Design networks and knowledge management for supporting small and medium enterprises. Cases from Italy

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Abstract
The shift from industrial economy to knowledge economy and from material resources to “intellectual resources” has supported new ways to look at innovation processes. More and more importance is given to knowledge diffused inside and outside organizations as the key resource to foster innovation.

Italian companies, above all in furniture, home accessories, fashion sectors, have gained a competitive advantage. This success was based on local knowledge network, connecting systems of small and medium companies, in which design played a distinctive role.

The global diffusion of knowledge, thanks to Information and Communication Technology, represents for Italian companies an opportunity and a risk as well: they can easily access new knowledge about design, technologies materials etc., but they can hardly protect their specific know how and their local capabilities.

This paper aims to explain how Italian successful companies created design knowledge networks and how they continuously support design innovation. Starting from this scenario it shows, through two case studies, how a public institution – the University – can support design knowledge sharing and creation inside local systems of SME.

1. Introduction
This paper aims to describe a context where design in small and medium companies can be supported by the University. In Italy there is a complex network of SME organized in Industrial District and linked with a network of professionals. In this scenario design knowledge is a “diffused” resource, acted inside and outside companies. Traditionally this system of knowledge and competences has never been supported by Public Institutions through specific policies. The role nationally acquired by the Politecnico University – School of Design, shows an effective way of supporting design innovation through research and education. In this paper two cases are presented.

The first case shows how the University can support design innovation in a single company by reorganizing the design knowledge resources of the company. This case is set in the fashion sector that it is one of the most important field in Italy and, despite some few well know brands, it is characterized by a large community of Small and Medium Enterprises that constitutes the real value of Italian Fashion industry. The case shows how the Politecnico di Milano can support though action research, a process of “self-knowledge” of the company. This drives it to reorganize its creative process supporting design core competences.
The second case regards methodologies and tools to organize and make design knowledge available research and design practice, for students but also professionals and companies. It describes the experience of DesignNet, a project for a local knowledge network developed within the academic community. The system address the needs of end-users and content providers interacting with the School of Design. It moves from the assumption that traditional modalities of archiving and displaying currently adopted by the Politecnico and other academic institutions are not coherent with industrial design process & practice. The chances offered by the ICT have been integrated into a knowledge-based system for the online cataloguing, retrieval and display of design rich media and heterogeneous resources.

2. Design management in the knowledge society

2.1 Knowledge and design
The shifting from bureaucratic organization to learning organization drove managers to move their attention from material resources to human resources: as the aim of bureaucratic organizations is working as “machines”, the aim of knowledge organizations is learning (Rullani E., Romano L., 1998; Crozier M., 1990; Drucker P. F., 1993; Reich R. B., 1991; Thurow L., 1996).

Knowledge represents the resource leading organizations in structuring their processes, as it is the key factor for supporting competitiveness and continuous innovation.

A main topic students are dealing with relates to the nature of knowledge. It is considered anymore as codified and transferable only through language, signs and symbols. It is instead composed both by codified and tacit elements which individuals acquire through experience and interaction. Tacit knowledge is becoming more and more important as it represents a unique and not replicable asset for companies (Penrose E., 1959; Polanyi M., 1966; Polanyi M., 1985; H., Collins, 1993, Nonaka I. e H. Takeuchi 1997). Moreover users’ tacit knowledge can be a unique source for innovation being related to unexpressed needs and behaviors.

Knowledge is not a static resource but it is a process. Many students dealing with “knowledge economy” are moving their attention from knowledge to learning as the process that can provide organizations with a continuous source for fostering innovation. (Argyris C., Schön D., 1978; Blacker F., 1995).

In this scenario design seems to be a resource able to promote knowledge acquisition and transformation (learning). Designers are knowledge workers and can find a proper role inside organizational structure. In fact, they shows attitude and competences typical for “knowledge workers” and this can legitimize this profession in being not just a simple tool or skill for developing products but a knowledge resource inside organizations. Indeed students talking about knowledge workers often use the term “designer” referring to top positions inside companies: design skills seem to represent today a “typical” requirement for leading positions inside businesses. (Crozier M., 1990; Drucker P. F., 1993; Reich R. B., 1991; Borja De Mozota, 1998).

