Managing Creative Eco-innovation: Structuring outputs from Eco-innovation projects

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Increasing legislative pressures and consumer awareness of environmentally efficient products are causing businesses to look at Sustainable Product Design (SPD) as an opportunity to improve their products and processes. Business and academia have identified a need for strategic approaches to SPD that will result in 'step-change' improvements in the design of products and services. Eco-innovation aims to develop new products and processes which provide customer and business value but significantly decrease environmental impact. Eco-innovation considers environmental aspects of the product at early stages of the New Product Development process. The research presented in this paper looks at the use of eco-innovation tools and focuses on idea generation within ecoinnovation processes. Two novel tools were developed to help review the results from previously conducted eco-innovation workshops: the Standard Design Process Form and the Product Ideas Tree (PIT) diagram. This paper shows the development of these two tools and demonstrates their potential to assist in structuring and documenting ideas throughout the eco-innovation process. The paper discusses the benefits of using such documentation and how it may subsequently improve the management of eco innovation throughout the design process.

Introduction

Sustainable Product Design (SPD) has been defined as the balancing of economic, environmental, ethical and social issues in product design and development. SPD requires creativity, innovation and the participation of many different actors such as policy makers, business strategists, managers, designers, engineers, marketing managers, consumers, etc. Business strategies that include SPD can stimulate the development of new, innovative products which may improve a company's competitive advantage. For example, a company might expand into new markets, through the launch of a new product with environmental attributes which consumers desire. An environmentally pro-active company may also benefit financially from the optimisation of production processes, reduced material use, and reduced waste generation.

SPD encompasses various approaches such as ecodesign (including the use and integration of Life Cycle Analysis (LCA) tools) and eco-innovation. Ecodesign aims to reduce the environmental impact of the product throughout its life cycle: from materials extraction, through production processes, packaging and transport, product use phase, and finally to end-of-life disposal. The results from ecodesign are limited because it is a design specific activity that focuses on the redesign or optimisation of existing products. The changes to the products tend to be incremental and result in only a percentile reduction of the overall environmental impact of the products (Hoed, 1997).

Business and academia have identified a need for new SPD approaches that will result in more significant improvements in the design of products and services, known as 'non-incremental' or 'step-change' improvements. This calls for more creative approaches and an awareness that environmental factors need to be integrated earlier into a company's product development processes. A discussion is emerging that focuses on the integration of different environmental issues and concerns at different stages in the product development processes (Charter, 1999; Sweatman and Simon, 1996).

Eco-innovation aims to develop new products and processes which provide customer and business value but significantly decrease environmental impact (James, 1997). Ecoinnovation differs from ecodesign in that it considers environmental aspects of the product at earlier stages of the product development process, such as at the strategic product planning stage or the new concept development stage. A number of tools and concept demonstrator projects have been developed to support the process of eco-innovation. Concept demonstrator projects such as the Clean textile project (Vergragt et al., 1995), the MMU prototype telephone (Simon and Sweatman, 1997), the Eco-kitchen project (Sherwin et al., 1998) and the Sushouse project (Quist et al., 1999) all explore new approaches to achieve environmental benefits beyond small step improvements. Streamlined environmental design tools such as the Life-cycle Design Strategy (LiDS) wheel (Brezet et al., 1996) and the Eco-compass (Fussler and James, 1996) condense environmental information into a visual map that can compare the environmental merits of new design options against the original design. Other examples of tools that support ecoinnovation are environmentally focused strategic product planning processes such as the Philips STRETCH methodology (Cramer and Stevels, 1997).

The focus of this paper is on the idea generation process within eco-innovation. There are many design tools available to assist in the idea generation process, 'brainstorming' is one of the most commonly used techniques. Brainstorming is a method to help groups produce large quantities of ideas. It is necessary for participants to suspend judgement, and build on the ideas of others. In general, idea generation within ecoinnovation uses brainstorming techniques similar to those used in conventional product development practice. However, in eco-innovation the objectives and the key starting points for brainstorming sessions emphasise improvement in product environmental performance. Tools such as the LiDS wheel and the Eco-compass can provide key starting points to structure brainstorming sessions for eco-innovations, alongside their main use as tools to assess and compare the environmental merits of new product (or service) concepts.

In order to review case studies in eco-innovation that included idea generation processes, two novel tools were developed; the Standard Design Process Form and the Product Ideas Tree (PIT) diagram. These two tools contribute to the consistency of a review by helping to structure and document the idea output from the case studies. This paper shows the development of these two tools and demonstrates their potential to assist in documenting ideas throughout the eco-innovation process. This paper discusses the benefits of using such documentation and how it may subsequently improve the management of eco-innovation throughout the design process.

