Organizational Assessment Of Integrating CAD And Product Data Management Tools In The Furniture Industry

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Abstract

This report begins with an overview of research relating to the organizational and management issues of integrating CAD/PDM systems into furniture companies. Some of the primary areas where CAD/PDM technology affects an organization are in the areas of: 1) job design, 2) organizational structure, 3) power distribution, and 4) user communication patterns. The technology/organizational interaction, however, is bi-directional. Central to the successful integration of new CAD/PDM technology is awareness of social and organizational contingencies which can impact the technologies' effectiveness. Key contingency issues include: 1) user acceptance, 2) management acceptance, 3) communication to users, and 4) user training. Through this review of technology/organizational interaction, specific examples of issues faced by furniture companies are given. The literature review closes by focusing on additional issues that must be accounted for when implementing a group level technology (i.e., groupware) such as CAD/PDM. The next section outlines the method and results of organizational assessments done at three furniture companies over this last year. These assessments lay the groundwork for planning the integration of CAD/PDM and help identify contingency issues to be tracked. These results are followed by a recommendation for the use of pilot groups as a central element in a companies' implementation plan. This recommendation comes out of the background research, results of the surveys, and observations of efforts to date at introducing CAD/PDM technology in the furniture industry.

Introduction

The use of 3-D Computer-aided Design (CAD) computer systems in manufacturing and design has popularized the concept of the virtual product database. Product Data Management (PDM) and similar computer-based information management tools, coupled with 3-D CAD, have made this database available to a much wider audience within the organization. An important component of technology making this distribution possible has been the growth of local area networks (LANs). Generally, the introduction of computing and networking tools within an organization has greatly outpaced the organizational restructuring needed to maximally leverage the technology (Majchrzak, Chang, Barfield, Eberts & Salvendy, 1987). Researchers such as Schaffitzel & Kersten (1985) have noted that the introduction of CAD systems requires not only systems engineering development, but also a redesigning of the organizational context in which the system functions. It is also important to note that the introduction of the new generation of 3-D virtual product models distributed and managed over Intranets involves a unique set of organizational issues that only partially overlaps those issues involved in the introduction of 2-D computer-aided drafting tools.

The central purpose of this research is to assist in the implementation of CAD/PDM into wood-based furniture companies located in the Southeastern United States. Specifically, this research prepared organizational assessments of product development divisions with a particular emphasis on product design information flow among the departments. The motivation for the assessments was a recognition of the deep intertwining of technology and organizational issues when integrating complex software tools such as CAD/PDM systems which have the potential of altering work structure at the enterprise level.

This report begins with an overview of research relating to the organizational and management issues of integrating CAD/PDM systems into furniture companies. Some of the primary areas where CAD/PDM technology affects an organization are: 1) job design, 2) organizational structure, 3) power distribution, and 4) user communication patterns. The technology/organizational interaction, however, is bi-directional. Central to the successful integration of new CAD/PDM technology is awareness of social and organizational contingencies which can impact the technologies' effectiveness. Key contingency issues include: 1) user acceptance, 2) management acceptance, 3) communication to users, and 4) user training. Through this review of technology/organizational interaction, specific examples of issues faced by furniture companies are given. The literature review closes by focusing on additional issues that must be accounted for when implementing a group level technology (i.e., groupware) such as CAD/PDM. The next section outlines the method and results of organizational assessments done at three furniture companies over this last year. These assessments lay the groundwork for planning the integration of CAD/PDM and help identify contingency issues to be tracked. These results are followed by a recommendation for the use of pilot groups as a central element in a companies' implementation plan. This recommendation comes out of the background research, results of the surveys, and observations of efforts to date at introducing CAD/PDM technology in the furniture industry.

Technology / Organizational Interactions

An organization is not passive receiver of technology nor will it seek out and implement technology in purely 'rational' ways (Contractor & Eisenberg, 1990; Fulk, Schmitz & Steinfeld, 1990). When work practices use technology for communication, changes in those technologies will affect organizational functioning, but groups and individuals within the organization will also actively influence how the technology gets implemented. These interactions are recursive. The organizational, social, and technological factors not only interact with each other, but also within their respective groups (Badham, 1995). Sociotechnical approaches to technology integration do acknowledge that both technological and social issues must be addressed if implementation is going to be successful, but often the technology is accepted as an unchanging, fixed factor (Karlsson, 1995). This design-oriented sociotechnical approach, however, does not take into account that successful implementations of technology respond to the needs of unique social/organizational structure of the company.