2.2 Design knowledge in a system of SME: the Italian case
The Italian case seems to be an interesting context to explore the role of design in the knowledge processes driving organizations toward product innovation. In Italian small and medium companies design has always been a knowledge source, able to bring inside organization external knowledge. Users communities and local networks of suppliers, professionals, producers, represent an economic, social, and cultural value, design takes part in. By sharing practices and uses and by interacting with the local productive community, design is able to promote change according to this context. It brings new knowledge inside organization promoting continuous innovation inside a specific group of products and services charactering Italian life style - apparels, lighting fixtures, furniture, textile fabrics, shoes and accessories, even food products –.
The international success of made in Italy products, such as fashion or furniture goods, have been recently analyzed by Italian and foreign students (Marshall A., 1890; Antonelli C., 1986; Piore M. J., Sabel C. F., 1987; Becattini G., 1989; Becattini G., 1998; Paniccia I., 1998; Porter M. E., 1998; Perulli P., 1989; Perulli P., 1998).

This success is mainly due to a peculiar organizational models based on local networks of industrial producers, linked with professionals/services networks. The relationship between industrial and service districts, which together create a so called “systemic area”, has been a key factor in creating an environment that facilitates as well as promotes entrepreneurial initiatives. The small size of local companies, the flexibility of management structures, and the local availability of technological solutions and knowledge about mature products have historically provided the conditions for entrepreneurs to start new businesses. In a “systemic area”, outsourcing local capabilities is the main competitive advantage for developing product and business innovation. Designers act in this system as knowledge agents (Bertola, Teixeira, 2003), working in a fluent way within different companies.

2.3 Supporting design management trough specific policies
As described above, Italian innovation system have been structuring through informal practices and relationship among industrial and professional resources. This can be considered a competitive advantage as the system doesn’t functions through codified processes supported by codified knowledge assets, therefore it is hardly reproducible. Never the less this situation is risky because it must face global markets and organizations, always developing and structuring new knowledge about products and organizational innovations

A variety of design processes and practices worldwide corresponds to a multi-organizations-scenarios. In many different countries, the relationship established by design with organizations is very different It is in fact affected by the way institutions have been supporting “design knowledge” creation and codification through specific policies. This is rare, above all in western countries, where policies have usually focused more on technological innovations than on design driven innovations. In Japan design has always been considered a key resources for innovation, and Public Institutions has always been promoting policies supporting design management inside companies.

In Italy just in the last few years institutions have been founding research programs aiming to understand the real value of design in Italian Industrial System. The School of Design at Politecnico di Milano, supported by the Ministry of the University and Scientific research, have been taking part in this new program, leading a national research about design resources in industrial and local companies, involving seventeen Design School in Italy.

Starting from this first experience, the Politecnico di Milano continuously promotes research and educational programs trying to involve the industrial system. It operates now on different levels: from the single enterprise, to regional or national systems of companies. The aim of this program is to support local knowledge networks and assets, and to drive design from being an informal resource to a managed resource.

The cases presented on the next represent two different actions promoted by the University. On one side a research and educational program promoted on the scale of the single enterprise, Mangiameli, a fashion small company. On the other side a complex knowledge and information program, DesignNet addressing design students, professionals and companies on the national scale.

3 Design management for a small company
3.1 The case study.
Mangiameli is a small company operating in the fashion field. It produces women leather accessories and bags. It has a typical structure of Italian small companies operating in Made in Italy successful sector: in fact, it is a...
design driven company. It is a family business, driven by the two owners, which are responsible for both the creative process and the business process. The owners are two ladies, Anna and Lucia Mangiameli, coming from the Milanese bourgeois society and they are together the design and management soul of the company. Mangiameli started its business in the middle of the 50’s and gained an international success during the ’70 and ’80, exporting products worldwide above all to Japan. At that time famous ladies wore Mangiameli bags and Anna was a talented designer while Lucia managed the company, always establishing relationship with new retailers and costumers. Starting from the end of the ’90’s Mangiameli began to lose its market, first in Italy and then in the other countries, and in 2001/2002 was crossing the worst crisis of its history. In 2002 it was acquired by a financial group, Mixia 2, operating in the field of fashion accessories. The new owner, after trying to renew Mangemeli, introducing new managers and designers into the organizational structure, then decided to work with the University. Mixia wanted to understand how to support this company with a new organization but without losing its history and its core competences.

