

Computer Aided Development of Knowledge in the Construction Process

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ABSTRACT

Many of the failures in the construction process occur due to a lack of information and knowledge. The problem is not solely that the information demanded and knowledge are lacking, it can as well be the opposite. In other words, there is too much information available. The problem is usually to give the site manager and others involved in the construction process the necessary information when they are receptive to it. This research project is accomplished with a computer aided system for the development of knowledge in the construction process, in order to study the possibilities and problems with a computer aided system.

Key Words

Computer aided development of knowledge, problem-based learning system,



Introductions

Background

Many of the failures in the construction process occur due to lack of information. The information system in the construction process must ensure that every participant will have the correct information at the right time. The problem with information in the construction industry is not only that the required information is lacking but that the problem is rather the opposite; there is too much important information which makes it impossible to handle. It is also a fact that the demands are rising in the construction industry, e.g. assurance of quality is not an unusual demand from the client.

The information and knowledge is often provided at a time when the site manager and other participants in the construction process are not receptive.

Therefore, the development of a system for an ongoing extension of knowledge and competence should have high priority. Nowadays, labourers are working permanently for construction companies in Sweden. Before 1988 they were hired at a particular site and when the construction was finished they looked for a work at another site. This means that it was possible for a company to train the labourers in an efficient way.

The same failure is often repeated many times within a company because foremen are just learning themselves instead of teaching each other. If you are a foreman and you have a question about something at the building site, it is very likely that some other foreman may have the same question sometime, and if not it is very likely that he will have in the future.

The flow of information does not fulfil all the demands that have to be met today. The situation today is that all the labourers in a company must both give and receive information so that learning becomes a natural thing in daily work. We think that the use of a computer in the learning situation will make information flow more easily in the construction industry.

A General Situation

The concept of computer aided development of knowledge in the construction process is not connected to a certain country or language. It is up to every firm and individual using the system to put in information and facts that can give the user the right knowledge. The solution does not depend on a specific computer or programme.

Assumptions

Below a basis is stated for a better system for the development of knowledge in the construction process.

The information must be adjusted to the persons to whom it is addressed. This means that the information in time, as well as in form, must be adapted to the needs of the individual.

The system for the development of knowledge must be so designed that it stimulates people to try to find the required information themselves with the help of the system.

The system for the development of knowledge is complex and thus it follows that changes in one part of the system have an impact on other parts. Many processes in the company, such as education, quality assurance, control, feed-back and internal news letters, are part of the system for the development of knowledge.

The system for the development of knowledge must be open, that is it must be useful, not only for internal, but also for external information.

The system must be accommodated to changes in the surrounding world. It is important to make the system adaptable to present and future requirements.

The system for the development of knowledge can be improved by computer aid.

Purpose

This project is intended to show the potentials and restrictions of computer aid today:

- all essential information must be made available to all parties involved in the construction process
- the system must facilitate co-operation and communication in the construction process
- the information must be adapted in time as well as in character to the receiver and his ability to use it
- to reduce the number of faults
- to facilitate the use of systematic methods for quality assurance and as a consequence increase efficiency
- to supply information that can bring down the number of working damages
- to make the individual feel more deeply involved and engaged in the building project and consequently help the company to develop
- to develop techniques for the solution of problems

- to contribute to the description of concepts concerning information on products and processes.

In other words, the purpose is to develop a system for the development of knowledge that is both interactive and computer aided.

Method

The Research Approach

As a first step, we asked the production groups in the construction company involved in the project, about what kind of information, knowledge and development of knowledge they needed. At the same time, literature on the subject and similar systems was studied.

As a second step, the working group served as an expert group to the production group in the construction company. The working group supplied the requested information to the production group by means of computer aid. They also supplied the information they thought the production group would need or request later on.

Through this approach to the problem, a prototype was developed. This prototype shows what a future system for development of knowledge can look like. All parts of the system cannot be treated in the same way, but the system increases awareness of how a computer aided system for knowledge development should be designed. This would support the development of knowledge within a production group at the site of the construction project. We also hope that our approach to the problem will benefit the development of a computer program that can be of use at the construction site.

The work in this project has focused on a problem-based learning situation. The system is meant to work as an aid to creative problem solution. The user must feel that the system makes him more creative.

Delimitation

The starting point of this work was mainly an ongoing construction project. We considered the knowledge required during the design stage too complicated to begin with. The design stage often requires feed-back and knowledge from earlier projects but this takes long to gather. As a consequence, we started with the production stage where more concrete knowledge and information is required. For practical reasons we restricted the dialogue with the construction site to questions of a building technological nature.

Accomplishment

In order to gain a conception of the kind of information that is requested at the construction site, we designed a questionnaire for the employees in the construction company. They were requested to put down all questions that arose during their daily work over a period of two weeks.

