e-Knowledge: An Approach To Fostering Manufacturing Know-how At The Shop Floor

Electronic Commerce Applications

Abstract

This paper presents an application of the web technology in promoting knowledge management at the shop floor, known as *e*-knowledge. The system is expected to promote sharing and reusing various levels of manufacturing information from assembly cell to testing area, and from documentation to training. The implementation of such a system has been made possible by utilising the web-programming environment. To investigate how the *e*-knowledge works, a case study involving a major cellular telecommunication industry is presented.

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Introduction

Manufacturing organisations are continuously seeking innovative ways in utilising Information Technology to remain competitive. One of the recent examples is the use of web technology. Not only has the rapid growth of the corporate Intranet provided significant improvements in communications, it has also been used to support manufacturing operations by providing an open environment for information sharing.

The purpose of this paper is to introduce an application of the web technology to provide knowledge support to shop floor personnel. The system, known as *e*-knowledge, enhances process know-how management with multimedia technology.

The paper starts by introducing the background about process know-how and its importance in manufacturing organisation. Then an industrial case is presented to illustrate how the concept of *e*-knowledge may assist the organisation to speed up the knowledge creation, presentation and utilisation. This includes a description of the system development and implementation. The paper concludes with a discussion on how *e*-knowledge will benefit the company in practice.

Knowledge Management, Know-how and Learning

At least for the last two decades, researchers have put forward that knowledge is becoming a driving force behind the success of the organisation in the information age. Nonaka commented that one certain source of lasting competitive advantage is knowledge (Nonaka, 1991), meanwhile others also underlined that knowledge has to be considered as organisational assets besides physical and financial resources (Davenport *et al*, 1997).

In general, knowledge is available in two different forms: explicit knowledge and tacit knowledge. Maintenance procedures consisting of a step-by-step instruction that a technician must perform, would be an example of the explicit knowledge. Tacit knowledge could be personal knowledge, subjective know-how and intuitions. Human knowledge is created and distributed through the interaction between tacit knowledge and explicit knowledge. This interaction is known as knowledge conversion (Nonaka & Takeuchi, 1995).

See Figure 1

Figure 1 shows four different models of knowledge conversion:

- *Socialisation* is a process of sharing experience, stories and perhaps exchanging technical skills to each other.
- One disadvantage of tacit knowledge is that human memory is not unlimited, and therefore converting tacit knowledge into explicit form is essential. This process is known as *externalisation*.
- The process of transforming knowledge absorbed from external sources into tacit knowledge refers to as *internalisation*.
- The last one is known as *combination*, where an explicit knowledge can be added or manipulated (in a database system for instance) to produce another knowledge. It usually does not involve direct interaction with human.

While the explicit knowledge is generally easy to manage, tacit knowledge is more abstract. It involves context-specific that may not be formalised explicitly. Unless the knowledge has been made explicit, it cannot be easily leveraged to the organisation.

In industrial context, knowledge is often used interchangeably with process know-how (Kryssanov *et al*, 1998). In a research on a maintenance diagnosis system for instance, Winchheringer and Miklavec describes that know-how is a practical knowledge about all aspects of the maintenance process, including assembly and functionality of the equipment (Winchheringer and Miklavec, 1996).

A research in an automotive company points out importance of the process know-how within the quality management framework (Wu *et al*, 1999). They found that the inability of the quality system to effectively capture process know-how was one of the crucial quality problems, since the quality system should provide assistance to all members of the organisation in the execution of the process. Other studies also showed a significant improvement achieved by a number of manufacturing organisations, having substantially adjusted the process know-how (Bohn, 1999). The output from one company was reported to be doubled and the yields from others increased during a period of several years.

Common Issues in Knowledge Management Practice

Preliminary analysis and literature survey (Nonaka, 1991; Kasvi, 1998) reveals three common issues in knowledge management practice:

- Capturing tacit knowledge (*externalisation*) is difficult and often time-consuming.

- *Socialisation*, although argued to be the most human-centred method of leveraging the knowledge, is mainly dependent on the social environment itself resulting in inconsistency of knowledge delivery.
- The need to enhance the *internalisation* process, so as to enable effective knowledge provision to the members of the organisation.

Therefore, a more practical solution of adopting know-how management to suit manufacturing requirements is proposed in this paper. This concept is known as *e*-knowledge, where process know-how is captured, structured and shared electronically. The *e*-knowledge concept aims to:

- Speed up the knowledge creation cycle (see Figure 1) by shortening the time to convert process know-how into explicit form.
- Mimic socialisation process in leveraging process know-how via an electronic medium.
- Enable on-demand knowledge provision to all members of the organisation (*e*-learning).