3.2 The research methodology
The School of Design of Politecnico di Milano usually promotes project with companies to collect case history to use as didactical tools. Usually creates a research group that has the purpose of collecting data about the design process and management. The case study is useful for the university to understand how design acts inside companies and how it can be supported and qualified though educational programs, but is also useful for the company. In fact, the case gives the enterprise an external and new point of view on its process and resources, and the chance to understand which are the best assets and competences the company uses to innovate products. The research group usually stays inside the enterprise for a long period, collecting data, analysing documents, giving interviews, making movies and photographs, analysing contemporary and historical products. The company must be really helpful with the research team but usually it is as the University is seen as a no-profit institution willing to understand and not to impose ideas or changes. Nevertheless the results of the research is to make the enterprise understand its structure and operations and to redefine together the design process. This methodology represents an action research process as its results is a case study that has important feed back on the company organizational structure and, also, it is also used as an educational tool.

3.3 The research diagnosis
The result of the research process is a multimedia case study, telling Mangiameli story, and giving information on processes, products, people. An other important result is the interpretation of the case study given by the team together with experts of the fashion field. It is summarized in a diagnosis of the company, listing the main weaknesses.

First problem: Informal family business
Mangiameli built the capacity of designing and innovating products on the perfect coincidence between Anna Mangiameli, the designer and one of the owner, with her costumer: he began designing products for herself, fashionable and beautiful bags for upper class elegant women. With the passing time the company and its products have been becoming old with their owners. This is a very common problem of small family business, as they have no formalized process and structure. It is very difficult to understand how they function and how to translate informal practices and personal attitude and talent, into explicit and reproducible processes.

Second problem: Lack of documental and explicit memory
Mangiameli design process is almost totally implicit. Anna Mangiameli sometimes made sketches of the bags, but more commonly just told her “modelist” how to create the first prototype. They have always been communicating through verbal language, understanding each other immediately and magically. The process of designing products is implicit, there is no documental memory of the past collections, just the final products, and Anna is not able to explain clearly her ideas about design, how she creates and develops products, which are the
main characteristics of Mangiameli bags. This makes really difficult to introduce new designers because there is a lack of internal communication and the company memory and capabilities are implicitly known to Anna and Lucia, but not communicated.

**Third problem: Lack of relationship and partnership with local productive resources**

One of the strong point of Mangiameli bags has always been the particular, the small components, the precious and particular materials. This was granted in the past by the capacity of Anna and Lucia of brokering components inside the local networks of suppliers, always making unusual combinations and sometimes working with their suppliers to obtain new effects and finishing. The innovation capabilities of Italian small and medium companies are often supported by these complex network pf enterprises that work together. Mangiameli is losing this relationship with the local resources and it shows less and less creativity in finding suppliers for components and materials.

**Forth problem: Lack of relationship and feedback from retailers**

Lucia Mangiameli, the management soul of the company, was personally responsible for the placement of products to retailers. She knew personally all the shops worldwide and she was used to travelling continuously to present them the new products and collections and to have feedback from the market. Also this collaborating relationship with retailers was interrupted as Mangiameli uses now an external commercial agent to place its products.

### 3.4 The action research results

Starting from the diagnosis, together with the company the research team redefined the design process, as it is showed in the Figure 1 (Figure one: the new design process for Mangiameli). The design director, whose role is managing the design process according to the company values, works with Anna Mangiameli trying to understand her way of working and acquire the capacity of designing bags according to Mangiameli image. He manage a team that has the purpose of structuring the design process reproducing, with roles and functions the old implicit process. There is a Marketing function to monitoring retailers and shops and giving the design team feed back of products and competitors. There is a new modelist, working with the old one, whose purpose is not just prototype products but to experiment new solutions and materials and become a problem solver for the design team. There is a buyer, called also *creative broker*, whose function is to re-establish the relationship with local resources and suppliers and also to explore new markets and opportunities to find creative and new components. There is a design research activity, outsourced by the company whose function is to provide information on trends and future scenarios to suggest new products and collections (Bureau del Style, Trend Institute). There is also the chance to outsource consultants designers, giving them a clear brief, managed by the design director according with the company vision and capabilities. This new form of the organization is now being implemented, but already a new collection is being producing, designer together by Mangiameli and a group of teacher and students of the Politecnico School of Design.

