SUPPLYING PRODUCTION INSTRUCTION KNOWLEDGE TO THE CONSTRUCTION SITES

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A systems analysis of construction project management revealed inconsistencies within and between subsystems that aim at supporting the in-service training of the craftsmen and utilise their ability to perform their tasks effectively. The information and knowledge that construction workers were provided on construction site appear to be poorly matched with what is required. Site managers, designers and suppliers could and should have better means and informational resources to adequately instructing the site operatives (craftsmen) in details of the task at hand. The process of accumulating and transferring knowledge on construction site is poorly developed. To improve this situation, it is important to facilitate the coordination of various system components and increase site operatives potential to perform their work in accordance with specifications and what has been agreed upon. A set of general site-use-adapted work instruction (ByggAi) was developed which is applicable to a wide variety of tasks of construction workers. ByggAi aims to be a means of furthering knowledge development and strengthening continuous improvement.

KEYWORDS: Knowledge transfer, site management, labour efficiency, craftsmen involvement, near-zone planning, working instruction guide.

INTRODUCTION

Lack of knowledge leads to mistakes

Construction firms are expected to conduct work at the construction site in accordance with drawings and specifications that are agreed upon. The client expects this to be done in a professional manner, even if this is not explicitly expressed in the contract. The specifications and the contract are normally based on national standard reference frameworks (such as NBS in the UK and AMA in Sweden). Basic workmanship and knowledge of the regulations applying to building and construction work are essential pre-conditions to perform the work in accordance with the contract.

Studies of the frequency and effects of flaws and errors in the Swedish construction process indicate that these account for some 6% of the total production costs and that about 10% of the working time is spent on correcting errors and reworking on what has been done or planned (Josephson and Hammarlund 1999). Part of the errors were caused by deficiencies in the design work, among which include the shortcomings of the knowledge of those engaged in production have at their disposal. A considerable proportion of the errors can also be traced

to difficulties caused by vagueness or imprecision in the instructions that the design team provides (Josephson and Saukkorpi 2005).

Information failing to adequately support knowledge development

Architects and designers base their specifications on standard reference works and directions from suppliers, whereas site operatives (i.e. construction workers, craftsmen etc.) almost never have direct access to information sources of this type. Any contact they have had with them is usually no more than superficial, such as an introduction to such matters in upper secondary school (Persson and Bergh 2004). The knowledge of the individual is then scarcely renewed although the standard reference framework may be updated continually.

Site operatives, as well as those in charge of work at the site and others engaged in the practicalities of a construction project, are in need of adequate knowledge for carrying out properly the work to be done and to update their working knowledge to keep abreast with latest technology (Persson and Bergh 2006). A common scenario on construction site is where operatives receive at most some 4 hours of training a year, in contrast to their supervisors, who underwent about 40 hours a year. The education obtained in upper secondary school remains the most important component in the training of the majority of construction workers. When new methods and materials are developed, new knowledge is needed. In order to acquire the information needed at a construction site, the personnel (both management and operatives) should be provided with relevant information and be motivated to learn and generate such knowledge themselves (Persson and Bergh 2004, 2006).

Knowledge concerning a task that has been completed can be of genuine help at a later time (positive feedback) and may result in a new and more effective approach to the task. (Persson 2006)

Management of knowledge development is lacking

The knowledge development of site operatives tends to be very much neglected (Larsson et al. 2005). As employment is in many cases contract/project based many employers are not willing to invest in the workers further training. This is further magnified by the nature of construction with many specialised subcontractors constituting a temporary organisation on site (Persson 2006). Before performing any work, the site operatives and the site management usually discuss the planning and the execution of the work (Persson and Bergh 2003). Although this could in principle lead to optimising of plans, sadly the lack of fully adequate knowledge on the part of both the workers and the management could sabotage efforts in this direction. Another example is that according to project managers who were interviewed in a project performed in Uganda, the most important steps in improving productivity involve eliminating the incompetence's among supervisors and the lack of knowledge and skills on the part of many workers (Alinaitwe 2006: see appendix III p 10).