In the next section, an application of *e*-knowledge is presented. The case is based upon an ongoing research project sponsored by a major manufacturer of cellular telecommunication infrastructure based in the U.K (Wu, 2001).

Industrial Case

The company manufactures high technology base transceiver stations (simply called base stations). These products are used as the infrastructure to support the cellular phone service providers world-wide. The quality of the products is controlled through a complete inspection by a number of operators performing system test. When testing the base station, the operator must follow various test procedures (mainly manual operations) to connect the base station to the test station. The test station itself is under software control emulating the communication functionality in a cellular network. During the test, the software may run the test or prompt with instructions to the operator. Therefore, the quality of the product and the speed of the process do not only depend on the test software, but also the operators' skill to perform the operations.

Problem Identifications and Solutions

At present, the system to support test procedures is found ineffective when dealing with rapid change of products and processes. Although the basic products remain similar to a large extent, the configuration of the base station is virtually unlimited, depending on the customer order and specification. Emerging technology in telecommunication and electronic fabrications to shorten product lead-time put a greater pressure on product testing, as it is in fact the last process of the assembly line before the product is shipped.

The total lead-time required to perform the test can be roughly calculated as the time taken to produce the documents, i.e. test procedures and test specifications, added up to the time required to authorise them before launched to the shop floor. At the shop floor, the lead-time may become even longer with some issues either caused by the hardware or by the nature of the document that is sometimes ambiguous or inconsistent.

To summarise the situation, the following issues are identified:

- The long lead-time to produce and/or to update the related information about process know-how in the documentation system for a particular variant of product. In addition, there is a need to store this process in a repository system as the product range progresses.

- Inconsistent knowledge transfer from the trainer to the operator. At present, training is given by experienced operators or qualified engineers on a face-to-face basis. The main drawback of this approach is that the amount of information or knowledge transferred from the trainer to the operators is highly influenced by social environment and the human factors.

- Physical separation between the process know-how and the procedures or instructions in the conventional format of the documentation systems. Although this provides control mechanism of the document and to comply with the quality system standard, the format of the document is rigid and thereby unable to effectively describe the process know-how.

To address the these issues, the *e*-knowledge concept is introduced and developed as part of a shop floor information system known as ManTIS (*Man*ufacturing *T*est *I*nformation *S*ystem). ManTIS is essentially a comprehensive and interactive hypermedia system aimed at the shop floor personnel. It supports the test processes and has the following attributes:

- *Virtual socialisation*. In order to simplify knowledge elicitation from the process expert or process owner and in the same time to shorten the lead-time, a practical solution is required. Emerging technology in multimedia and digital video now simplifies knowledge elicitation process and enables *virtual socialisation*.

- *Virtual learning*. As the process know-how captured from the process owner now becomes explicit, a virtual training environment can be provided. This also addresses the need for on-demand training by providing the user with not only the knowledge about the products, but also the step-by-step instructions on how to test that product. Furthermore, this also enables new operators to learn about testing procedure in virtual mode.

- *Task and knowledge support*. The final problem was tackled by adopting the task-centred concept (Wu *et al*, 1999), in which manufacturing know-how is provided in the form of '*how-to-do*' video, linked to the associated task. The argument for this is that the knowledge gained from the system will be used to support the operators in performing their task.

System Development and Implementation

ManTIS is a distributed system and available to all shop floor personnel. This feature leads to the selection of the HTML format as the basis of the application. Another reason is that the skill required to create HTML document is relatively low (Wu *et al*, 1999).

Simulation Module

The simulation module of ManTIS is a typical web-based training application. It enables users to learn the test procedures without directly working with the equipment. The benefits expected from this module include the provision of consistent know-how and the acceleration of the training process for the first time operators.

Figure 2 shows the screenshot of the user interface of the simulation mode. The interface is divided into four sections: main navigation illustrating the tasks to be carried out, simulation of the test software, virtual environment and '*how-to-do*' video.

See Figure 2

Process know-how was recorded with digital camcorder and edited as to reflect the execution of tasks. The MPEG-4 CODEC was used to compress the videos without sacrificing the image quality too much. To simulate the test software, screenshot of the test software was taken on each step of the entire test procedures. By using Macromedia Flash, the series of screenshots were converted into a dynamic application that simulates how the test software works. Creating virtual environment was rather complex task because it incorporates JavaScript to create interactivity such as drag and drop using mouse.