### 4 DesignNet

#### 4.1 DesignNet and industrial design education at the Politecnico di Milano

The project is part of a wider program of the Politecnico di Milano, Italy, focused on developing digital tools to support the teaching and research activities of the School of Design community (Ciuccarelli 2002; Innocenti 2002). It aims to satisfy the dynamic information needs of the academic community in the interdisciplinary industrial design field. At the same time, DesignNet aims to nourish documentation and experience's exchange and creation. Project goals are to define methodologies and create tools to enable the efficient management, retrieval and visualization of 3D and 2D resources within an open, integrated and collaborative structure. Efforts have originated a prototype for a knowledge-based system for the online digital display, retrieval and archiving
of rich media resources for industrial design education, research and practice (Boghetich, Ciuccarelli, Innocenti, Vidari, 2002 (a) (b). This system is deeply connected to the dynamic structure and organization of teaching of the Industrial Design Degree at the Politecnico di Milano (Bertola, Penati, Seassaro, 2000): here experimental research on new didactic methodologies and tools and a systematic weaving of relationships with professionals, companies, associations and design-related institutions parallels current transformation in the design productive system, such as digital prototyping processes, rendering techniques, digital mockup.

4.2 Issues on project-related resources
Industrial design project deals with specific typologies of heterogeneous resources used in design practice. For those resources it is not possible to use traditional cataloguing standards and search engines, as their performances degrade with multimedia data, made of images, 3D models, 2D graphics and sounds instead of words (Paquet and Rioux, 1999; Grosky 1997). Project-related resources within the School of Design are specifically characterized by:

1. an exceptional richness and heterogeneity of typologies concerning products, processes and strategies: mostly multimedia documents (both 2D and 3D files) with a small percentage of textual materials (mainly grey literature, informally published material harder to identify and to obtain and difficult to organize), marketable goods, semi-manufactured products, material samples;

2. diversified typologies of content providers and of users: students, professors, researchers, design professionals, companies;

3. acquisition and conservation modalities with no standardized procedures, so that most of those materials often results “invisible” and hasn’t got a defined and organized location through time.

Those complex features don’t allow easy usability, transfer and visualization of design knowledge, which is mainly visual and manipulable (thus difficult to be formalized through procedures). Project-related resources in a networked and online environment require therefore different cataloguing, retrieval and visualization rules and tools from those elaborated for traditional documents.

4.3 Needs and solutions
In the design field it’s essential to perceive, compare, organize, link and interpret as many forms of knowledge expressions as possible within a community, bringing people together around a pool of quality information. As the president of a knowledge management company states, ‘to leverage knowledge we need to enhance both thinking and information (…). The technical challenge is to design human and information systems that not only make information available, but help community members think together’ (McDermott 1999: 107). Among tools supporting design didactics, research and practice, hypertext and hypermedia tools are currently preferred, despite having significant limits such as the link to written text in the first case and the lack of ad-hoc interfaces in the second. This clearly constitutes a limit, since interdisciplinarity is a distinguishing mark of design teaching and explorative experiences are necessary to the development of novel relations among heterogeneous digital knowledge bases (Ciuccarelli 2001).

To avoid those problems it was chosen to create a rich media database using a metadata repository, stimulated by current experiences from other gateway and digital library projects. After analysis of a variety of schemas, we selected Dublin Core Metadata Schema, a recognized standard allowing simplicity, flexibility, interoperability and modularity. It’s semantic model allowing to offer basic descriptive information about any kind of resource, independently from the media format, area of specialization or origin. Distributed resource description with Dublin Core is feasible and practical, content providers and staff can readily use it. A Web client/server architecture was preferred as it enables remote access to resource in ways not easily possible with conventional applications. Changes in server-based information can be made immediately and collectively available and simultaneous
collaborative sessions are possible. Access control provides a mechanism for creating multiple user classes having different access rights to the information. Web servers were selected to serve content over the Internet using XML.