Problems in systems for the knowledge development of construction workers

The present system of knowledge development for the on-site personnel of construction companies (operatives, management and supervisors) can be envisaged as characterised by the following statements:

- The *large numbers of errors* occurring at construction site (and the considerable costs this results in) appear to be largely due to insufficient knowledge transfer on the part of the personnel involved.
- *Information* obtained from clients, designers, suppliers and the contractor that could potentially further the knowledge development of the on-site personnel appears not to be well adapted to this purpose or to be only particularly suitable for it.
- A management function (process) supporting the system for knowledge development appears to be either poorly developed or to be missing entirely.

The flow of information to the personnel at construction sites concerning how the tasks at hand can best be carried out is highly important for the development of knowledge of work procedures generally. With better knowledge of this sort, the number of errors can be minimised or eliminated.

Aim, objectives and methods

The aim of this paper is to investigate typical features of the knowledge management system for the construction site and to propose a guide to improve the coordination of various system components in the knowledge management process on construction sites. The paper will also examine the mismatch and interaction between sub-systems in terms of both synergy effects of the mismatch and finally a guide/tool that can be introduced for site managers, supervisors and site operatives is presented.

A systems analysis is used to describe the processes within construction companies, efforts being made to pinpoint mismatches between subsystems involved. Interactions between subsystems in terms both of synergy effects and of mismatches (Arbnor and Bjerke 1997) are analysed.

THE PROCESS MODEL

A generic process model for the performing of construction Task A at location n is shown in Figure 1. The process model contains flows of information, machinery, tools and materials. The site management prepare for the task and the site operatives carry it out. The preparations include studying the drawings and specifications with referenced, standard reference works and information accumulated in the project regarding the task at hand. There should also be some kind of check before the task is handed over to the next step in the construction process.

In efforts to gain an understanding of how various tasks are actually performed by those who carry them out, 41 cases of task performance of this sort were studied (Persson & Bergh 2006). The results are compared with the approach to solving tasks prescribed by the generic process model described in Figure 1. Results revealed that flows of information of the following types were usually absent:

- Information from a standard reference work being made available to the site operatives
- Information from legislation and building codes of relevance being made available to the site operatives

- Information about labour safety regulations being made available to the site operatives
- Further education being provided for the site operatives

