Exploration in Knowledge Capital improvement through Social Media in Complex Product Design

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Currently, Knowledge work is fundamentally different in character from physical labor. This new reality dramatically alters the methods by which a worker can manage, learn, represent knowledge, interact, solve problems, and act. In this paper, a knowledge-intensive company, who is characterized as such that a highly educated workforce engages in mainly intellectual work, has been studied. To realize effective knowledge management, a complete architecture is proposed to integrate different tools and methods (e.g. Wikis, and blog) that collect, store, categorize, present business and engineering knowledge. Storytelling is suggested to be used to engage, involve and inspire employees, represent tactic content in a more authentic and narrative form. All these efforts and approaches will greatly benefit the company in our case study for operating its business successfully. As a result, managing knowledge effectively for such company will offer itself the primary opportunity for achieving substantial savings, significant improvements in human performance, and competitive advantage.

keywords: knowledge management; product design; social media, design process

Introduction
As Baets describes (Baets, 2009), “knowledge is the potential of an individual to enact innovation.” Knowledge assets in a corporate context normally include processes, technologies, people, and many other aspects (see Figure 1). All knowledge can be classified according to its complexity on a continuum from explicit to tacit. Michael Polanyi
(Polanyi, 1966) identified the distinction between two types of knowledge: *Explicit knowledge* (sometimes referred to as *formal knowledge*) can be articulated in language and transmitted among individuals; *Tacit knowledge* (also, *informal knowledge*) is personal knowledge that roots in individual experience and involves intangible factors, such as personal belief, instinct and values. Regarding the role of knowledge in any business organizations, *tacit knowledge* is often viewed as the real key to getting things done and creating new value. While tacit knowledge potentially can represent great value to any organization, it is, by its very nature, far more difficult to capture and diffuse.

The term of knowledge-intensive companies (Alvesson, 1995; Starbuck, 1992) refers to those where most work is said to be of an intellectual nature and where well-educated, qualified employees form the major part of the workforce (Alvesson, 2000). Typical examples of knowledge-intensive firms include management, engineering and computer consultancy companies, design agencies, research and development units and high-tech companies. High knowledge intensity within certain industries means that advances take place at such speed that cutting edge knowledge is rendered outdated within a short period. Now the life cycles of technologies and innovations are even shortening. In semiconductor industry, where time spans relevant to the development of smaller and faster chips are typically counted in a year (Moore’s Law). The demand for chips is directly related to the demand for electronics products by the end consumer and is, hence, extremely sensitive to market fluctuations and often unpredictable. Popular products such as iPhone, etc. may lead to an almost explosive demand for the most advanced equipment in chip manufacturing.

In this paper, we select a company who designs, manufactures and produces lithography systems as example to examine how its knowledge sharing through social media during its complex product design process actually helps itself in maintaining its competitive advantage.

![Knowledge Assets are](image)

**Knowledge Management in a Hi-Tech Organization**

The development, production and even marketing of any semiconductor manufacturing equipments are extremely complex and highly knowledge-intensive. For the company in this case study (it is called Company A in the following sections), it is well aware that the access to and/or the ability to share existing knowledge and create new knowledge has become a major source of competitive advantage (Teece, 2000; Nonaka et al., 2000; Brännback & Carsrud, 2002). Knowledge management (KM) is one of the keys of its success because of the growing importance of knowledge and becomes a new challenge in
current dynamic business environment. It has managed to be a people-oriented and knowledge-intensive organization from the beginning.

The company studied has several thousand employees. Most of employees have a scientific or technical background and the educational level is, as a whole, quite high (university and college graduate). The average age of its employees is 33. Its organization structure is shown in Figure 2. In this company, knowledge exists in different business units or departments in different forms. In the development and engineering department, knowledge is regarded as the know-how of the research and engineering (software, mechanical and electrical) processes. In the marketing department of the business support unit, the market trends and size of semiconductor industry are the important knowledge to implement correct marketing strategy. In the legal department, the patents owned by the company and its competitors, and the law of intellectual properties are relevant knowledge. In short, different forms of knowledge exist and are growing, which contributes to every aspect of the business. How to effectively manage and share these knowledges presents a big challenge in terms of KM.

