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Implementing information management in construction: establishing problems, concepts and practice

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Abstract: Information management practice falls under various themes: vision and policy, change implementation, alignment of strategies to information technology (IT), business process re-engineering, the review of new systems and IT infrastructure. It has been found from exploratory case studies in the construction industry that the current management of information is characterized by systems in which: i) information exchange between project parties is limited to paper, a medium in which retrieval is very slow and inefficient; ii) functional departments maintain their own data structured to suit their particular needs; iii) most information searching and transfer between project parties and clients are paper based, providing constant source of delays; iv) no efficient interfaces exist between departmental systems to access information electronically; and v) the impact of IT investment to date has been limited. These characteristics can be first traced to the general lack of coherent management policy and vision on information management. Also, although construction is a distinctly collaborative business environment, for historical, cultural and legal reasons, there is no desire to consider seriously the use of collaborative IT tools. Thirdly, although there is a degree of knowledge of business process evaluation and improvement techniques such as business process re-engineering (BPR), it appears there is less confidence for management to adopt such tools in its drive to solve information management problems. Finally, the lack of progress in adopting IT to widely improve communication is related to the fact that until now stand-alone departmental systems have been the norm. Above all, the culture of the industry dictates that each function maintains total independence in all aspects including information retrieval and exchange. The result is that experience of implementing corporate IT systems is lacking and it is clearly affecting the ability to examine the potential of emerging IT or appraise current infrastructure.

Key words: construction; information management; information technology; project management; re-engineering

Introduction

Information management is the overall management and control of an organization's investment in information, including identifying and sharing management information, and ensuring standardization, control, security and integrity of data stored (Johnson, 1992). This means that where good information management practice exists, information intended for

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decision makers has to be relevant, clear, complete, accurate and available when needed because these factors affect decision making and have a direct bearing on whether an organization can cope with a changing business environment (Wilson, 2000).

In the construction industry, the capacity to focus and find solutions to information management problems is further complicated by the question of whether information management in construction is the same as or includes document management. A document is the presentation of information in a structured way (Joia, 1998) or according to Levien (1989) a unit of recorded information structured for human consumption. Despite the emergence of modern information technology (IT), documents remain the best way of communicating and creating information. This is especially true for the construction industry. As a result, issues relating to the improvement of the management of the vast amount of information transferred between the construction team cannot reasonably be discussed without addressing document management itself.

Importance of document management

The scale and importance of document management as an essential facet of information management is illustrated in the research on consulting engineers by Joia (1998). It found that i) on average, only 5% of the company's documentation is on-line and 90% is on paper; ii) the information received by engineers is often outdated; iii) engineers, on average, waste more time looking for documents than using them; iv) it is barely possible to create documents with the collaboration of partners, as there is no process to achieve a workgroup environment; v) documents are created from scratch, as it is very difficult to find a template that might be useful; and vi) it is sometimes difficult to find the most recent version of engineering documents.

These observations are collaborated to varying degrees by commentators and industry reports. Latham (1994) stated that communication methods among project participants were inefficient and Kangari (1995), after a study of the influence of documentation on arbitration outcomes, concluded that small- to medium-sized contractors suffer from the outcome of poor information exchange and control systems. Finch *et al.* (1996) argued that information provided during the contract process is almost always incomplete, causes long tendering and lead times and results in inaccurate cost estimation. Vidogah (1997), Betts *et al.* (1999) and Gyampoh-Vidogah *et al.* (1999) supported these views.

These observations suggest serious deficiencies in five key tests for good information systems (Wilson, 2000). However, this bleak assessment does not suggest that no attempts have been made by the industry to address them. If one takes the Co-ordinated Project Information (CPI) initiative in the UK carried out under the auspices of the Chartered Institute of Building (CIOB) to standardize information presentation and sharing (Snook, 1995) and the work of Baldwin *et al.* (1996) on electronic data interchange then it can be argued at least that the problem is recognized.