In section two of this paper the authors describe the 'Standard Design Process Form' (SDPF) which was developed to understand where existing eco-innovation tools and methodologies fit within the product development process. This form is used to describe *where* idea generation is taking place in the design process, and what *type* of design activity is being conducted.

In section three of this paper the authors introduce the Product Ideas Tree (PIT) diagram which was developed from a need to review the results from idea generation workshops in further detail. Tassoul (1998) suggests that it is not easy to summarise the outcomes from creativity workshops. He states the need for frameworks to enable the clustering of results from creativity workshops. The Product Ideas Tree (PIT) diagram is a novel method for clustering eco-innovation ideas and documenting them clearly. The PIT diagram is different from any existing idea-recording or 'mapping' technique because the ideas are simultaneously clustered according to ecoinnovation strategy 'headings' (taken from the LiDS-wheel or Eco-compass) and are placed within the applicable stage of the design process. The PIT diagram is intended to be used as an integral part of eco-innovation processes: firstly alongside existing ecoinnovation tools and methodologies as a method of documentation and secondly 'live' during creative sessions as a recording tool.

Introducing the Standard Design Process Form

The Standard Design Process Form (SDPF) splits the development of a product down into chronological stages. This enables a more structured and consistent review of case studies in eco-innovation. Each stage has a distinct starting point and an expected output type in terms of work. The SDPF is a simple form based on a design process developed by Inns (1994) for product/ industrial designers, which in turn is based on a British Standard design process: BS 7000 (BSI, 1989). The SDPF is a version of a design process adapted for eco-innovation processes, where the output types defined are those typically expected from ecodesign projects; e.g. a new *environmental* business strategy, an *eco-innovation* project plan, as shown in Figure 1.

The SDPF can be used to identify where existing ecoinnovation tools and methodologies fit within the product development process. This is done by taking the relationship between the 'design stage' and the 'output type expected' and using it in reverse. Case studies in ecoinnovation can be studied in detail using the SDPF:

- First, the idea output from the case-study is classified as to the output type that it shows closest resemblance to. This determines the theoretical stage of the design process at which the activity took place. The idea output is entered in the form (Step 1 in Figure 1).

- Secondly, the type of design activity can be classified by looking at the idea output from the case-study. Design activities at each stage can be made up of a mixture of the following three distinct design activity types: information gathering, synthesis (divergent thinking) and analysis (idea-selection). Looking at the idea output from the case studies will determine dominant design activity (Step 2 in Fugure 1).

Using the SDPF to review the STRETCH methodology

The STRETCH (Selection of Strategic Environmental Challenges) methodology is an approach for strategic environmental planning developed at Philips Sound and Vision as described by Cramer and Stevels (1997). Philips Sound and Vision have a history of ecodesign and use an extensive set of ecodesign tools. In the 90's ecodesign became more product-focused and the next stage for Philips Sound and Vision was to aim for more far-reaching environmental improvements in their products. Four 'levels' of improvement were defined (Stevels, 1996):

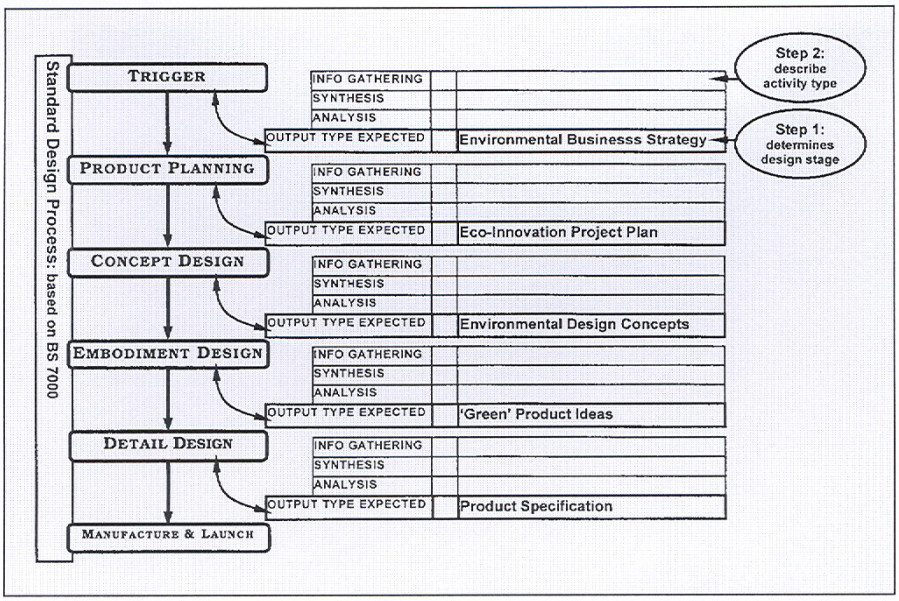

Figure 1: The Standard Design Process Form showing the output types expected at the stages

Level 1: Incremental improvement to existing products
Level 2: 'Green limits': radical redesign of existing products
Level 3: 'Product alternatives': new product or service concepts
Level 4: Design for the sustainable society.