At the same time as the prototype was developed, the working group communicated with the selected construction site via facsimile. The site transmitted their questions to the working group, which returned the answers. It was possible to continuously set the right course for the development of the prototype by using "real" questions. The prototype was evaluated by the staff.

Sources and Requirements of Knowledge

Knowledge normally signifies the cognisance acquired by learning, active or passive, or by some kind of influence. Learning may come about when a person searches actively for knowledge or by a more or less active participation in courses, conferences or other forms of education. With the accomplishment of a building project, situations often arise in which participants in the project need information in order to solve problems. In these situations a person is especially susceptible to learning. This is why it is important that the information is easily accessible at the site when it is needed.

The problem with existing sources of information is their complexity and in consequence the difficulty of access. The information supplied must be designed in a way that allows a person to easily find his way to the proper level of both detailed information and general knowledge. In one way or another information about the production process and building construction has to be structured. Within this project, a conceptual system was developed as a tool to handle and structure information. We had to produce a simple model of the process and the object to help the production group find the information and knowledge they demanded.

The information requested by the production group can be derived from various sources and is often composed in such a way that it can readily be extracted from sources and forwarded directly to the person seeking information. The knowledge required for the accomplishment of the tasks at a construction site and at the design stage can be found in directions and production data.

Manuals, which are more frequently used as a complement to the directions from the authorities, demand a fairly good knowledge on the part of the reader when he is trying to find the requested information.

The Requirements for Knowledge in the Production Group

In order to establish the knowledge most frequently demanded in the production groups, we made an investigation among the staff in the construction company. We also wanted to get an indication of their demands for knowledge and information, as well as ideas of how to design a future information and knowledge system.

The staff frequently thought that the information was accessible compared to the need. The predominant sources of information at present are, production drawings, technical descriptions and production cost estimates. The most frequently used media to transfer information are the telephone, conversations (without telephone) and production drawings and this coincides with the preferred ways of receiving information. The attitude to receiving information by mail or by computer was very negative although some persons would like to use computers. Everybody thought they could find the information they needed to solve problems in their work most of the time. Few people were able to find the information every time, but equally few were unable to find it at all. Nobody found information rarely or never. Most of the persons employed at the company had not worked with computers before but would like to do so. Those who were positive to computerisation gave the arguments as follows:

- It facilitates the work and make it more efficient.
- It gives you a better control of your work.
- It gives correct up-graded information quickly.

Those who had not worked with computers and who did not want to do so in the future gave the following reasons for their point of view:

- computers often cause great errors
- it is difficult to use a computer if you do not remain at the same place all day.

Some people had worked with computers and would like to continue since they thought they facilitated the work, being quick and easy. A few people had worked with computers but did not find them user-friendly and did not see the advantage of their use at the site office.

In order to get a clear idea of what kind of information should be easily accessible during daily work, we asked the workers to note all the questions that arose during a two-week period. These questions were of varying nature and concerned many subject fields. However, this project is limited to building technology and therefore only questions concerning this field were taken into account.

The Handling of Information within a Structure

While working on a building project you often think of it in terms of sections. In Sweden a matrix for standardised building sections has been developed. This matrix is made for universal application and therefore possible to use it for all kinds of building projects. Though the matrix is quite a general one it is not sufficient to function as a selection ground for every piece of information and therefore some additions have to be made. The result of the test among the staff gave us hints on how to develop a structure for the flow of information between the building site and the head office.

First of all it must be possible to search for information with the help of keywords related to a list of words. Furthermore, there is a Ishikawa-diagram added to each of the squares in the matrix, which makes it easy to delimit the subjects more precisely. The Ishikawa diagram is built up according to the subjects that are most frequently obtained.

The additions made to the building section matrix are illustrated in figure 1.

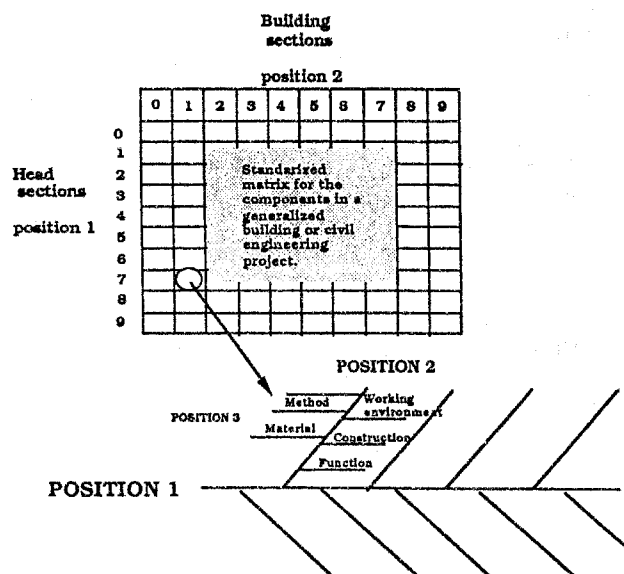


Figure 1. This structure is the base for the classification system in the prototype.