The reason for the lack of progress in this area of project management is often not well understood (Laitinen, 1998). Baldwin *et al.* (1999) argued and concluded that existing models of the design process are inadequate if a detailed understanding of information-related events is to be obtained. Laitinen suggested that the reason is that the industry has concentrated on general quality management, although clients are more concerned with what information is provided and exchanged. Walton (1991) stated that problems with developing global business

strategies have not been addressed before consideration of new technologies. Newcombe *et al.* (1990) expressed the view that the primary tasks of all organizations are affected by the internal culture of the business. This implies changing the way work is done and integrating information sources using 'cutting edge' technologies such as EDMS to reduce costs of managing documents, accessing information across functions, improving quality of documents, and reducing disputes through more efficient and effective documentation (Gyampoh-Vidogah *et al.*, 1999). However, because of cultural and historical issues, the challenge is how to reconcile the human, organizational and technical factors when managing information systems (Gyampoh-Vidogah, 2002a). In fact, Mukherji and Mukherji (1998) suggested that managing change on the way work is done and how to process information might become the new competitive edge for organizations, more so than any other resource in the twenty-first century.

Managing change within the context of information management will mean aligning business goals to maintain a strategic link between new processes in information management and overall business strategy (Robson, 1994). However, the benefits of information technology (IT) are dependent on whether business processes have been transformed in any way to maximize the impact of IT.

Embracing business processing implied the process of aligning business strategy with IT using a business process re-engineering (BPR) approach to set clear business objectives, analyse and define key business processes, assess their value, and prioritize them for investment (Grant *et al.*, 1998; Gyampoh-Vidogah, 2002b). Business process re-engineering has been seen as a technique for achieving this alignment (Hammer, 1990). Although researchers suggests a level of awareness of BPR (Betts *et al.*, 1999), using such concepts can result in the identification and modelling of high value processes to meet business objectives (Grant *et al.*, 1998; Ward, 1990; Walton, 1991). BPR includes automation of capturing, sharing, storing and routing of 'process knowledge' such as schedules and resources inherent in every process (Butler, 1999).

Robson (1994) suggested that, as society moves forward and new ways of accessing, storing and manipulating information are found, companies need to appreciate these trends in order to deploy resources more effectively. This requires management to implement information systems that support project management needs. Above all, technical infrastructure requirements should be carefully evaluated because systems cannot be selected without understanding the culture and softer people dimensions (that is, values and beliefs) contained within information systems development.

This paper takes this position further by using the data gathered from case studies to examine and compare industry practice to the elements of information management required for development and implementation of information systems and technologies.

Research approach

The perceptions and practices of information management were examined through an exploratory case analysis of three construction companies. The multiple case design was chosen to match the objectives and description of theory building (Benbasat *et al.*, 1987). Multiple case designs are an empirical research approach suitable for studying emerging and complex organizational systems (Yin, 1994).

Research questions
The major research questions were:

- How did the implications of information management issues affect the company's ability to interact with project participants (both internally and externally) during the project cycle and did the company appreciate the fundamental problems with managing information?
- How did information management capabilities constrain the implementation of process re-engineering and how did the company measure up to the requirement of best information management practice and its goals?
- How can the company's perceptions of information management problems be overcome and its goals be attained? Which IT infrastructure capabilities have the largest impact in implementing an integrated IT solution?

Yin (1994) suggests that the choices of research approach should be governed by the nature of the research questions. In particular, survey research is most appropriate when addressing who, what, where, how many and how much questions, while case study research is appropriate when addressing how and why questions. Case studies are useful for revealing the details of a phenomenon, in particular the relationship between the phenomenon and its context. Therefore case study approach has been adopted for this research, using a combination of interviews and document analysis.

Selection of companies
Three main companies from the construction industry were chosen to provide three different organizational settings for the study and also to limit sector bias. A multi-site approach was used in order to understand the nature and complexity of the processes taking place as suggested by Benbasat *et al.* (1987), Eisenhardt (1989) and Broadbent *et al.* (1999).

The companies were a contractor, a multi-disciplinary consultant and a supplier who essentially operate and interact in the same construction project environment. However, they provide a contrast in their strategic use of information during the project cycle. The inclusion of each sector of industry is not aimed at cross-comparisons. Rather, the aim is to establish the problems and their perception of information management.

Data collection
Qualitative (open-ended interviews) techniques were used (Benbasat *et al.*, 1987) with multiple respondents in each company to achieve triangulation data and insights. Corporate documents (for example, forms, internal reports) were also studied and analysed using structured systems analysis and design approach (SSADM). SSADM, according to Yeates *et al.* (1994), is a process-oriented approach useful for the analysis and design of complex information management processes within organizations requiring to develop an integrated solution.