A 'green TV' demonstrator project was organised, which aimed to incorporate all the ecodesign knowledge available at that time. The 'green TV' never went into production but could be used as an internal benchmark for future generations of the product. The project highlighted the need for some guidelines for systematically determining the selection of promising environmental opportunities. For this purpose the STRETCH methodology was developed. The objectives of the STRETCH methodology are:

- To focus on the incorporation of environmental aspects into the company's business strategy.
- To anticipate future environmental opportunities and threats in an earlier phase of the design process.
- To achieve higher eco-efficiencies than current incremental environmental improvement methods.

The use of STRETCH at Philips Sound and Vision has resulted in 'advanced concepts' for various products including telephones, faxes and audio products (Stevels, 1998). The 'Typhoon II' monitor is one example of an 'advanced concept' taken through to production. In May 1998 Philips launched a green product range presented in the catalogue 'From Green to Gold' (Philips Electronics, 1998).

The STRETCH methodology consists of five steps which each consist of several activities, including several brainstorming sessions. The SDPF (see Figure 2) shows the breakdown of the STRETCH methodology's five steps that are described in Cramer and Stevels (1997). Figure 2 confirms that the STRETCH methodology focuses completely on the earliest stages of the design process: 'trigger' and 'product planning' stages. Using the SDPF to analyse eco-innovation tools in this way enables objective comparison of where those tools and methodologies fit within the product development process.

Using the SDPF to review an eco-innovation workshop

The project reviewed here was a collaboration between Manchester Metropolitan University, Cranfield University and a major household appliance firm (Sweatman, 1997). The project's aim was to generate ideas to reduce the environmental impacts of a vacuum cleaner. Specific objectives were:

- To consider environmental aspects of the design at the beginning of the design process.
- To work with a multi-disciplinary design team to generate concepts prior to the product specification stage.

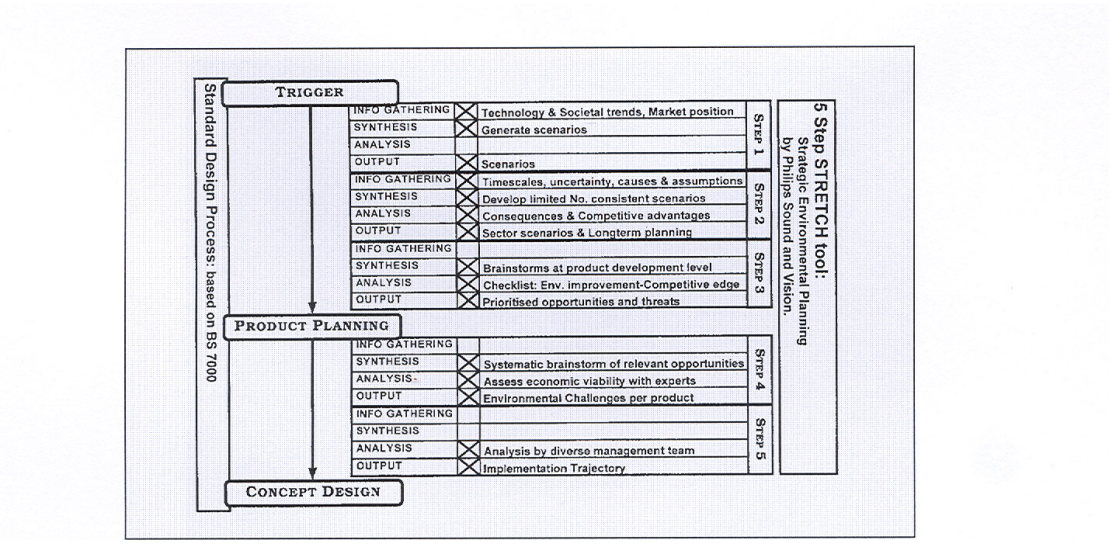

Figure 2: The Standard Design Process Form: the breakdown of STRETCH using Cramer and Stevels (1997)

A brainstorm session was held, attended by representatives from all departments of the design team. The team was introduced to the most relevant environmental impacts of an existing vacuum cleaner that had been selected for this project. Environmental impact information for the vacuum cleaner was presented in the form of an abridged LCA. The four starting points for the brainstorm session were taken from the eco-compass tool: reduce energy intensity, reduce mass intensity, extend service and function and design for recycle and re-use. For each starting point two rounds of idea-generation and two rounds of idea-selection were held using eco-compass selection matrices. Seven promising ideas resulted from the workshop. The final stage of the workshop involved identifying links and similarities between the ideas to form a single concept that could be embodied in a new vacuum cleaner design. An evaluation session was held at the end of the workshop, which highlighted the following points concerning the workshop's methodology (all cited in Sweatman, 1997):

- To include more creative methods and focus on a smaller number of ideas.
- To spend less time filtering the ideas generated.
- The role of the workshop within the company's product development process could be explained better to the participants.
- A briefing document with the background information should be distributed in advance of the workshop, thereby allowing the participants a longer 'incubation' period.
- More marketing people should be included in the workshop.