Job design

2-D CAD was largely introduced into furniture companies using a 'status-quo' model, in which few or no changes in organizational structure were planned. Though users were required to develop new, computer-based skills, their actual job description and their place in the organizational structure did not change much. It is unlikely that this will be possible with the more far-reaching effects of a 3-D CAD/PDM system, especially if the potential of such a system is going to be realized. There is no question that current generation CAD/PDM systems, along with ancillary groupware technology can open up many more possible pathways of communication, but which ones are used and how effectively will be determined by organizational and social forces within the company. The decisions of which tasks are done by a new CAD/PDM system and which ones are done by the human operator need to be made carefully. All too often, new technology is integrated with the assumption that the human operator will simply do what the new system is not capable of (Helander, 1994). In fact, this situation should be turned around by first assessing what the operator does best and then finding out how the new technology can support this activity best.

One worthwhile goal is to find out how to reduce an operator's time spent with routine tasks that distract from the performance of the highly cognitive decision making and analysis tasks which humans typically perform much better than machines. To this end, CAD/PDM systems are well suited to perform 'clerical' tasks of filing and retrieving drawings and data from centralized databases. Engineers and designers should maximize the amount of time they spend reviewing manufacturing and design data to check for errors, evaluating structural stability, developing improved manufacturability, and the like. All too often, whole days are spent hand transcribing data already contained elsewhere, making phone calls to track down the latest revision of a drawing, or pulling drawings and route sheets for a manufacturing run.

If, however, central databases of product information are going to be used and if multiple individuals are going to contribute information, then a higher degree of standardization is going to be needed than is currently practiced in many engineering groups. The move to 3D modeling means that constrained (i.e., parametric or variational) models will be created of the furniture pieces. Typically, the upfront time it takes to build a constrained model from scratch is longer than it is to create a set of 2D drawings of the part. If the model can be reused with minor variations for multiple parts, then very quickly time savings and error reduction can be achieved. This can be done only if the next user who modifies the model knows how it was constructed and how the parameters were assigned. If not, then the operator might as well start from scratch building the model again, losing any efficiencies of using the model. This is a specific example of how the lack of standards thwart efforts to share and reuse 3-D model elements among designers and engineers. Last years' technical report to the FMMC by the authors (FMMC-96-1) outlines a process by which standardized models of upholstered seating frames can use a common set of overall dimensions to describe the frame assembly and generate specific overall part sizes and locations of machining (primarily boring) operations.

Increased concurrency in engineering and design operations, a key business goal of many manufacturing companies, is supported through the use of shared databases created by CAD/PDM systems. To achieve this, individuals must be comfortable with working in an environment where they are likely to become more interdependent on others in the organization to provide timely information concerning work in progress which is posted in the database. Concurrency usually goes hand in hand shorter development and manufacturing cycles, increasing the pressure on all individuals to get it right the first time. Shorter cycles may mean that groups downstream in the process, like manufacturing, must review design work in progress as it is posted to the database since they may not get an opportunity once final release to manufacturing is made. This makes plant managers and engineers dependent on central engineering to notify them when new work is posted and to provide guidance as to what changes may have taken place in the design. Conversely, central engineering now is more dependent on manufacturing providing timely feedback and properly documenting this information in the database.

Organizational structure

The effort spent building accurate 3-D models of furniture parts is best maximized when it can be stored in central databases and linked to related manufacturing and design information created with other software tools. The linkage of product information created enterprise-wide demands for what is often an unprecedented level of cooperation and coordination between different organizational units in the company. Furniture companies, like many other manufacturing areas, have historically had disparate computing systems develop in different organizational units; each unit stored and managed its own information sets and if this information was to be shared with other divisions, it was typically through paper-based printouts or read-only displays on computer terminals.

In a typical furniture company, scheduling and costing functions were among the first to be automated and continue to be done on a mainframe system managed by a central MIS group. The product development group historically generated their detail assembly, part drawings, and product specification sheets by hand. Currently, most furniture companies use 2-D CAD as automated drafting tools. By simply automating existing functions, they have avoided the need to alter the organization structure and information flow within their companies. Drawings that were once hand drafted are now plotted out and circulated much in the same way the hand drawn drawings were. While email over a LAN is a common commodity, centralized servers for CAD drawings generated on PCs are not. Even after a product development group automated their drafting functions with a 2-D CAD system, this was done on PCs supported internally within engineering and not linked to the mainframe, requiring the same hand entering of information through terminals. It is now only with 3-D CAD/PDM systems that there has been a strong push to link information across computing systems and require a new level of cooperation between Engineering and MIS. This is an example of another area where the full potential of a CAD/PDM system can only be achieved through the evolution of organizational structure in a company and a rethinking of traditional lines of responsibility for information generation and management.

