Editorial: Fostering creativity and innovation during early informal phases in industrial design. Part 2: methods and tools

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Abstract: Innovation and collaboration are two main topics of actual research activities. In the worldwide competition, companies need to develop new and innovative products. The more innovation is fostered early in the product development process, the more costs and time of development will be under control. Despite many works achieved for years on methods and tools in design, very few frameworks exist to support designers during the early design phases. This special issue focuses on frameworks that can support designers to generate and select concepts and new ideas during the first phase of design process. Several points of view are expressed from the generation of design information, sometimes in a collaborative context, to its sharing and to their evaluation and decision making.

Keywords: decision-making; distributed environments; early design phases; information and knowledge representation; innovation; multi-disciplinary creativity tools.

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focused on the problematic of methods and tools to foster innovation in early design phases. His work is based on both observation/participation of industrial design situation and development of software and information tools to foster interaction and coordination between actors in integrated design and concurrent engineering.

The development of new products requires the implementation of various and complex technologies. Computer-Aided Design (CAD) systems have been improved over the years to become the central application of product modelling. They allow easy and fast modifications of 3D models and reduce product development time (Tichkiewitch, 1994). Nevertheless, CAD systems are still dedicated to geometrical information. On the one hand, many specialised systems have been studied and implemented to re-use CAD geometry: as for example CA Manufacturing (CAM) systems, CA Engineering (CAE) tools or knowledge-based applications (Lovett, Ingram and Bancroft, 2000; Myung and Han, 2001). Most such systems have now reached a good level of maturity, as indicated by their extended use in companies. In parallel, methods have been developed for an adequate use of these tools in each company as well as methods for managing the design process, such as integrated design or concurrent engineering (Prasad, 1996).

On the other hand, a lot of work has been done to extend the abilities of product modelling by designers. These works can be divided into two categories. The first category deals with the product definition itself and researchers intend to help designers to formalise non-geometric elements such as behaviour, structure, or knowledge from experts with specific technical skills. The second category aims at modelling the product before the detailed design phase where CAD systems begin to be fully used. The main idea is to define integrated product models (Roucoules et al., 2006) available since the conceptual design phase when the technical specifications can be defined. Such models are generally multi-view models integrating the functions (Kitamura et al., 2004), structure and interfaces elements, and sometimes behaviour (Gero, 2004). Nevertheless, such models are often defined in a routine design context and have not been tested during early design phases or for innovation. The use of tools implementing integrated models is most often limited to prototypes that are still under experimentation and evaluation.

Product Lifecycle Management (PLM) systems offer many possibilities for product data management, process rationalisation and project structuring. PLM systems manage product data throughout the development of products, from design to recycling or destruction (Saaksvuori and Immoen, 2004). The collaborative aspects (Helms, 2002) are fundamental in such platforms by the implementation of centralised databases and the proposal of shared but controlled access to product data. Their integration with CAD systems or other specialised systems offers large possibilities to designers to achieve their tasks and share data (Morris et al., 2004). Nevertheless, being industrial systems, PLM systems do not take into account the integrated models and tools. Moreover, as few research works exist on the early design phases, nowadays, PLM systems are not able to manage informal or semi-structured information, which is a characteristic of design activities in the early stages of design processes, e.g. identification of concepts of solutions, proposal of a technological principle, or characterisation of new ideas for product innovation.

The aim of this part of the Special Issue 'Fostering creativity and innovation during early informal design phases' is to present some frameworks that can support designers in the generation and selection of concepts and new ideas during the early phases of the design process. Several points of view are expressed, from the generation of design information, sometimes in a collaborative context, to its sharing and evaluation and decision making.

This part of the special issue is composed of six articles:

The first paper is 'Visualising early engineering design information with diagrams', by Filippo A. Salustri, Rob H. Bracewell, Nathan L. Eng and Janaka S. Weerasinghe. The authors explore two complementary research axes. The first one deals with the study of design rationale tools and the recording of early design decisions. The second one concerns design schematic by studying tools dedicated to concept mapping, i.e. formulating concepts and links that help to manage design project structuring. The authors demonstrate the interest to integrate such tools into a PLM environment and propose a third tool to visualise information based on concept mapping. Such an environment supports engineering activities during early design phases by enhancing designers' abilities and by managing generated information for innovation fostering.

On the same theme, the paper 'A sketching alphabet for paper-based collaborative design', by Philip J. Farrugia, Jonathan C. Borg, Xiu T. Yan, Kenneth P. Camilleri and Graham Green, considers sketching as a natural and powerful means for formalising concepts and sharing them. A framework based on the use of a prescribed alphabet is proposed to support human sketching and then generate an automated 3D modelling of the future product.

In the third paper, 'Digital support for net-based teamwork in early design stages', the authors Christoph Ganser, Thomas Kennel and Andreas Kunz focus on creativity sessions during early design phases. They propose a new kind of system for supporting such sessions between people in different locations. Based on an internet-based architecture, the system not only integrates traditional components such as audio and video devices, and communication and collaborative software tools but also new tools dealing with Tangible User Interface (Sharlin et al., 2001). Different physical devices are so defined to help designers in achieving collaborative tasks during creativity sessions.

The fourth paper is entitled 'The collective innovative process in intermediate graphic representation in the early stage of the design process: toward a conceptual framework for improving the collective exploration of innovation'. The authors, Nadine Stoeltzlen, Benoît Roussel and Thomas Vallette, study the relationships between design actors in order to help them to exchange, and moreover, understand the different points of view from different professional cultures. They propose a methodological framework for characterising the information to be shared in a graphical way and demonstrate its added value for improving design coherency and creativity.

The preceding papers examine methods and tools for supporting creativity and concept formalisation, but the next paper, entitled 'A driver for selection of functionally inequivalent concepts at varying levels of abstraction', explores the evaluation and the comparison between design concepts. Several reports have examined this subject and most of them are based on the assumption that concepts can be compared directly. But the authors Sudhakar Teegavarapu, Mark. Snider, Joshua D. Summers, Lonny L. Thompson and Mica Grujicic propose here a method dedicated to the selection of non-equivalent concepts that satisfy several different functions and are at various levels of abstraction.

The work presented in the sixth paper, 'Supporting early design decision-making using design context knowledge', also tackles the decision making during conceptual design. The point of view mentioned here by Fayyaz U. Rehman and Xiu-Tian Yan is based on the definition of the design context knowledge and taxonomy, and models are proposed to structure it. A software prototype has been implemented for a specific kind of product and tested to support the corresponding method.

The frameworks proposed in this special issue are based on existing and innovative IT technologies. We expect that such tools will demonstrate their utility at the industrial level and that some of them will be integrated into future PLM systems.

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