Each company had a minimum of four participants, some interviewed more than once. These included senior partners and contract managers and head of functional departments.

In each company, the respondents were interviewed about their understanding of the issue of information management, the impact on efficiency, and the vision of the future. Response forms were completed by each of the respondents, followed by interviews (of one to 10 hours over several meetings) and seminars in the companies to explore the issues in more depth. All deliberations focused on the respondents' vision for information management and their

perception of the problems they currently encounter in document handling, exchange, creation and storage within functional areas during the project cycle.

Case A

Case A is one of the top 10 national construction companies in the UK. The company formed more than 20 years ago and undertakes both building and civil engineering works with an annual turnover of £1.5 billion and a workforce exceeding 5000.

Information management vision
The respondents were asked to describe their expectations of a modern information management practice to yield a number of key objectives that they believed should be achieved. Top on their list were improving productivity, removing duplication of information and reducing paper, avoiding disputes, changing the 'cultural web', cutting costs, being able to process and secure information, and gaining competitive advantage. When asked how these goals could be attained, all interviewees agreed that the company requires an information system that provides timely and appropriate information for the project team to effectively administer all resources. To paraphrase one senior manager, a structured method to process and exchange appropriate project documents is needed to allow a collaborative working environment with other members of the construction team.

Current situation
Asked for the initial impressions on the state of information management, the contracts director (CD) indicated that the company receives numerous documents per week and submits a similar number to various parties every week through the company's accounting, estimating, planning, site management and personnel offices. Consequently, over the years, they have gradually run out of space to store documents.

According to the senior QS, the current system is such that decisions are often delayed because information cannot be retrieved efficiently. The system is not only slow but documents are also often misplaced, lost and are rarely up to date. As such, they are often unable to respond to sudden requests for information from consultants (architects and engineers). In many instances, these become the subjects of disputes. They all agreed that they were yet to find a viable modern tool that could handle the communications with external parties and information flow/exchange among internal functional departments in a manner that would meet their requirements.

The complexity of the contractor's problem
The views expressed were principally problems with exchange of documents with clients (which includes both external bodies, a host of specialist subcontractors, as well as consultants). The contractor's difficulties are particularly acute in the areas of project management and site management regarding information as well as document management. This is made worse by the fact that each functional department maintains its own data to suit its particular needs. As such, using data from other functions requires the data to be reformulated. The absence of adequate interfaces means that in many instances, data on cost items such as materials, equipment and labour have to be extracted from paper records.

Document handling, exchange and storage

Working methods with information within the organization of the contractor has evolved over time and there are few rigid procedures or methods. Project and client records are collected and returned informally by various members of staff. This includes senior members of the project team and clerks.

When it comes to filing progress reports and requests for information, site managers often have to travel to the head office to submit them. If they are unable to make the journey, the reports are sent by post. This is not secure, because documents are often misplaced. One manager recalled that, on many occasions, design changes are carried out without proper authorization. These cases lead to disputes and additional costs to the company. Individuals responsible for changing design work are never traced, while in the former case exactly how documents get lost or misplaced is never documented.

Planning. Apart from general administrative documents such as memos and minutes of meetings, the most important documents created by the planning department are the construction method statements (MS) and construction programmes or schedules. The method statement is one of the control documents used by the site managers and project managers along with other essential contract documents issued by the consultant. The method statement i) describes how the contractor proposes to carry out actual construction including estimates of resources, ii) is used by the design team at the tender stage to assess whether the proposed method of construction is viable; iii) assists in the preparation of calculation sheets, as the basis for developing a draft pretender programme; iv) at the pretender stage, helps to co-ordinate the efforts of the contractor's project team in developing an agreed method of construction; and v) provides other functional departments with detailed information on which to act and contribute to the tender document. This information is extracted by each function manually.

Construction programme. Whether the construction is progressing according to the programme is the project manager's responsibility. At the head office level, schedules (or programmes) are used to compare the anticipated progress to actual progress for all construction activities. Copies of the original and updates of programmes are routinely prepared by the project team to inform subcontractors, the estimating department and consultants during construction.