Adaptation to Man's Requirements

The users' varying practice with computers and the varying attitudes to computer aid make great demands upon the adaptation of computer aid to man. The specific performances in this project are aimed at the adaptation of the prototype required by the human being:

- work through the suggestions of data routines in order to secure simplicity and be easy to read

- the interactive work with the computer should be designed so that it stimulates problem-solving instead of just gathering facts.

- revise the form of the system so that it can be implemented in a practical construction environment

- use the possibilities that the system offers to develop the construction organisation and create greater commitment, participation and co-operation.

The procedure involved:

- several meetings with the production group where the various design alternatives were tried and suggestions on how to carry out the ideas mentioned above were brought forward

- co-operation with the expert programmer to devise user interface.

The Shape of the Computer Aid

The characteristic approach in this system is that it is based on questions from the contractors' work force (mostly from the construction site), and other participants in the construction process. The chosen approach takes advantage of a situation in which a person is specifically motivated and receptive to learning. The answer is given as quickly as possible close to the problem that has been identified. The user of the system can put his questions to the computer in the form of text and picture.

The production manager, the quality manager, or other persons in charge can connect themselves to the computer on site and give answers. Figure 2 illustrates the information flow.

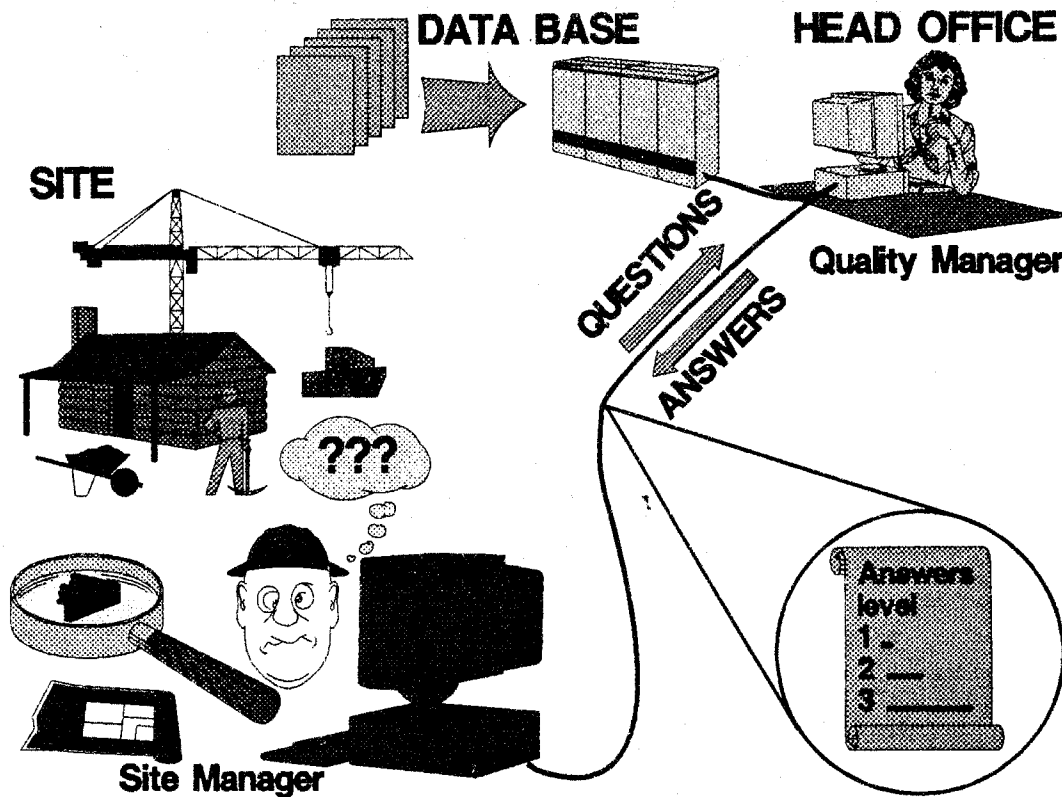


Figure 2. Information flow in the project.

Use of the Interface

Computer aid has to be user friendly. Since a computer aided system for the development of knowledge has to meet various demands, some of which may be difficult to anticipate in the early stages of its development, we gradually developed a prototype in order to find the existing impediments and possibilities for such a system. It would have been too big a task within the framework of our grant to create a completely, independent program. The prototype makes it possible to show new ways of using current information technology and to formulate a description for future computer aided information systems adapted for construction companies.