Figure 2  The Organizational structure of a High-Tech Company studied
The Need of Knowledgement Management for Company A

A common definition of KM is “the collection of processes that govern the creation, dissemination and leveraging of knowledge to fulfill organizational objectives” (Lee and Yang, 2000). Davenport and Prusak (2000) define KM as: “to identify, manage, and value items that the organization knows or could know, including skills and experience of people, archives, documents, relations with clients, suppliers and other persons and materials, often contained in electronic databases.” Walter Baets defines KM as:

1. “Support of the networked act of ‘cognizing’ of the actors (employees, clients, ...);
2. Manage the empty spaces between functionalities (creativity resides in those empty spaces).”

Ann Macintosh (Macintosh, 1997) has identified several business factors that create demands on KM, including marketplaces, the reduction and mobility of work force and the change of corporate strategy. In Company A, those factors become even more apparent:

- The semiconductor industry and lithography equipment markets are extremely competitive and the rate of innovation is rising.
- After the burst of the Internet bubble, competitive pressures and financial constraints force Company A to reduce the size of the work force that holds valuable business knowledge. Company A has reduced the numbers of pay-roll employees through using contractors. Increasing mobility of the work force definitely leads to the loss of knowledge. Reductions in staffing create a need to replace informal knowledge with formal methods.
- The amount of time available to experience and acquire knowledge has diminished. The research and development cycle in Company A is forced to become shorter. Its customers often require shorter lead time.
- There is a need to manage increasing complexity in business operation process.
- Changes in strategic direction may result in the loss of knowledge in a specific area.

In addition, other factors also have created the needs for KM in Company A.
Modern organizations, especially high-tech industry, compete on the basis of knowledge. Most of the work in Company A is information based.

- Products in Company A become increasingly complex, endowing them with a significant information component.
- The need for life-long learning for employees become inevitable.

These aspects are embedded in different processes of KM (see Figure 3). In Company A, many aspects can be easily recognized, which include identifying and mapping intellectual assets, generating new knowledge of designing lithography system for competitive advantage, making vast amounts of corporate information accessible, sharing of best engineering practices, and implementing technology that enables all of the above, including groupware and intranets.

![Figure 4 Standard knowledge infrastructure](image)

The current situation of KM in Company A was analyzed from four aspects of the standard knowledge infrastructure that is shown in Figure 4. It is recognized that the management team within the company indeed is aware of the importance of the knowledge ownership. Knowledge is remained with employees who need and use it. For particular knowledge, engineers or business professionals decide what to learn and keep. In company A, there is a culture of learning. Management team encourages learning and exchanging knowledge within the organization. There is also an ICT infrastructure that includes intranet, database to provide a KM platform. The problem with this infrastructure in company A is that it is technology driven rather than content driven. A lot of standard technologies are used without being customized to meet its special needs. And the existing platform is effective for managing explicit knowledge only. Explicit knowledge here, which includes engineering guidelines, marketing brochure and etc, is organized and stored in the database for employee’s usage. However, there is no effective means to deliver and share tacit knowledge that is pervasive within the company. In addition, because huge amount of information and documents exist, employees often encounter difficulties in searching and retrieve desired information. Hence, in the following sections, the existing problems are discussed in details and several tools and techniques are proposed to tackle those issues.

**Social Software for Knowledge Exchange and Sharing**

Knowledge-intensive firms like Company A need to share knowledge held by employees for triggering more innovation and engoucraging enhanced creativity in order to gain the most from their intellectual capital and compete effectively in the marketplace. There is growing recognition that sharing/transferring knowledge is essentially a social activity,
that knowledge has a social life and therefore operates often beyond formal organizational structures. The current KM system in Company A cannot meet this need because efforts were focused on the creation of central knowledge repositories, encouraging knowledge reuse and collaboration based on these repositories in a typical top-down approach where knowledge was seen as a separate entity.