Estimating. The estimating department prices the bills of quantities for tender and project management purposes and regularly produces this for cash flow forecasts for each project. These forecasts predict overheads, income and expenditure during the construction phase. According to the senior QS only the accounts and estimating departments have direct access to the information contained in this document. Some of its contents such as material specifications, cost data and labour data are duplicated in schedules and method statements.

Bills of quantities. Although primarily prepared as a tender document, the bills of quantities have an important contractual task in the pricing of variations. Any variations to the original contract sum form part of the final account. Additionally bills of quantities are used to compute the valuations of interim certificates. This document has additional roles in project administration. The most important one is the identification of construction processes as the

basis for cost planning. This information includes the costing of preliminaries, detailed descriptions of materials, workmanship and all measured works.

Accounts. The accounts department deals with the day-to-day accounting functions. Documents handled include invoices, receipts, payments and supplier details. All the documents are filed manually. For the purposes of monitoring costs, the department receives site records for material deliveries and plant and labour reports. Using information from the estimating department, a summary of the costs, profits and overheads of the project is prepared for the estimating department and the project team.

Project management. Where a bid is successful, copies of all project documents, including architectural and engineering drawings, bills of quantities and method statements, are passed to the project management team for reference purposes during the construction stage. During this phase, the project management team continually communicates with the estimating and planning departments as well as the various consultants to monitor progress.

The project team processes information on site activities, monitors material supply, and uses resource allocation sheets to ensure compliance with agreed method statements and the master construction programme. Crucial to the project team is the ability to access the latest information on construction progress such as design changes and revisions to drawings and materials usage.

In order to maintain and monitor construction progress, the project team also generates a range of documents. For example, equipment schedules are used to monitor the type of equipment required and the duration they are needed on site. The schedule provides vital information on the cost of plant hire and ensures that equipment is available when needed for specific construction tasks.

Site information management. Project or site managers, under the supervision of the project management, head each construction site. The project manager, with the help of site engineers, processes and produces a number of reports, which are copied to the project management, the estimating, planning and accounts departments. These reports include information about labour deployed for payroll preparation.

The range and purpose of information exchanged within the supply chain (industry) is depicted in Figure 1 as a structure group of generic links of information.

The site manager, for example, submits labour, materials, construction equipment and operative reports of projects for onward transmission to the project management. The study found that, because these daily reports have to be completed manually, it could take several days for them to be received by the project management team. As a result of this, the project managers rarely have up-to-date reports on resource use.

Main observations of information management

The problems and features of information management are: i) each functional department has independent filing and despatch processes and the processes appear to be duplicated across each department; ii) the process is not secure in that anyone can access sensitive records and change data; iii) the system is slow and labour intensive; and iv) the process is becoming more expensive to maintain as demand for storage space grows.

