet been examined thoroughly within in the design community.

Future opportunities and challenges for sustainability in industrial design

Considering the designer's role as mediating between 'what is possible by nature and our knowledge from the natural science on the one hand and of what is accepted or wanted by society on the other' (Hermansen 2006), an opportunity for future design research and education lies in the development of methodologies and design solutions which combine social, technological and aesthetic aspects. In terms of sustainable design research, a combined methodology can contribute with both ecological and technological know-how, *and* with methods and tools to advance social sustainability and social inclusion. Based on my own research and education practice, the following guidelines for future sustainable design within such a holistic framework can be outlined:

- The onsets for sustainable design strategies are *real-world challenges*.
- *User and stakeholder involvement* are fundamental attributes of meaningful sustainable product design solutions.
- Facilitating an *interdisciplinary experience* that includes comprehensive learning opportunities for different stakeholders is essential.

Meeting some of these guidelines, Morelli's work (2007) is a good example of how to create cross-cutting values by combining sustainable design strategies with social entrepreneurship within a food delivery system to activate elderly people. Social, technological and aesthetic aspects interact in this system on:

> [S]emi-finished platforms meant to organize material and immaterial flows, specify roles and competences, and possibly generate new knowledge that some actors (such as service providers or institutions) may add to their existing competences. The generation of a solution platform therefore is the basis for the design process.
>
> *(ibid.: 15)*

As this example illustrates, meeting sustainable development provides opportunities and new roles for industrial design in form of collaboration and ways of networking. Involvement of local users, stakeholders from municipalities and regions seem important when thinking about the industrial design contribution to sustainability. Some methods applied in these arenas are based on traditional product development strategies, while others originate in the natural and empirical sciences or deal with users, life styles and life quality on a social science foundation. One challenge for future research and education activities is to specify which methods are applicable and what their use implies for 'design for a sustainable society'. Figure 10.5 gives an overview of different methods available in design for sustainability.

Level	Tools
1. Micro level: Analyze and improve products, processes and services.	– design for the environment, life cycle assessment, material flow analysis dematerialization, energy effectiveness – material recycling, material exchange, material intensiveness – improvement of service, process and distribution and product chain oriented strategies
2. Meso level: Design new products, processes and services	– biomimicry, nature aesthetics – design semantics, product language, personas, narratives – universal and participatory design – emotional design
3. Macro level: Design new action and infrastructures	– user-driven innovation – ethics for the environment (analytical tool) – intellectual property management – social metabolism – sustainable production and consumption mechanisms – strategic sustainable development (stakeholder theory)

Figure 10.5 Methods for sustainability in industrial design

Source: Keitsch (2011).

Conclusion

> There are no passengers on Spaceship Earth. We are all crew.
>
> *(Marshall McLuhan 2005)*

The designers of tomorrow are likely to act in markets characterized by crises, innovation and constant variation, in professions undergoing continuous change, and hence they need to be competent learners. The biggest challenge for future sustainable design curricula comprises today in the systematization and the further development of methods. Methods for sustainability in industrial design are still cook-bookish. Even on the macro level when focusing on user activities, experiences, emotions or social surroundings, methods often look like directions for use rather than representing systematic and reflective steps towards improved practice. However, development and application of methods are only as good as the understanding of the theory behind them, and another challenge for future sustainable design is to generate knowledge on the relationships between sustainable development concepts, their analysis, with help of methods, and their 'translation' (Verganti 2003) into products and services. The tasks of design students usually include idea generation, concept development, strategic design, project planning, and project management. Besides applying the methods available, students should become familiar with the area of sustainable design thinking. As long as integrated models for sustainable design are still few (Wigum 2004; Morelli, 2007; Hussain 2011), theories and methods from other disciplines have to be utilized as well (see Figure 10.5). The future of design curricula is to graduate reflexive and skilful practitioners with a fundamental understanding of sustainability principles, capable of working in multidisciplinary teams, and aware of the contexts and systems, in which design acts. Augmented insights into responsible, acceptable and comprehensive

design strategies will then contribute to pursue paths of innovation for products, services and structures for a sustainable society.

Design is implicated in the world in its actions and words – design practice is social practice. When design meets future sustainable design challenges, a systemic approach is required that joins the forces of different disciplines and stakeholders (Watson 2002; Innes 1995). A forthcoming contextualized, sustainable design practice comprises at least two components: First, developing profound situational knowledge when dealing with local sustainable problems and circumstances and, second, realizing workable, 'satisfycing' (a term coined by Herbert Simon 1956: 129, 136) solutions that are acceptable for the majority of involved stakeholders while considering the specific surroundings and conditions. Furthermore, future practitioners should be able to communicate with their surroundings – not only instrumentally about what is possible to achieve and how, but also ethically about what is worth achieving and why.

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11

IS MANAGING ECOSYSTEM SERVICES NECESSARY AND SUFFICIENT TO ENSURE SUSTAINABLE DEVELOPMENT?

Mark Mulligan and Nicholas J. Clifford

Refining the concept of ecosystem services

Ecosystem services flow from stocks of natural capital and provide benefits to humanity, for example, the carbon sequestration of forests that regulates global atmospheric composition and thus climate; the clean, fresh water flowing from natural landscapes and provided to dams and irrigation projects downstream and the flood storage capacity of wetlands that regulates floodwaters upstream of flood-prone urban areas. These services and the natural capital stocks from which they are derived are critical to the life-support functions of the Earth and contribute to human welfare in direct and indirect ways (Costanza et al. 1997). Ecosystem services are variously classified (see Fisher et al. 2009) including by the Millennium Ecosystem Assessment (MEA) (2005) into provisioning, regulating, supporting and cultural services. Provisioning services include the provision of food, timber, textiles and water, regulating services provide regulation against hazards (such as floods and droughts). Cultural services are the non-material aesthetic, recreational, spiritual and health benefits provided by nature. Supporting services support the aforementioned through, for example, maintenance of soil fertility. Ecosystem services are considered to be fundamentally dependent upon biodiversity (Hooper et al. 2005; Balvanera et al. 2006; Tilman et al. 2006). The term ecosystem services is used for both goods (provisioning services) and services (regulating, cultural and supporting services).

The sustainability of ecosystem service provision is threatened by human impacts on the environment. While these impacts are necessary to provide a number of the provisioning services, e.g. agriculture for food and deforestation for timber, these interventions by a given beneficiary can negatively impact the same services available to other beneficiaries or different services provided by the same landscape. These 'external' impacts of ecosystem service 'farming' are not accounted for in the economic system that drives most interventions in the environment and, as a result, these interventions can threaten the equity and sustainability of ecosystem service provision. These services have thus undergone various attempts at valuation, including economic valuation (Costanza et al. 1997) in the hope that their value can be better understood and so that 'market-based' mechanisms (Gómez-Baggethun et al. 2010) can contribute to better and more holistic management of ecosystem services. The cost and futility of replacing the services currently provided 'for free' by 'green' infrastructure with those engineered using grey infrastructure are often highlighted in this work.