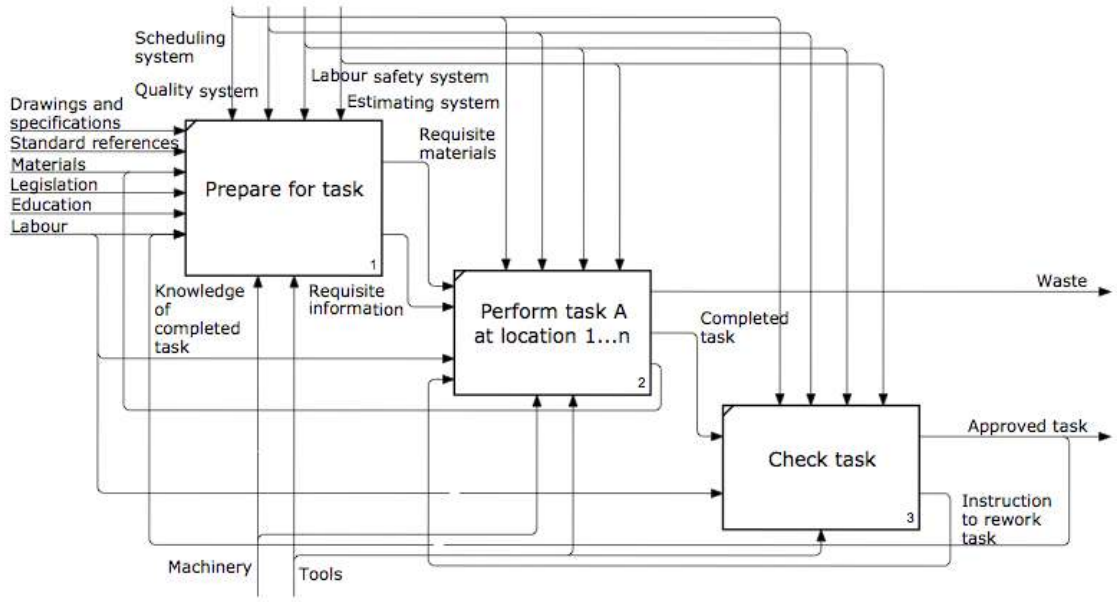

Figure. 1: A generic process model illustrating the flow of information and resources needed to perform Task A at location n on the construction site. (Adapted from CIB78 1997)

THE SUPPORT OF KNOWLEDGE MANAGEMENT SYSTEM TO THE CONSTRUCTION SITE

The knowledge development that takes place in a construction firm should be supported by a capable quality management system, as well as by the systems for cost estimating, time scheduling and labour safety. The site operatives should possess sufficient knowledge to be able to demonstrate workmanship in their work, be able to utilise effectively contract documents, drawings and specifications as the starting point for their work, and have the support of the site management and the overall management system of the firm and lessons learned and knowledge accumulated.

The task of *the knowledge management system* is to direct, enhance and coordinate knowledge development in the firm, utilising the different subsystems of relevance and seeing to it that the knowledge needed for carrying out the construction work is made readily available. A clear objective of the knowledge management system is to develop the knowledge of the staff in such a way that the conditions of each and every contract will be met and to satisfy client's desires in an effective and professional way. In most construction companies, however, an explicit knowledge management system has not been developed at all, and normally an ineffective system approach for collecting and storing knowledge within the organisation is found and little emphasis is placed on developing the competence of workers. The large numbers of errors made in construction work and the virtual lack of

further training suggest knowledge management, in whatever form it may be present, to usually not function well.

The individual site operative should obtain knowledge on a continual basis so to maintain a satisfactory level of workmanship. A major part of the knowledge that a site operative possesses for the tasks to be performed is obtained during the initial professional training and as an apprentice. The formal training provided after that is usually very limited. For workers to be well prepared for the tasks to be performed requires further sources of knowledge of general or specific character and should be made readily available to them. The following are certain important considerations pertaining to this:

- Drawings and specifications (in a form that the person in question can readily comprehend) pertaining to the work at hand should be provided.
- A work execution plan (or detailed plan of the work to be done) should be made known, at the latest by the time the work gets underway.
- General descriptions of the work to be carried out should not only be accessible but also be easy to read and understand.
- There should be ample access to suppliers' instructions on how to assemble and use the materials or equipment involved.
- The laws and regulations that apply should be clear to everyone.
- Inspection routines should be clarified and any checklist to be used for control purposes should be handed out to everyone.

MISMATCHES BETWEEN SUBSYSTEMS

Figure 2 indicates the subsystems that particularly influence the knowledge development of the individual site operative. The following are various mismatches that can occur between subsystems (Persson and Bergh 2004):

- Drawings and specifications pertaining to work to be carried out often refer to standard documents or reference works or to instructions provided by suppliers. Such standard documents or reference works are usually not available at the work site. Also instructions provided by the manufacturers of material or equipment, may be lost track of. Construction workers are usually not trained in reading standard documents or reference works. Although these may contain potentially useful instructions on how work of various types is to be carried out, the instructions are often either incomplete, not up-to-date or are not easy to assimilate. The target groups for such documents are often designers and procurement personnel, since site operatives practically scarcely are involved in procurement and have limited access to them that they contribute little to the knowledge development of the work force.
- Planning sessions and toolbox talks regarding how work is to be carried out are seldom attended by site operatives, despite its being they who perform the work.
- Only in exceptional cases do site operatives have the opportunity to read the specifications for the project they are involved in or a particular standard reference work.

- Only seldom does a site operative get to read the manufacturer's instructions.
- Only in exceptional cases is a site operative encouraged or given the opportunity to reflect over, plan or carry out the quality assurance work that is usually called for.