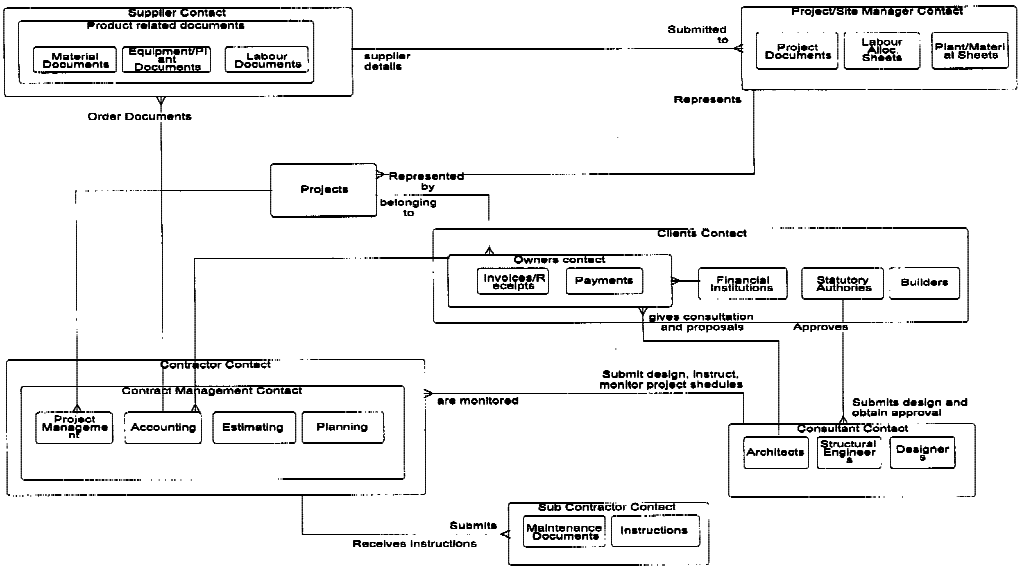

Figure 1. Generic structure of information links

Case B

Case B is a multi-disciplinary consultancy company specializing in architectural and engineering design with a turnover of approximately £8.6 million, with 200 employees. The consultant has been involved in the planning and design of projects in both the private and public sector.

The consultant's functions

The consultant has two main functional divisions: architectural and civil engineering design. The architectural division specializes in the design of spatial layout for office blocks, industrial centres and housing. The civil engineering section specializes in planning, designing and operating of civil, structural engineering and/or highway projects.

Information management vision

According to the technical director, the company aims to offer clients a better service and new ways of providing such services to exploit new technologies. The respondents want this to be achieved through improved information management. They also want their vision to embrace the best way advanced architecture can be adopted because exchanging of information with other external participants is a problem.

Current situation

Project initiation begins when the consultant receives general requirements from the client. This is followed by detailed discussion with the client leading to the preparation of a detailed design brief. If the client accepts the brief, then a formal contract is signed before detailed design is carried out.

Before inviting tenders, the responsibility of the consultant is to define clearly the general requirements of the project, provide initial estimates of the contract sum, and create a project schedule so that a valid proposal may be presented to the client. Thereafter, the full tender documentation is made available to interested contractors. Notably, these functions are similar to the estimating and planning functions of the contractor yet all the information generated is not directly accessible or available to the contractor for planning and for estimating purposes. At the moment, exchanging and securing information with other external parties is problematic.

Design stage

After obtaining approval from the statutory authorities and the cost estimates for implementing, the plans are reviewed. The architectural division then prepares specifications, design and contract documents for use by the contractors. The consultant's architect is often involved in the preparation of feasibility studies and strategic asset investigations.

Once the structural engineers complete the structural solution that meets the client's needs and budget, detailed designs and documentation for construction are prepared. Although the design office uses computer aided design (CAD) to prepare architectural and engineering drawings, the sole means of communicating the design is by paper copies.

Construction stage

During construction, the consultant constantly negotiates with contractors when there is a change of design, assesses the cost and authorizes changes or variations in design. They liase with the contractor and other clients in order to monitor project costs.

The complexity of the problem

The study found that the main concern with clients is the inability to exchange information or documentation effectively and ensure that changes are monitored. As one senior partner explained, many clients prefer a process that ensures smooth exchange of information. For example, if an event necessitates modification or changes in design and/or construction, there is often a substantial delay before all parties are informed of the changes. The senior partners confirmed that there was a need to improve their document management processes in many areas, especially responding to incoming documents, the removal of duplicated information, and reduction of paper wastes.

Main observations of problems

The study of the consultant shows that its problems are similar to those of the contractors although to a lesser degree. However, an additional concern was how to track design changes and associated drawings, and at the same time ensure that the changes are communicated to other parties during construction. They appreciate the fundamental problems of managing information and that finding a solution to this would go a long way to reduce costs, duplication, increase quality and sustain profitability.

Case C

Case C is a major international manufacturer and supplier of construction products and equipment. The firm employs 1600 employees at two sites, less than a quarter of a mile apart. One site houses the main headquarters which deals with the day-to-day management of the UK group, and the second houses the manufacturing facility and divisional headquarters for the corporation's building construction products unit. The divisional office is responsible for logistics services under the supervision of the head office. The organization employs both permanent and temporary staff. The number of temporary staff fluctuates depending on the level of production. Currently, the company has an annual turnover of approximately £350 million and a group turnover of more than £20 billion.

Information management vision

According to the general manager, although renowned for its innovative engineering, building products and services, the same cannot be said for the way documents are managed on a day-to-day basis. As part of their desire to improve information management, the firm conducted a preliminary study to identify the general problem areas and make recommendations that could lead to the implementation of an effective document management system.