Adaptation to the Needs of the Construction Company

In order to make the system for the development of knowledge a useful tool, it must be adapted to the working situation at the site and to the working methods. This is why co-operation with the contractor is necessary at the creation a system. It must be possible to operate both short or long sequences of problem solving without feeling that you get stuck in unnecessary complexities. Two important characteristics of the system have to be simplicity and swiftness.

A building project is often an economic risk had a heavy responsibility for the contractor. The profit margin in a construction is very small. Relatively minor mistakes in the production may cause considerable reduction in the profit margin. A more efficient production with fewer mistakes will make the company more profitable and more competitive.

The model for problem solving must give a feeling of security as well as invite experimenting.

Evaluation, Conclusions

Through a demonstration we could show our prospective users how computer supported knowledge development within building processing could be shaped. Thereby we were able to receive the first opinions on and demands for a computer aided system for knowledge development in the building process.

Knowledge Development without Computer Support

The experience from the opening question and the follow-up of knowledge development through mainly one project, contributed a great deal to the creation of such a system within the building process. First and foremost it should be established that there is no established organised system for knowledge development known to us in any company today. There is not even an example within any individual company that even has parts of a similar system. Some have fragments of a system of knowledge development in the building process. Some companies, for example, have developed quality assurance routines which could be said to be a part of the company's system for knowledge development. Others have programs for education and work leaders' meetings that could be called parts of a knowledge development system. Among the experience from the follow-up of knowledge development within one project, the following could be mentioned:

- The seeking for knowledge varies from person to person
- The awareness of others' knowledge is imperfect
- Current sources of knowledge do not give practical answers
- Knowledge development is a part of work dressing while the problems are often connected to reflections on how to make the best of a situation.
- The required knowledge is strongly connected to ongoing production
- The more interesting and "easily reached" the first information is, the more the desire for a well-structured and long term knowledge will increase.

Mankind has, even with the structure faults that occur, an impressive ability to solve the tasks and problems that, for example, occur on a construction site. Although it is obvious that by increasing the efficiency of knowledge development among those involved in the building process, the faults in construction will decrease. Increase in efficiency can be achieved by better use of the organisation, the participants work, and by improving their own learning capacity. Knowledge development can be supported by a computer, if combined with human interaction.

Experience of Information Seeking

The developed prototype was evaluated by the staff of the company. None of the test subjects had any great computer experience and most of them had never even worked with a computer. All of them were generally very positive to the use of computers. Roughly 50% of the test subjects found it natural to seek information the way the prototype demanded. The other 50% found it unnatural, especially the classification system was found to be time demanding and complicated. The division was found to be the same when it came to the reading of the screen. Half the group did not have any problems with reading large texts on the screen (maybe it should be added that they never read as there was no time for that during the evaluation) while the rest of them did not like to read what was on the screen, most of them wanted the opportunity to choose different alternatives, for example:

- colour of text and background
- text size
- print-out

The classification system was found to be the most abstract. That is not so strange because the classification of the question is made first, before the actual question, which results in a dilemma where you are classifying a question while it still is blurred in your mind. During the evaluation, the test subjects had the questions on paper but they were still impatient, they wanted to answer a direct question instead of doing a bunch of classifications. The search worked and 18 out of the 50 searches resulted in that the right question came in on 1:st 3:rd place. The time of the search was very different. The average time was 12 min (none below 5 mins are counted), irrespective of which search it was or who was carrying it out. This implies that those used to computers cannot search faster. Finally, when it came to the answers, the test subjects trusted them, and some took it for granted and some only trusted the answers if they found them reasonable and in agreement with former experience. Most of them found that there was too much

text and the opinions on what it was like to read on the screen were divided.

Demands on the Hardware

The prototype has worked as a method to grasp, test, evaluate and communicate ideas generated by the final user and programmer/tool user. It has been advantageous to work on the selected platform, Apple Macintosh. It has been easy to implement a variety of ideas rapidly and effectively and to gather and present criticism. We also believe that this concept can be transmitted to other platforms, such as IBM and Digital Equipment, while the development goes in the direction of equal functions for the user and the structural systems.

Demands on the Source of Knowledge

From these experiences, the following recommendations on how the source of knowledge and the information should be formed to facilitate the process of knowledge development:

- The information should be structured out of the problems each worker at the construction site has to solve.
- The information should be structured for different kinds of knowledge seeking. The individual is seeking a single solution to a problem and wants an answer as fast as possible. However, it is important to shape the source of knowledge to stimulate the interested party to seek new alternative solutions of his own based on the facts given. This divergent thinking gives a development from an area of problems, with help from the knowledge given, towards new alternative ideas.
- Knowledge in the shape of text and pictures, from a technical point of view, must be easily put in and of course easily accessible to the user.