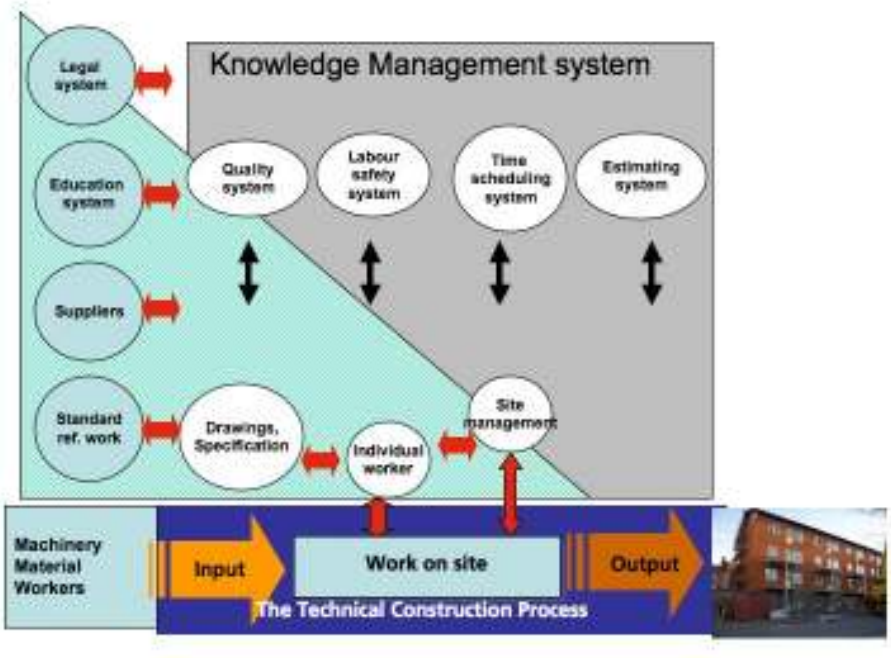

Figure 2: The subsystems that have a particularly strong influence on the knowledge development of the individual craftsman.

Mismatch between subsystems and lack of knowledge management can apply to different levels in an organization. If one aims at changing practices in respect to matters of the type just referred to in an entire construction firm, this must be undertaken at a variety of levels: Individual – site – firm – national construction sector – construction sector (Persson 2006).

The knowledge management of the sector and available information for personnel at site is not well organised to allow for an transfer from explicit to implicit knowledge according to the SECI-model of Nonaka and Takeuschi (1995) as pictured in Figure 3. The process of socialization (tacit→tacit) is shown in the bottom of Figure 3. On the left side Externalization (tacit→explicit) is shown. In the top Combining of knowledge is shown (explicit→explicit). On the right side the important process of Internalization is illustrated (explicit →tacit)

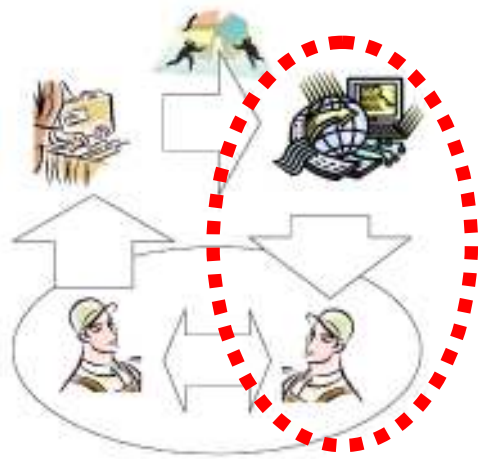

Figure 3. The SECI-model of knowledge transfer with the process of internalisation highlighted (Nonaka & Takeuschi 1995)

SUGGESTIONS FOR IMPROVEMENT

Various problems concerning mismatches between subsystems within the system that a construction firm represents have been outlined. There are various approaches that aim at suggesting, describing or providing various solutions to these problems. The Ratu-file for planning construction (www.rakennustieto.fi) is one such attempt. This file is intended to improve the productivity, safety and quality of construction work. Information regarding work procedures and work planning is collected at construction sites and is made available, information about safety in the work situation is provided, and quality assurance information is included. The file is available in a Finnish language version only. The program CITB-Construction Skills is concerned with educational matters applying to the entire construction industry (www.citb-constructionskills.co.uk).