Current situation

In order to address perceived and practical problems with document (records) management, a project team was formed. The drive for the formation of this team appears to be the result of legal problems the company experienced recently. The remit of this team was to identify, initiate and implement corporate strategies aimed at making significant improvements to the company's document management system.

One of the first actions of this team was to recommend the destruction of documents emanating from projects more than eight years old in order to cut the cost of maintaining paper archives. In addition, with certification for ISO 9002 in mind, the team decided to introduce a set of guidelines. However, because the guidelines were based on US practices, they were found not to comply with UK legislation.

To conform with these requirements the team recommended that, based on US practices, all documents be destroyed after an eight-year retention period. To facilitate this process a commercial paper shredder machine was purchased to recycle the paper. How this process was to be managed was yet to be decided.

Records management

The records department currently manages all the archive documents for the company. This archive contains literally thousands of documents from different departments. The first problem with the archive is that it is a manual system. Secondly, various departments duplicate the archiving system so users are not sure whether the archive is actually up to date. Consequently, all respondents indicated that the current system is slow and ineffective.

In view of this, the departmental managers interviewed stated that the ability of their records department to adopt new methods and technology to radically improve the efficiency of the archiving system is unlikely to happen soon. This is because of uncertainty over whether to develop and initiate guidelines based on UK practices. On the other hand there seems to be confusion over the appropriate technology to adopt. The need for urgent action

was underlined by the fact that the weaknesses of the system have been blamed for disputes with clients in recent years.

Document handling, exchange and storage

Presently, the only way documents are transferred amongst participants is via e-mail using Microsoft Outlook's file attachment facility. Owing to issues such as security and general traceability of this method, the majority of data for day-to-day information transfer are in the form of paper. Interviewees acknowledged that communication between departments and staff: i) is ineffective because large volumes of paper are exchanged; ii) produces duplication of documents and work; iii) allows the loss of important documents; iv) is such that retrieval is slow; and v) leads to information not always being accessible to project team members when required.

Storage space

The effect of these problems and methods of information exchange has put further pressure on the storage space for documents in offices and in the records department. As such, documents are piled up in every available storage place.

To tackle this pressure, microfilming technology has been attempted. Even with this technology, only a small percentage of documents (estimated at less than 10%) are held on microfilm archives. Such is the pressure that plans are under way to build another storage site for keeping documents. However, because of financial constraints it has been decided to extend microfilming further to release more storage space.

Current database system

As pointed out so far, a concerted attempt has been made by this company to reduce the pressure on storage space and improve access to archives using microfilm technology. However, because this has not been successful, the shredding of 'expired' paper records has been recommended. This apparent lack of success underlies the fact that documents are being generated faster and in larger volumes than these solutions can possibly handle. The reason is the widespread use of software for document creation and editing and yet IT solutions are not in place to manage the archiving and retrieval process. Some attempt has been made using the company's database, which was set up to hold information on where all records are held. This includes information on the physical location such as shelf number and client's name.

Main observations

The fact that the current database has not been developed further, despite the availability of such technology, suggests that barriers for IT utilization in this area exist. This is because the potential benefits for managing information electronically and reducing the handling of physical documents such as drawings are immense. Savings in management time, disagreements with clients and demand for office and storage space can be addressed in the long to medium term.

Comparing and discussing these problems

Based on the findings from these case studies, the current state of information management practice was recognized. The problems fall into five main areas: i) inability to develop information management policy; ii) cultural issues; iii) barrier to IT adoption; iv) unconsidered business process techniques; and v) inability to assess information, adopt new systems and IT infrastructure. Figure 2 depicts the sources and symptoms of information management problems and how these problems can affect individuals and the organization.

Inability to develop information management policies

The ability to develop a coherent and sustainable information management policy appears to be lacking. For example, in Cases A and B, although the importance of efficient information management was acknowledged, no attempt has been made by either company to formulate one to initiate change. On the other hand, Case C illustrates a situation where the problems of information management are accepted but the attempt to develop a corporate strategy lacked focus. Interviews with senior executives suggest the dilemma is whether their prime concern should be cutting the cost of current systems or applying new technology to work in an entirely new way.

The lack of success experienced by Case C is an example. Consequently, each company appears to be concentrating on tackling the result of poor information management practice rather than undertaking a fundamental reassessment of the value of information as an asset.