Power distribution

It is not possible to talk about the generation and management of information without discussing organizational power distribution. Though it may seem counter-intuitive, centralizing the product data can either centralize *or* decentralize information control and decision-making. Centralizing the data enhances control over the data, but it also allows for distribution of this information to a wider audience via internal networks (i.e., Intranets) within the company. Managers responsible for setting up the central databases can either lock down the data and require centralized approval for all changes or allow for varying levels of information access to a broad audience ranging from view-only privileges to limited data notation to full modification rights. In summary, with modern computer networks and data management systems, access to information needed to make decisions is no longer an issue of physical location, it is strictly a managerial decision.

If product databases are going to be accessible and modifiable by a wider range of individuals, then standard protocols typically need to be followed in order to assure uniform entry and modification of data and methods of notification of interested parties about changes. In some cases, uniform entry and modification can be enforced through ‘smart forms’ on-line which limit the type and range of data values entered into a particular database table. In other cases, the information attached to the database was not entered into the database directly and is archived in a format native to an external program. An example of this might be a parametrically constrained CAD model. A data variable such as part number might associate this CAD model to the database, but it will be up to the CAD operator to followed standard protocols as to how the model geometry is generated and constrained and how text is notated on drawings generated from the model. In some cases database modification, notification, and approval is managed by a specific workflow software package associated with the product database. In other cases, individuals within the organization are responsible for properly routing the information.

User communication patterns

Research has shown how new information technology can affect the patterns of communication within a company (Ancona & Caldwell, 1990). The establishment of Intranets and the accessibility of enterprise databases over this communication network opens up the possibility of many new communication patterns. Formal communication channels that are restricted by physical or barriers are typically not as much of an issue any more; nor are the costs of reproducing the information for distribution. Formal communication channels with these new technologies will continue to move within the hierarchies of organizational units, but the information can now just as easily flow laterally between organizational units. ‘Virtual groups’ can form on-line that may not meet often face-to-face but may communicate regularly via email and on-line conferencing (i.e., news) groups. These groups can either be formally established for a particular project or coalesce in an ad-hoc fashion around a common interest or concern.

In a more specific example, drawings and 3-D models accessed from a remote server and displayed on a computer monitor can take the place of a face-to-face meeting over a set of blueprints. Whereas the same technical information contained in the drawings might be exchanged in both these circumstances, the face-to-face medium will take place in a much more 'media-rich' environment capable of both clarifying technical information and reinforcing important social ties (Daft & Lengel, 1986; Fulk & Boyd, 1991). Engineers and designers are large consumers of rich information, and such lines of communication must be supported (Lakin, 1990; Springer, Herbst, Schlick & Stahl, 1995). It is not clear that advanced technology will, in the short run, be able to provide for the same level of richness found in more traditional modes of communication (Huber, 1990). At the individual company level, careful assessment in needed to determine under what types of circumstances a more media rich face-to-face meeting would outweigh the advantages of communicating remotely via a PDM database.

The removal of physical barriers to communications can extend beyond the office walls. Within the company intranet and via connections to the Internet, workers can communicate electronically from most any location; whether it be on the factory floor, at home, on an airplane, or from a retail outlet in another city. With the increased speed and accessibility to exchanging information, new organizational protocols need to be established as to when individuals are expected to be in touch with their communication channels. Just because an individual has the ability to always plugged into the communications network does not mean that it is always advantageous to do so. Instant accessibility to information networks can encourage needless information exchange and distract from other aspects of ones business and personal life.

For both these cases, new technology creates changes in both information access and control and, just as importantly, 'social presence' of those collaborating on the design work. These examples also point up a case where current organizational dynamics of institutional and geographic structure may drive the selection and implementation of technology, but the technology itself will have (maybe unintended) effects on the same organizational structure. Implementation of technology is not simply a matter of identification and specification of technical features, but also of important managerial and strategic decisions.