Qualification Module

Qualification module was considered as a gateway to qualify shop floor personnel to higher grades, for instance from the operator to the technician level. With *e*-knowledge, it becomes possible to use this as a tool to measure how well the user has learnt from the system or how much the process know-how has been absorbed. There were, of course, modifications in the traditional qualification system to suit the purpose. One of them was the conversion of the current qualification paper into an electronic format incorporating digital videos. The operators have to pay attention on the videos in order to answer the questions.

Macromedia Authorware was chosen to create the application. Should the qualification module is used to assess an operator, it must ensure the confidentiality of the questions being asked. The software provides a solution for this. Although the final piece was a compiled format, the questions and the associated multimedia objects (still pictures and digital videos) are linked externally to simplify updating process. The qualification result and the data about the candidate are stored in a relational database using ODBC. The application tier to handle data transfer from Authorware to the web server (and vice versa) was implemented in Visual Basic/Active Server Pages (ASP).

Future Work

As the project is ongoing, there are a number of issues to be considered in the future:

- The need to investigate how *e*-knowledge concept fits into the company documentation control. This is the challenge for multimedia/hypermedia developer to effectively manage multimedia objects and to make it reusable. Web application opens the possibility of linking these objects together by using hyperlinks management. However, further investigation is

required to ensure that the digital videos are always up-to-date and to provide the revision control.

- The need to provide such a method to evaluate the information system and to provide feedback to the developer and management. Literatures in management information system (MIS) has ascertained that the failure of such IT system is simply because of its low usage. Since the application is aimed at the shop floor workers, care must be taken to ensure that not only the application is easy to use, but also more importantly it is useful. Therefore, a model incorporating technology, knowledge and the task is essential to understand the extent to which the *e*-knowledge is actually supporting the task (Tjahjono *et al*, 2001).

- From the business point of view, there is a need to have a standardised procedure on how *e*-knowledge concept is implemented to other manufacturing processes. If an application is intended to reduce manufacturing lead-time, the pitfall to be avoided is when the development lead-time is long. Therefore, such approach needs to be expanded to enable the content-driven web application.

Conclusions

This paper has shown an approach of promoting manufacturing know-how at the shop floor through the *e*-knowledge concept. The development of such system described in the industrial case has been made possible by utilising multimedia/web technology. In manufacturing organisation, *e*-knowledge intends to improve the performance of the workers by providing just-in-time knowledge support. It is not only an effective approach in eliciting the process know-how, but also an innovation to which the knowledge is structured and disseminated to the shop floor workers. The benefit for manufacturing organisations implementing such system is the speed of documenting a comprehensive process know-how, which will also accelerate knowledge delivery to the shop floor. In addition, the *e*-knowledge fulfils the needs for timely provision training and therefore improves worker's performance.

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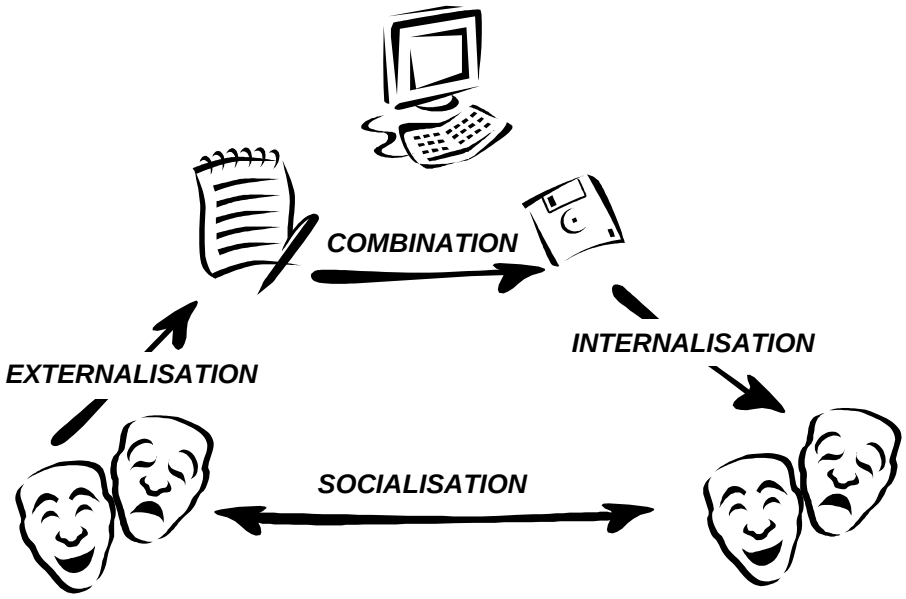

Figure 1 – Knowledge Creation Model

Figure 2 – ManTIS Simulation mode

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