One of the objectives for the project reported by Sweatman was to generate concepts prior to the new product specification stage. The use of the SDPF in our observations makes it clear that the actual idea output from the workshop spans several stages of the design process. Figure 3 shows a few idea statements from the project.

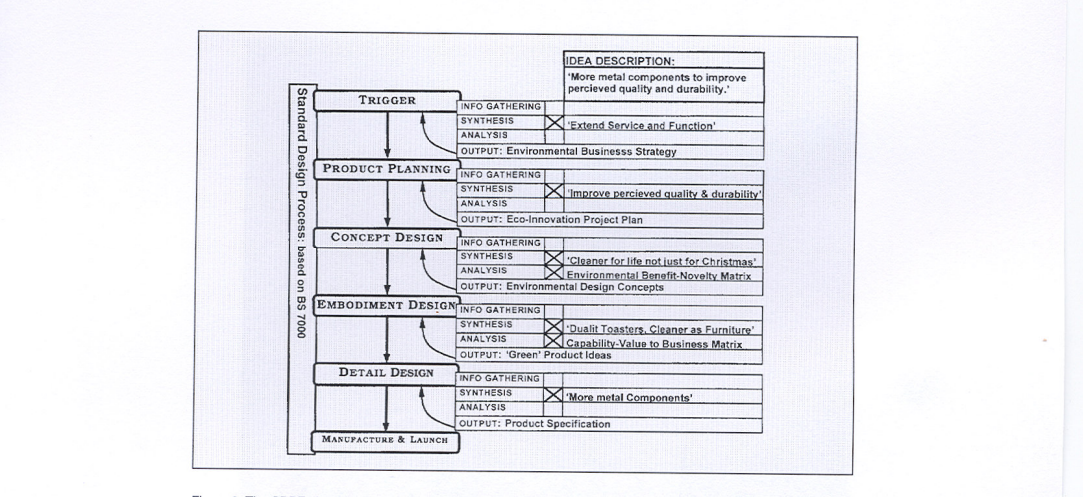

Figure 3: The SDPF showing the breakdown of a 'compound idea'

Some of the ideas from this case study are 'compound ideas': ideas that contain ideas within themselves. For example the idea description "more metal components to improve perceived quality and durability" breaks down into two parts: "improve perceived quality and durability" and "more metal components". These two ideas are each appropriate for different stages of the design process "more metal components" could be a detailed design specification for a vacuum cleaner, "improved perceived quality and durability" could be an ecodesign project plan for a vacuum cleaner or a range of consumer products. This is illustrated in the shaded boxes in Figure 3. Compound idea statements may obscure the most valuable aspects of ideas. Using the SDPF it is possible to separate out the ideas and make explicit where they fit in the design process. Thus the most valuable ideas may be highlighted and if necessary developed further in subsequent sessions.

Introducing the PIT diagram

The Product Ideas Tree (PIT) diagram is a hybrid-mapping tool, useful for reviewing the ideas resulting from creative eco-innovation workshops. The PIT diagram can record all ideas generated in these workshops whilst simultaneously mapping them onto the stages of the design process. The PIT diagram was synthesised from elements of the SDPF, Mind Maps (Buzan, 1995) and visually based ecodesign tool types such as the Life-cycle Design Strategy (LiDS)-Wheel (Brezet et al., 1996) or Eco-compass (Fussler and James, 1996) shown in Figure 4.

The "starting points" of the PIT diagram are drawn from the Eco-compass or the LiDSwheel, (e.g. reduce energy intensity, design for recycle and reuse), the labels on the "rings" come from the standard design process model, (e.g. concept design, embodiment design), and the radial idea-recording technique is drawn from mind mapping, as illustrated in Figure 5.

Using Mind Maps to record output from ecodesign creativity workshops

Tony Buzan has developed Mind Maps as a way to generate and record ideas. Mind Maps are now a well-established creative technique and a powerful graphic representation of ideas. Every key-word or image added to a Mind Map adds the possibility of a new and greater range of associations, which in themselves add the possibilities of new and greater ranges:

'By contrast, linear notes in the form of lists directly oppose the working of the mind, in that they generate an idea and then deliberately cut it off from the ideas preceding and following it.' (Buzan, 1995,p. 86)

Using a Mind Map type representation it is possible to get an overview of the raw ideas output from creative ecodesign case studies.