Until recently, the growing phenomenon of Social Software offers a good chance to complement this traditional approach with tools that are simpler and more flexible. Social Software uses computing tools to support, extend, or derive added value from social activity. Sharing and integrating knowledge within an organization can benefit greatly from social activities through those social softwares. Typical applications of social software include social sharing, e.g. Flickr, social collaboration, e.g. Wikipedia, social bookmarking, e.g. del.icio.us, social communication, e.g. WhatsApp, and social networking, e.g. Linkedin.

What could Social Software do for Company A in KM? Knowledge emerges in conversations; actionable knowledge is mainly the result of collaboration. For example, testing and installation lithography machine in a clean room is a rather complex process. Senior engineers can share their experiences and lessons learned with junior employees. Social Software provides the necessary support for such conversations and collaborations, for knowledge creation, sharing and publication, for identifying experts and getting access to expert opinions worldwide. It leaves the control of knowledge with the individuals owning it. Each individual is able to maintain his own space for which he has complete control over the information/knowledge he chooses to share. This creates a bottom-up style of information sharing and collaboration, rather than an imposed or corporate top-down strategy (Fisher 2005).

There are several categories of Social Software (Boyd 2003), in which three kinds (weblogs, Wikis and social networking) are more relevant in connection with the core KM activities in Company A:

- **Weblogs** A weblog or simply a blog is a web application enabling periodic posts on a common webpage with public access. These posts are usually in reverse chronological order. Unlike an official web site, a weblog is highly subjective, reflecting the thoughts, opinions and preferences of its author(s). Most weblogs are written by individuals. These coexist on the World Wide Web with group weblogs, project weblogs and organizational weblogs. The blog from Prof Walter Baets in KM (http://euromed.blogs.com) is a good example. Weblogs is quite useful for senior engineers and experts to record and share their knowledge and expertise.

- **Wikis** A Wiki is a website (or other hypertext document collection) that allows users to add content, as on an Internet forum, but also allows anyone to edit the content. "Wiki" also refers to the collaborative software used to create such a website. A Wiki enables documents to be written collectively in a simple markup language using a web browser. For example, the development team members of one product line in Company A can use Wiki to share and edit information with each other easily, particularly when they are physically located in different places.

- **Social network services** The so-called “social networks” are circles in which people interact and connect with other people. They transcend strict delineation
between personal and business (there is often overlap between the two). Those popular social networks of web-sites are Facebook (www.facebook.com), and LinkedIn (www.linkedin.com). For a big organization with thousands of employees like Company A, social network can transcend organizational boundaries and hierarchies. It helps building network for business operation between different function units.

Introducing Social Software into the KM system in Company A leads to several benefits including low-cost, high bandwidth, coupled with self-motivated and gregarious employees. These tools give individuals a chance to network in online versions of real world social systems (Boyd 2002).

**Storytelling for Transferring Tactic knowledge**

It is generally acknowledged that knowledge, particularly tactic knowledge is not similar to information. Information can be canned into databases, papers, lists, guidelines. However, knowledge stays embodied, which means that experiences, insights, memories and judgments cannot be easily extracted from the bearer. Thus, most knowledge is uncodifiable, only pertinent at a given moment in time and often remains tacit. This presents organizations or corporates with a major challenge.

KM is essentially a teaching-learning interaction. Research indicates that the brain works by detecting patterns in information. “One of the brain’s best tricks is to extract meaningful patterns from confusion” (Liston, 1994). As one of the most prevailing forms of communication, storytelling is useful in the teaching-learning interaction and it possesses great potentials as a teaching-learning tool. Storytelling, as a tool to share knowledge within business organizations – especially when attempting to share tacit knowledge, is increasingly being recognized and deliberately used recently.