The main advantage of the adoption of those solutions is that they provide meaningful access to valuable and validated resources. Multiple levels of description, established criteria and standards are meant to guide the selection of resources for inclusion in the collection. Information Retrieval tools were selected to perform “creative” and personalized visualization, recombination and interaction with documents and with design community members. As a metadata repository, the system shows what kind of resources we have, what is their meaning within the context of industrial design, where they are located, how they were acquired and which retrieval modalities are necessary to access them in a distributed and integrated environment. Those documents are finally made “visible” and accessible through a combination of a more industrial designer-friendly interface and cataloguing and retrieval tools shaped for industrial design issues. In this way the DesignNet framework can represent a powerful aid within the training of the industrial design project and in design practice.

4. 4 The system: Dublin Core Metadata Schema, Design Thesaurus, Graphic User Interface

DesignNet has been conceived as integrated online database to bring together collections, services and people in support of creation, dissemination and use of design knowledge and design practice. It features a searchable, browsable repository of high quality resource collections and services, specific interface modalities and recognized standards that allow interoperability with other collections, to provide different types of users and content providers to access or add contents in a user friendly manner and through a collaboration mechanism.

The application profile schema used in the project is based on Dublin Core Qualified Schema, implemented for the use of XML and adopted worldwide. The standard schema, composed of 15 elements, remained unchanged and a subset of qualifiers was added, modified and integrated according to our needs. This allows to share resources via the Web with other communities, using commonly understood semantics and choosing the richness of description, and to provide unified access to databases within different underlying schemas.

A textual retrieval approach based on a thesaurus was chosen in order to provide a unified integrated access to 3D Virtual World and 2D animated graphics data, which haven’t been created to be catalogued and in which textual data are implicitly contained but not explicitly declared (Paquet and Rioux, 1999). Unlike current automated thesauri, manual thesauri improve the precision for descriptions and subject access to resources, enabling more exhaustivity, specificity and flexibility than classification and subject headings. There are practically no thesauri in Italian specifically created for the field of industrial design and it was decided to develop an in-house Italian Industrial Design Thesaurus for our needs, selecting and organizing terms according to the main issues in the project creation.

We referred to ANSI/NISO standard and manuals (Aitchison and Gilchrist, 1997), to pre-existing thesauri and to the direct experiences of the School of Design Community members. Parallel to the Industrial Design Thesaurus is the elaboration of authority files of companies, institutions and relevant people of the industrial design world, with particular attention to Italian industrial design districts.

A crucial problem of heterogeneous resource collections in Web-based applications, often preserved in different repositories which have adopted different standards and formats, is their management and visualization with a homogeneous interface. In DesignNet metadata are associated to resources inside a RDBMS with a Web interface appositely created. This allows effective and proven methods for information retrieval and manipulation through exploitation of Java and eXtensible Markup Language (XML), access to metadata but also to the very same resources (using a clear codification of archival standards for digital resources). Visualization is supported by previous selection of current available standards, to assure portability on different platforms. Traditional data visualization focuses on descriptive textual approach of query results.
DesignNet’s aim is to render data accurately while highlighting important patterns, introducing coherently codified graphical elements. This “semantic visualization” approach (Arnheim 1972; Tufte 1990) introduces assessments of the meaning and relevance of the data into the visualization evocative process. We do not think in pure abstractions, rather, our thinking is metaphorical.

In the design field, in particular, the rich visual data articulation requires a kind of visualization presenting a similar degree of iconicity and similarity. A number of information needs manifested by the School of Design community were also investigated: the possibility of finding resources (especially visual ones) that other subject specialists in the community have rated highly, having search results filtered or ranked according to rules based on a quality-related property of the resources listed, knowing other users’ exploitation of specific resources, tracking emergent trends and evolving patterns.