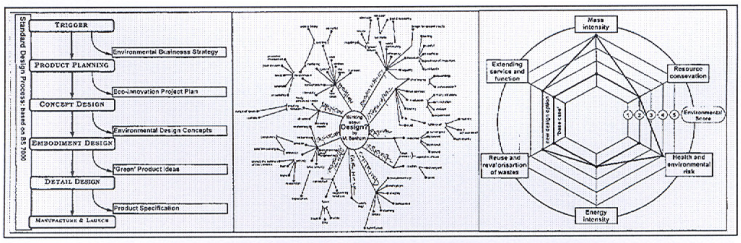

Figure 4: The SDPF, The Mind Map and The Eco-compass. After Fussler and James (1997)

'Starting points' from the Eco-compass and the LiDS-wheel methods

The Eco-compass (Fussler and James, 1996) and the LiDSWheel (Brezet et al., 1996) are two of the more successful streamlined ecodesign tools. The Eco-compass was designed to condense environmental data into a simple model which would assist in the integration of environmental issues within the business decision process. The Ecocompass has six poles or 'axes', which are intended to represent all significant environmental issues (see Figure 4): mass intensity, reducing human health and environmental risk, energy intensity, re-use and revalorization of wastes, resource conservation and extending service and function. The Eco-compass is a comparative spider diagram, which illustrates new options or designs against the original design or 'base case'.

The LiDS Wheel is another tool that was developed as a streamlined approach to LCA. The 'golden rules' are clustered on the eight 'axes'. Clockwise, the axes of the LiDS-Wheel follow the sequence of the product life cycle: new concept development, low impact materials, reduction of materials, optimisation of production techniques, efficient distribution, reduction of impact in the use phase, optimise initial life-time and optimise end-of-life system. The LiDS-Wheel draws a comparative visual map for the new product against the original product design and is similar in format to the Ecocompass.

To help cluster the ideas output from the case studies in Sweatman (1997) and Jones et al. (1999), it was possible to use the 'axes' from the Ecocompass and LiDS-wheel as the headings on the inner ring of the PIT diagram as shown in Figure 5.

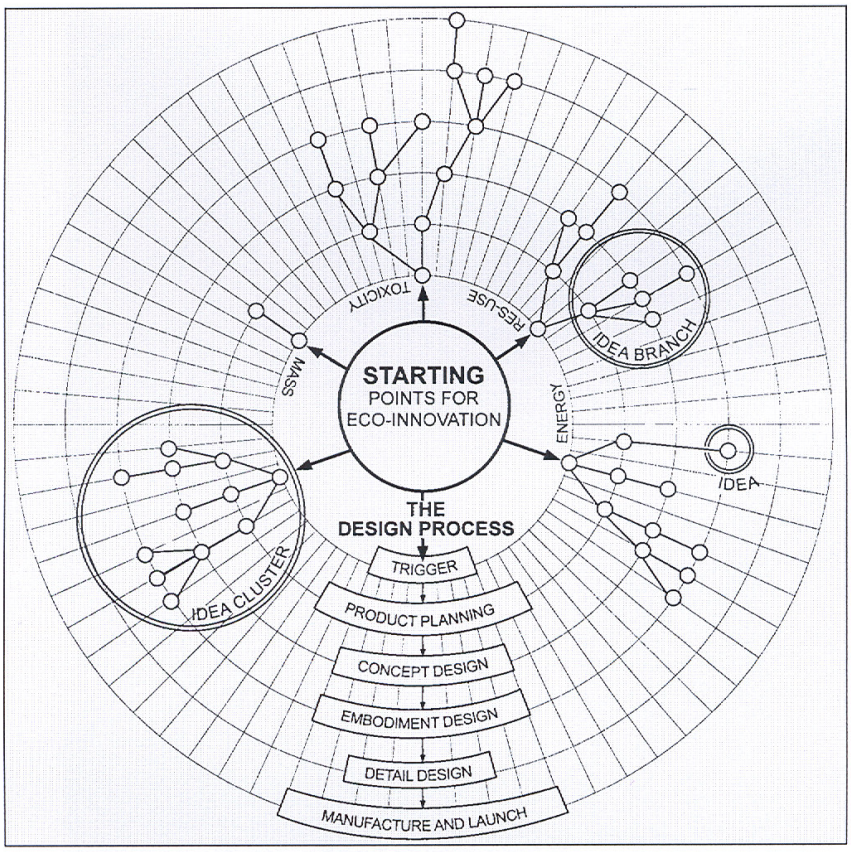

Figure 5: PIT diagram explaining its' elements and headings on the inner ring

Using the PIT diagram to review an eco-innovation workshop

In a previous section the authors reviewed *where* the ideas resulting from the workshop cited in Sweatman (1997) fit within the design process using the SDPF. Using the SDPF in this way, ideas cannot easily be clustered according to the environmental strategies which they address. However, using the PIT diagram, ideas are categorised according to their relevance to stages in the design process (as in the SDPF diagram) and their relevance to environmental strategies (taken from the Eco-compass and LiDS-wheel) as is shown in Figure 6. Using the PIT diagram in this way shows:

- The quantity of ideas recorded: each spot on the diagram representing one idea.
- The span of ideas explored: each cluster of branches on the diagram represents a brainstorming session during the workshop.
- 'Ideas space explored': the branches show which ideas were explored in detail and which ideas were left unexplored. This may help in identifying opportunities for further idea generation, or conversely identify a smaller number of relevant ideas on which to focus.
- The inset in figure 6 shows the breakdown of 'compound' ideas and their elements placed on the design process 'rings'. This assists in identifying which part of the idea is most interesting or relevant.

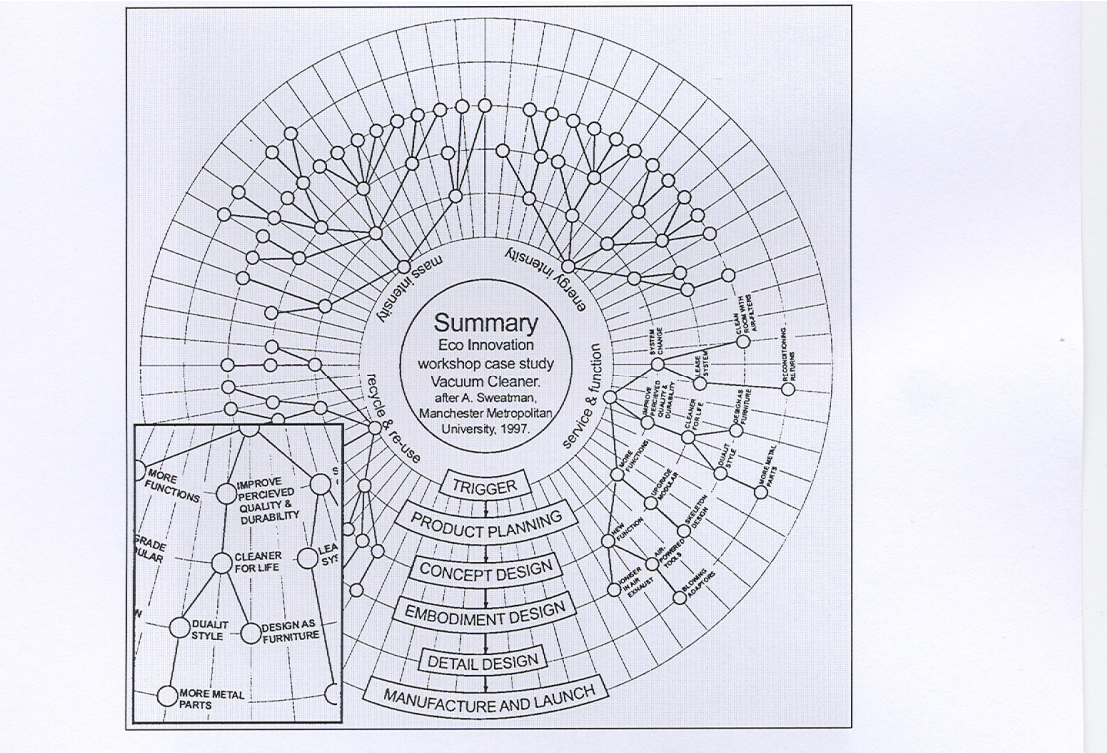

Figure 6: PIT diagram shows 'ideas space explored', inset shows breakdown of 'multiple ideas'. After Sweatman (1997)

Using the PIT diagram to review work in progress

The case study presented in this section is an ongoing record of ideas generated within the authors' research project. In the first months of the project several brainstorming sessions on telecommunications futures were held. The two areas of interest that were highlighted in the original project brief (Williams and Harrison, 1997) were 're-use and life-extension' and 'packaging'. Figure 7 shows the ideas generated under those headings but also other idea branches such as 'energy in use' or 'infrastructure' which were not explored in as much detail.

Using the PIT diagram in this case study shows:

- How the work from several different workshops is recorded together: the diagram 'grows', accumulating the output from several workshop sessions with different participants, thereby generating a library of ideas.
- Copies of the diagram have proven useful in design research meetings; facilitating the discussion of ideas. The inset in Figure 7 shows some note-taking during the discussion of ideas.