Cultural issues

There are many cultural issues to confront in order for the construction industry to succeed in this area. The extent of the influence of culture is illustrated in Case A where the majority of the senior managers believed the technology available to be neither mature nor flexible

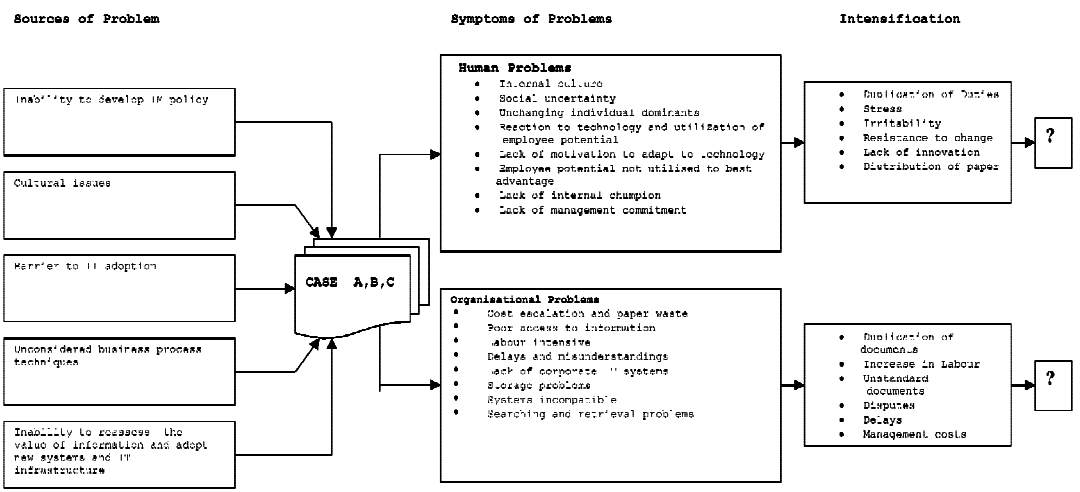

Figure 2. Sources and symptoms of problems affecting the industry and individuals (Adapted from Arnold *et al.*, 1992)

enough to aid their business processes because of perceived complexity. This resistance appears to be less marked in Cases B and C. The symptoms of these problems are a result of the difference in the scale and intensity of their unchanging individual dominants, resistance to IT take-up and lack of innovation and levels of interactions within the supply chain. These studies show clearly that an important factor in the adaptation of any new technology in construction is the management perception that there may be no immediate benefits. Clearly, this has hindered the construction industry's ability to change the way it manages information. This is particularly true of poor information access, which is seen by the project participants, at least in these cases, as an obstacle to their daily operations. The answer appears to be to give managers a good understanding of the likely impact and cost of information technology. This can only be achieved by education and through carefully targeted research such as this, to demonstrate the technology available.

Barrier to IT adoption

The three cases show that the efficiency of any communication process depends on the nature of the medium used. The obvious dissatisfaction with the limitation of paper as a medium is ample proof. However, only in one case is management attempting to initiate policy to use IT. This study confirms what Björk *et al.* (1994) mentioned, that 'handling of physical documents such as drawings has remained a major constraint on project information exchange.'

Overall, there is very little reuse of documents and very little information passes from design or construction to operations. As Cases B and C show, software applications are used routinely to generate documents, but for legal and cultural reasons paper is still the sole medium of information exchange, even within the same organization.

Unconsidered business process techniques

Although in Cases A and B, top executives and middle managers acknowledged that in general the processes related to information management were slow, labour intensive and that information was generally inaccessible, changing business processes has not been seriously considered. In Case C the recognition of the high cost of maintaining manual processes led to the development of a database system using a Microsoft Access tool, with limited success.

Even though all respondents had some knowledge of techniques such as BPR, few were prepared to use the concept to reassess their business processes. When the key steps in the concept were explained at seminars afterwards, most accepted that it offers a systematic way to document process changes required to adopt technology. All, however, accepted that the reassessment or re-engineering of business processes should include consideration of possible levels of automation in information sharing, routing company information as a means of establishing best practice.

Inability to reassess new systems and IT infrastructure

Information technology is constantly changing, but in all the cases studied all respondents were unsure of the real opportunities presented by IT systems at present. In Cases A and B, which are distinctly collaborative environments, none was aware or willing to consider the range of collaborative software and tools available to resolve interface problems that are widely blamed for delays and misunderstandings on construction projects.