Current organizational communications in Company A are somewhat dry and lacking in inspiration. At the same time, tactic knowledge in Company A exists everywhere from research, development, engineering to production, marketing and sales. Tacit knowledge is regarded as “knowledge that we do not know that we know” (Hughes, 2002). Most of time, it is difficult to convey, and to acquire in Company A. The common way to acquire it is from those employees who have seniority and who have been with the company or in the lithography business for certain period.

“Storytelling is a way of capturing what is unique, and what is unique per individual is tacit knowledge” (Post, 2002). Storytelling is the right way of getting tacit knowledge out in Company A so others or inexperienced employees can use it and refer to it. Stories serve as metaphors because they make information more meaningful and understandable. Stories transfer the difficult-to-uncover tacit knowledge within Company A by appealing to the natural learning process of the brain. Stories of experiences during development or marketing, trials and errors during maintenance of the equipments, for example, would likely benefit young engineers or junior business professionals who have not had much opportunity to acquire tacit knowledge.

The final question is how to implement storytelling as a KM tool. Based on the suggestions from Reamy (Reamy, 2002), stories can be used in several ways in Company A:
1. **Use of stories for describing new generation lithography technology** – The use of storytelling in innovation and knowledge creation can encourage employees to move away from linear thinking towards a more multi-dimensional view, to see connections between old and new lithography methods, and also to invent new lithography technology with a more creative or intuitive approach.

2. **Storytelling to enhance communicating technical knowledge** – In *Company A*, employees often find it difficult to communicate about technology. Engineers sometime have trouble articulating their needs and expectations, while experts have difficulty in ‘talking in plain English’. Wherever there is a gap in language and understanding, storytelling can provide a bridge, by communicating the real essence of what each party is trying to get across.

3. **Storytelling to embody and transfer (tactic) knowledge** – A simple story can communicate a complex multi-dimensioned technical idea, not simply by transmitting information as a message, but by actively involving the listeners in co-creating that idea. Furthermore, as a story is told and retold, it changes. So the knowledge embodied in it is constantly being developed and built upon. For example, internal magazines with stories should be used in *Company A*. It encourages the senior engineers writing stories about their experiences and hopes that other teams will learn from their mistakes about “what not to do” by reading these stories.

4. **Storytelling to build team** – Stories can bring people together and foster a sense of team. Storytelling is non-hierarchical. It unlocks feelings and emotions as well as thought processes. Hence it helps to build relationships and trust among employees within *Company A*.

5. **Storytelling for individual growth** – Storytelling is a skill, and one that is mostly related to interpersonal communication. The development of such skill for young engineers is an important component of the KM program in Company A.

6. **Storytelling to ignite organisational change** – Experience has shown that storytelling can be highly effective as a change agent, even in change-resistant organisations. Telling an appropriate story can stimulate employees to think actively about the implications of change within the *company A* and to projecting themselves into visions of the future, enabling them to better understand what it will be like if doing things in a different way.

In short, when used effectively, storytelling offers *Company A* numerous advantages over traditional organisational communication techniques. Together with spurring change, storytelling can work to capture tacit knowledge; embody and transfer knowledge; innovate; build team; enhance technology; and contribute to individual growth.

**Implementation of an Integrated KM system**

In previous sections, issues in KM and tools and methods as solutions are discussed, including using social software to boost communications, using storytelling to effectively transfer (tactic) knowledge.
In order to effectively and efficiently developing, transferring and applying important technical and business knowledge within Company A, a complete and integrated KM system that consists of all indispensable components is desirable. A proposed architecture of the KM system based on the example of Organik (Bibikas, 2008) is illustrated in Figure 5, which integrates different components mentioned above. As seen in the Client Interface Layer, the collaborative workspace is offered to employees, which comprises a wiki, a blog, a social bookmarking tool and a search interface. Every client interface corresponds to a server-side component in the Component Interface Layer of the architecture. The server-side building blocks include a recommender system, a semantic text analyzer, a collaborative filtering engine and a full-text indexer. They all locate at the Business Logic Layer. The Metadata Layer refers to repositories used for the persistence of syntactic and semantic metadata that support the functionality of all server-side components. The Data sources and Back-Office Integration Layer are business information systems and any form of resource container that Company A may depend on for its daily operations.