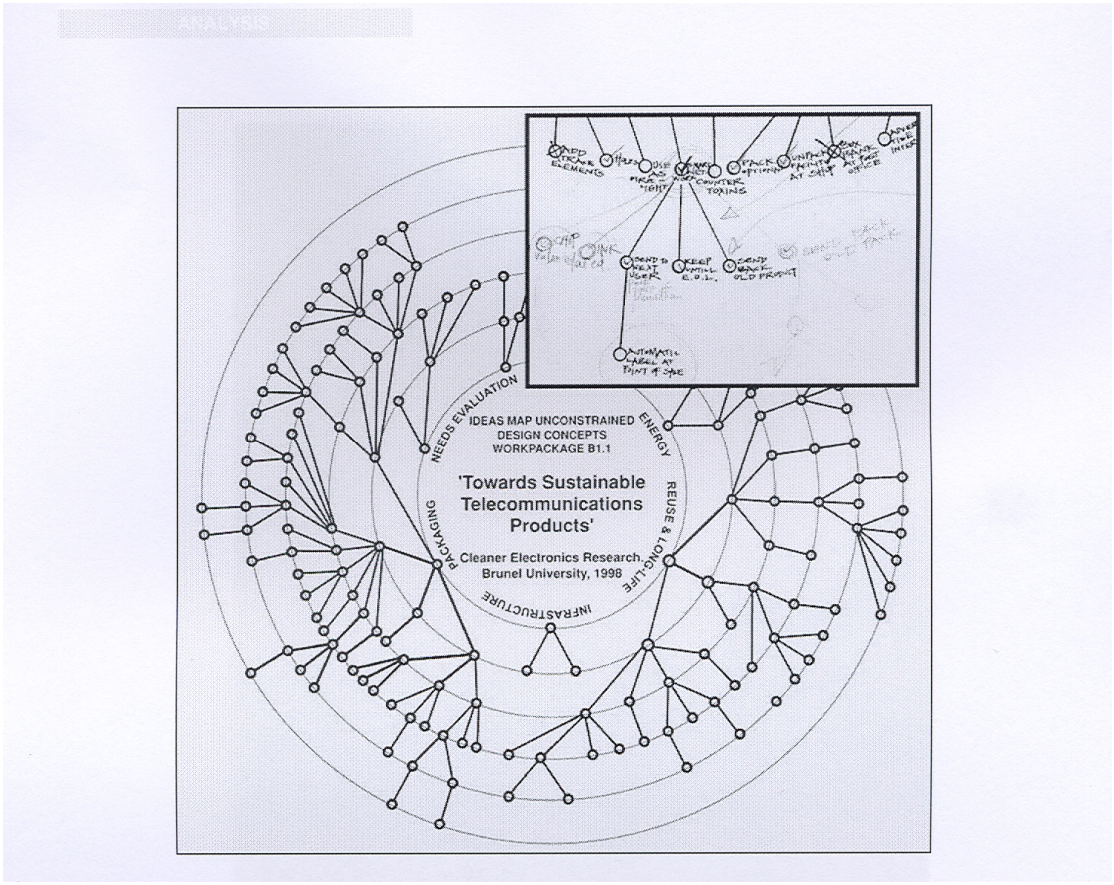

Figure 7: PIT diagram shows ideas from several workshop sessions, inset shows note taking during the discussion of ideas. Source: Jones et al. (1999)

Using the PIT diagram 'live' as a recording tool

Blank templates of the PIT diagram, with only the rings of the diagram marked, were prepared for 'live' use during creative sessions. The person appointed as the 'recorder' for this brainstorm session used these blank templates. At high speed, the 'recorder' made notes on the diagram linking the relevant ideas and starting new branches when necessary, as shown in Figure 11. The 'recorder' also facilitated the session by steering the brainstorm to areas unexplored on the diagram.

Applications of the PIT diagram during 'live' creative sessions are:

- To explain the starting points for a brainstorm in a briefing session.
- To explain the product development process.
- To indicate the type of ideas output desired: strategic, conceptual or detail ideas.
- To give all participants a distinct sense of achievement from the workshop. A comprehensive computer generated diagram can be circulated afterwards.