Two reasons can be cited for this. First, until now stand-alone departmental systems have been the norm. Secondly, the culture of the industry often dictates that each function

maintains total independence in all aspects including information retrieval and exchange. The result, as these cases illustrate, is that experience of implementing corporate IT systems is lacking and it is clearly affecting their ability to examine the potential of emerging IT or appraise current infrastructure.

To establish best practice information management to overcome these problems, the next section recommends proposals that, when followed, can help management in the construction industry find the way forward to tackle information management problems and implement information systems.

Recommendation

Development of information management policy

One way of assessing management attitude on the issue of information management policy is to determine whether information is viewed as an asset. Another is to determine who is assigned responsibility for what information within departments.

Findings from the study indicated that, business strategies are not formulated to take into account the impact of IT. As such there is the need to investigate how construction companies can align their business strategies to adopt IT so that information management needs can be fully supported and understood.

Cultural issues and implementing change

Managing change is required to implement information management policy in construction. This means some investment in time and effort to change employees' perception of the relevance of the changes and how they affect the company's ability to adopt IT while optimizing its human and physical assets. In most instances this requires changes to information processing, reclassification and design of documents and implementing new processes based on a detailed process map including a clear definition of roles and functions. Although resistance to technology is less strong in some sectors of the industry, the general influence of culture is immense. This can be tackled by giving managers a firmer grounding in information management principles in order to increase management's ability to assess IT systems. Implementing change will also mean continuous professional development of CPD strategy that offers levels of IT training. The scheme should be developed to provide a complete practical introduction to workflow technology, application and communication, information management in construction and approaches to software specification and development in construction. These schemes should be aimed at two audiences: i) project managers, IT managers and directors who need to equip themselves to tackle information management problems in the short term, and ii) students of construction masters degree programmes who can have training spread over the duration of their course (Gyampoh-Vidogah, 2002a).

Process re-engineering

Process re-engineering is an attempt to rethink in a systematic way the potential savings for management by examining functional processes related to document management. The calls

to improve communication will be elusive. The need to motivate re-engineering uptake should be adopted to meet the strategic vision and improve primary and business activities.

Reassessment of new systems and IT infrastructure

This requires management to implement information systems that support project management needs. Above all, technical infrastructure requirements should be carefully evaluated. The overriding concern should be that the technology has to fit into the business, not the business around the new system. This means reassessing new technologies before implementation to avoid confusion over the hype surrounding new and emerging technologies.

Experience of IT issues in a variety of software and hardware platforms needs to be shared and developed. This skill set is a compromise between having specific but discrete knowledge and the transferable skills that need to be maintained to enable the industry to assess and adopt the technology. This aspect of the study was designed to give an indication of the level of understanding of IT issues by senior managers.

Conclusions

Poor information management has serious implications for construction companies. At the moment, information systems are characterized by systems in which i) information sharing is limited to paper, a medium from which retrieval is very slow and inefficient, ii) functional departments maintain their own data structured to suit their particular needs, iii) information is often delayed and triggers disputes, and iv) there is no digital or electronic interface even between departmental systems, therefore the impact of IT investment to date has been limited.

The persistence of these characteristics is fundamentally a result of a general lack of coherent management policy and vision on information management. The cases studied found that attempts to solve information management problems have not been successful. This is partly because the industry perceives these problems as unique and that techniques and technologies used in other sectors cannot be adopted successfully. Secondly, although construction is a distinctly collaborative business environment, for historical, cultural and legal reasons on the supplier's part, the desire to consider the use of collaborative IT tools to resolve interface problems needs management's willingness to adopt the technologies. Thirdly, even though there is a degree of knowledge of business process evaluation and improvement techniques such as BPR to aid management in its drive to solve information management problems, the task of education is one of the key factors to the problems. Finally, the lack of progress in adopting IT to widely improve communication is due to the fact that, until now, stand-alone departmental systems have been the norm. The culture of the industry often dictates that each function maintains total independence in all aspects including information retrieval, storage and exchange. The result is that experience of implementing corporate IT systems is lacking and it is clearly affecting their ability to examine the potential of emerging IT or appraise current infrastructure.

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