4.5 The prototype’s implementation: system architecture, components, Graphics User Interface (GUI)

The heart of multilayered structure DesignNet Metadata Management System (Fig. 2 Schema of DesignNet Metadata Management System, schema by M. Boghetich) is DesignNet framework, based on a J2EE platform and on a Dublin Core data structure (more technical details can be found in Boghetich, Ciuccarelli, Innocenti, Vidari, 2002 (a).

The framework is a set of tools which enables to create, catalogue and search every metadata recorded within the database. With Dublin Core it’s possible to import metadata from other archives using different metadata schemas, such as UNIMARC or MPEG-7. The system operates over a remote connection to a server or a standalone application. Content is collected, selected and processed with metadata creation and validation (Fig. 3 Workflow of DesignNet system). Typical user of the system is people looking for or interested in making available specific, reliable and updated resources to be employed in a industrial design project, either for educational or professional purposes. The Industrial Design Thesaurus (Fig. 4 Application of the Industrial Design Thesaurus, created by M. Boghetich) is an information storage and retrieval tool: it’s used both by indexers (as a listing of words and phrases authorized for use in an indexing system, together with relationships, variants and synonyms) and searchers (as aids to navigation and retrieval, sitting behind a search interface and facilitating searches without requiring users to interact with it as a separate operation). A metadata application (Fig. 5 Application of the Dublin Core data entry, created by M. Boghetich) provide a template for creating records, a RDMBS repository stores the records and a application provides a searchable and browsable interface. In order to represent semantic values while searching documents, dynamically build schemas are provided to help users in the retrieval and to evoke the context of the searched resources, in terms of quantity and typology. The system supports different methods of search and shows users their search path to build a major consciousness of the researching context and methodology. The user can play with many different parameters, starting with the keywords. In the main search page we can filter results by keyword or document type, change values, see the table listing, ask for the metadata of a resource. To trace our activity we can use tags to insert an object into advanced bookmarks listed by category or related to a real active or past project. Users can see this tag and be able to ask the system such information.

DesignNet system includes components that reside both on the server and client Sides. On the server side a Web server serves client requests for static and dynamic content. The visualization and query architecture is a typical client/server architecture based on four main components: open relational database management system (RDBMS), Web server, Web browser, server side Web-oriented language and communication software to dynamically retrieve the contents. The system features a single point of entry for the user to cross-database resources, provided knowledge-based retrieval with dynamic visualization; advanced search and browse functionalities; sections with a variety of information and other features typical of gateway (Koch 2000).

Graphic elements collect search results as homogeneous sets, according to the keywords adopted in the search. The keyword-based search can be compared to drawing a line on a blank sheet, an incipit to enclosure a field.
of interest. The system then builds a map to let us find resources “near of”. Beside the map there’s a traditional listing of the best results, the way a search engine usually creates, but the added value is the academic accreditation. The map let us combine many parameters included in the metadata fields. With a dynamic visualization we can “play” with parameters, keywords and filters to adjust the “target” of our search (Figg. 6-7 DesignNet interface showing query results). Search refining is made on a single dynamic page, but the system logs all our activities and saves our path of search, to be eventually shown later. Each object is placed into a context inside the target, but the type of relationship shown by the target can change. We can ask the system to show what 3D model or 2D graphic files were used by somebody else while searching on a particular topic and learn how others used resources. The user profile too can be used in the retrieval.

5 Conclusions and future works

Mangiameli is now experimenting the new organizational form and the research team is monitoring this renewing process. The goal is to drive the company from its implicit and informal structure to an explicit one in which design has a new role. It must become a leading function inside the organization but also an outsourced resource. The design process is going to became a complex mix of capabilities and contribution, able to face the global market and opportunities without losing the link with Mangiameli history and core competences.

Also the DesignNet prototype is being monitored and tailored on user’s demands. As the system evolves, efforts will entail further investigation on visual retrieval techniques and personalized retrieval, implementation of GUI and personalized information environment, implementation of thesaurus and of multilingual access tools and investigation on access with palm and UMTS technology. In a longer-term perspective, DesignNet will provide new challenges for design education, research and professional activities, as a effective system of transferring, integrating and stimulating design knowledge sharing and creation within local communities.

The two cases are two small results of a main goal for the Politecnico di Milano: being able to support Italian design knowledge system on different scales, providing research results, educational programs and services.
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