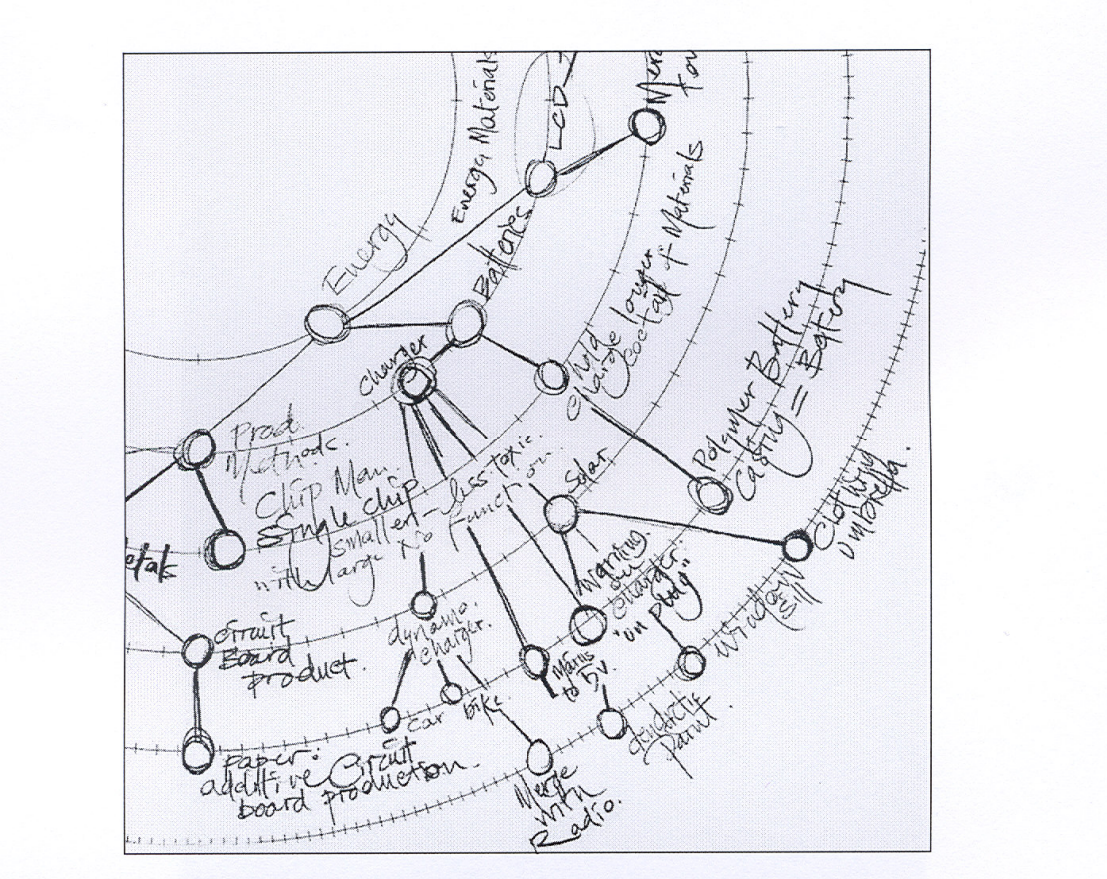

Figure 8: PIT diagram template showing notes taken 'live' during a brainstorm session

Conclusions

Two new tools have been presented: the Standard Design Process Form (SDPF) and the Product Ideas Tree (PIT) diagram. The SDPF helps to analyse the activities of eco-innovation methodologies and case-studies. The PIT diagram structures ideas output from chaotic brainstorming sessions by mapping these ideas visually. The PIT diagram combines: a model of the design process, some key-starting points for eco-innovation, and the Mind Mapping technique. The aim is to produce documentation of the creative process in the form of maps. The PIT diagram is intended to be used alongside existing tools and methodologies as an integral part of the eco-innovation process in the following ways:

- To comprehensively document and provide insights into the outputs from creative sessions.
- To record ideas 'live' during creative sessions. As an immediate visual output, the diagram can also aid the facilitator to 'steer' the session.
- To communicate the output from brainstorming sessions to all stakeholders in the design process (designers, managers, engineers and marketing), highlighting those elements of interest to them.

Previous research has shown that, by addressing environmental concerns at the early stages of the new product development process, greater environmental improvements are likely to result. Defining environmental business strategies at the start of the design process generates focused aims for eco-innovation projects which, in turn, can enhance the effectiveness of idea generation sessions. The PIT diagram emphasises this need for defined environmental business strategies, as they provide key-starting points on the inside ring of the diagram (Environmental Business Strategies). A PIT diagram can also be used in creative sessions to generate ideas that radiate across the whole surface of the diagram, thereby providing a great span of potentially relevant ideas.

Reviewing the results from various eco-innovation projects using either the SDPF or the PIT diagram suggests that ideas generated in the creative sessions tend to span across all stages of the design process. Analysing the outputs from creative eco-innovation sessions carefully is important. The SDPF helps to identify 'compound' idea statements which may be obscuring the most valuable aspects of the ideas generated. The PIT diagram may provide valuable documentation and insights into the outputs from creative eco-innovation sessions. The PIT diagram is also a useful communications device for stakeholders in the design process and thereby assists in the management of environmental product or service development.

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