![Knowledge Management System](image)

*Figure 5  Integration of heterogeneous data sources in a knowledge architecture*

The functionality of the main components in the component layer of the proposed architecture is envisaged as follows:

- The Wiki Component is a web-based authoring tool allowing engineers and business professionals to collaboratively create, edit, and share knowledge artifacts such as documents, diagrams, and etc. There can be a Wiki for software...
development team. Marketing or sales unit can also establish their own Wikis to exchange marketing information and sales strategy.
- The Blog Component provides a simple content management tool enabling employees to build and maintain open project monitoring diaries, complete with links to relevant resources and user commentary. The blog component is particularly suitable for individual project/product management.
- The Social Bookmarking Component enables employees to organize and annotate resources (intranet documents, web resources, wiki entries, source code, blog posts, etc.) relevant to their own activities and share them with their co-workers.
- The Semantic Search Component provides supports for browsing, searching, retrieving and displaying knowledge/information resources, leveraging semantic annotation indexing.

The function blocks in the function layer are supported by the business logic layer that includes the following parts:
- The Recommender System focuses on the suggestion of tags and classifications for content added to the system (e.g. wiki entries, bookmarked documents, blog comments, etc.), and the suggestion of information items relevant to the search query or feed subscription of a user.
- The Semantic Text Analyzer uses linguistic and statistical processing functions to analyze the textual content of knowledge artifacts added to the system, in order to perform named entity recognition and term classification. The goal is to identify concepts of interest and establish relationships among resources that can be subsequently used by the Recommender System for suggesting tags and classifications with respect to a taxonomy.
- The Collaborative Filtering Engine enables individual employees to benefit from the collective experience built within groups of peers. An analysis of subjective views that are explicitly or implicitly expressed by other knowledge employees can assist in the selection and recommendation of resources, as well as influence the ranking of search results.
- The Full Text Indexer is an indispensable component of the architecture’s Business Logic Layer and complements the content retrieval techniques proposed.

Successful release and implementation of such proposed architecture within Company A also relies on the input of required content, including information, documents and materials that are relevant to its business operation. These materials can be in form of text, diagram and audio-video. Related stories will be particularly suggested because they allow employees to express and share (tacit) knowledge in rich and meaningful ways, instead of being forced to articulate it in more “structured” ways that can detract from its value. This proposed architecture of KM system has been implemented within Company A and positive feedbacks were received from employees of different business units.

**Conclusion**

In brief, knowledge and information have become the medium in which business problems occur. Currently, the nature of business in semiconductor industry has changed in at least two ways:
Knowledge work is fundamentally different in character from physical labour.

The knowledge worker in Company A is almost completely immersed in a computing environment. This new reality dramatically alters the methods by which its worker can manage, learn, represent knowledge, interact, solve problems, and act.

As a knowledge-intensive company, Company A is characterized as such that a highly educated workforce engages in mainly intellectual work. As a result, managing knowledge effectively for Company A represents the primary opportunity for achieving substantial savings, significant improvements in human performance, and competitive advantage. To implement an effective KM system, a customized architecture is proposed to integrate different social media tools and methods (e.g. Wikis, and blog) that collect, store, categorize, present business and engineer information and knowledge. A suggested method - storytelling is used to engage, involve and inspire employees, represent tactic content in a more authentic and narrative form. All these efforts and approaches will greatly benefit Company A for operating its business successfully.

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