At the Lund University, Division of Construction Management, an approach to providing task-related information available "just when you need it" to those engaged in construction work tasks has been developed in cooperation with various construction firms (Persson and Bergh 2006). The Swedish name of the system is ByggAi. The general site-use-adapted working instructions are developed to transfer knowledge on site. In a well-structured form, the basic information needed to carry out different types of work is made easily available, the needs of site management and site operatives at a construction site being in focus. The Working instructions of ByggAi contain information on personal safety, quality control, requirements, suggested tools and supplementary fixtures/materials, and pictures and description of a suggested correct way of carrying out the work. The scope of the system is to make information available from Quality system, labour safety system, suppliers and standard reference work as mentioned in Figure 3

The ByggAi-system is available on the Internet at http://www.ByggAi.se. The reasons for these instructions being designed in this way are the following: The working instructions (WI) are *general*, meaning they can be used at most construction sites and that when they are used they need to be supplemented with information specific to the project at hand. The WIs are *site-use-adapted,* meaning that they are adapted to the information requirements of the personnel conducting the work on site rather than to the needs of purchasers, designers, etc.

At this initial stage the Internet portal contains working instructions for 94 different tasks, for each set of instructions the following main headings are being employed:

Requirements – Personal safety and health – mapping of risks and suggested preventive measures. Demands or recommendations in terms of Standard reference works and according to manufacturers and suppliers instructions.

Preparations – Checking on whether the basic prerequisites are met. Equipment – suggestion tools etc. Various supporting material (fixtures): Are they available? Materials handling - deliveries, on-site transportation and waste handling.

Quality control –A basic form for registering quality control data is provided. Other specific requirements of the construction project in question calls for needs to be added.

Performance – Selected pictures accompanied by brief texts are provided, these describing and presenting a standard way of carrying out the work in question.

The working instructions are available on the Internet portal in pdf-format. A CD in powerpoint format containing the working instructions, together with a template for those wanting to prepare their own working instructions, is also available. Example of pages from a WI is shown in Figure 5.

Figure 5: Example from Working Instructions of ByggAi. (To date only available in Swedish)

CONCLUSIONS

Currently there appear to be serious problems in the flow of information needed to provide adequate knowledge on how to perform tasks at construction sites. Lack of knowledge flow indicates there exists mismatch between subsystems at this point.

Often a problem of this sort was solved for a given task at one particular site under a given set of conditions, yet despite the conditions differing at some other site, the same solution applied there too. There is thus a certain generality to the solutions suggested, which may basically apply throughout the construction sector.

The system - *General site-use-adapted working instructions* – ByggAi – thus address to a wide variety of problems. Despite ByggAi providing solutions to many problems, there is the question of the extent to which workers obtaining access to it. The supervisory personnel at the site should either make computer facilities available to the personnel or provide them access to the instructions by printing them out. The initiative lies with the supervisors to initiate meetings for the discussion of new tasks ahead of time. The best option is presumably to provide information of this sort in a structured way at an appropriate time.

Changing the way of performing a given task at construction sites within the entire construction sector as part of a movement for "continuous improvement" calls for a wide and open cooperation between those supplying information resources, the contractor, the client and others involved in the construction process.

The system of working instructions described here is in need of further development. First, the number of working instructions available need to be increased so as to create as broad acknowledge base as possible. Also various technical developments should be monitored to determine whether they provide new possibilities for the distribution and storage of information that could be useful here.

In addition the effects of the working instructions should be monitored and assessed in order to validate their use and to consider the further development of them. An indication that the ByggAi are welcomed by the construction industry is that Swedish construction companies already have started implementing this method of working described and agreeing ByggAi to be an important tools for the improvement work undertaken. Similarly, various educators have tried them out and found them to be useful.

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