Identifying Factors Affecting Implementation

A plan for bringing in new technology may be solidly based on the strategic plan of the company and the information flow designed to optimize the distribution of information, but the performance of the human workers — both individually and as groups — who generate and process a bulk of the information of this system will determine its ultimate success. Managers', engineers', designers', and drafters' acceptance of the new CAD/PDM technology will affect how much it get used and how much information continues to flow through its traditional channels. Where the previous section outlined how information technology such as CAD/PDM can affect the organization, this section will focus on how the state of the organization affects the effectiveness of the technology. Researchers such as Tomaskovic-Devey & Risman (1993), Zmud (1990), Badham (1995), and Majchrzak & Klein (1991) support a contingency model of technology integration into an organization. Effectiveness of introduction of new technology will not only be contingent on 'rational' and engineered/scientific matching of technology to an organization, but also on contextual social factors. Successful implementation of technology involves not only proper specification of technology based on perceived short term and long term business needs, but also an implementation plan which pay close attention to organizational dynamics within the company.

User acceptance

Central to the success of bringing new technology into an organization is the acceptance of the end users of the technology. Job satisfaction heavily dependent on one's own perception of the job, not simply an objective analysis of workplace conditions (Hackman & Oldham, 1980). One's own perception of their job is influenced by many factors. It is not simply enough to tell someone that new technology such as 3-D CAD or a PDM system will improve their job, they must be internally motivated to believe in this fact.

One effective approach to generating commitment and enthusiasm toward the use of the new system is the participation of users in various components of the technology integration process (Levi & Slem, 1990). User involvement in the specification process can help both educate them to the capabilities of the system and the business goals of the organization. Similarly, user involvement in the implementation process creates a climate of understanding between the users and management as to what will be involved in the transition to the new technology. Additionally, opening communication channels early in the transition period will allow new and unexpected results of the transition process to be quickly communicated to all those involved. All of these factors lead to increased organizational effectiveness and reduced resistance to change.

User participation in system implementation will not be effective if the users feel that the request for participation is an ‘empty gesture’ (Long, 1990; Mackie & Wylie, 1988; Rouse & Morris, 1986). For example, if users are brought in late in the process, are not given enough time to research and examine the proposed technology before submitting their recommendations, or if they feel that they have not been given any real power to affect the decision making process, then there is likely to be little enhanced commitment to the success of the system. It is important to remember that discontent over the implementation of a particular system is likely to carry over to other aspects of a person’s job, too.

Of central concern to most workers is how they are evaluated on the job. New technology often involves a learning curve to both the particulars of how the software operates and how it will be integrated into day-to-day operations. This transition will typically lead to a period of lower productivity before the new system is integrated. This realization of ‘costs’ of new technology adds to the inertia working against change. Whether users of the system perceive a recognition of this fact by management will influence their attitudes towards the system. In addition to recognition of the transition period, users will typically expect some concrete contribution towards smoothing the transition period through additional staffing, providing training, or a reduced work load. Pressure for too fast a ramp-up time on the system may lead the user to feeling overwhelmed by the intricacies of the system, and lead to a strong motivation to fall back on tried and true practices in order to get the work done.

Middle management acceptance

Middle managers will also be evaluated on the success of technology integration. Managers are influenced, to differing degrees, by organizational constraints such as finances and the capacity of the division to absorb the downtime involved in transitioning to a new technology and by the response of their workers to the new technology (Tomaskovic-Devey & Risman, 1993). Personal attitudes, too, toward the new technology may play a role as to how they respond. Managers engage in ‘boundary management’: securing resources and identifying, thwarting, or satisfying external demands on the implementation team. How they establish incentives (or disincentives) to master the new technology and the degree to which they provide logistical and affective support to the users of the system will exert a strong influence on user attitudes towards the system.

One might think that factors such as 'ease of use', data format support, or inclusion of key features are the only types of factors involved in an analysis of potential systems. In fact, both users and managers often assess technology less in terms of how it actually functions, and more in terms of how it contributes in a broader sense to accomplishing job goals (Sokol, 1994). It is important to realize that these goals may be purely based on job functions, or they may be based more on social factors.

Issues of culture, especially the changing relationship between workers and managers, differing levels of management, and between divisions such as manufacturing and design are among the most difficult issues facing the implementation of CAD systems (Adler, 1989). Managers are often in critical influence points where they can manipulate organizational behavior (Badham, 1995; Zmud, 1990). In the past, information technologies offered only a limited ability to facilitate strategic behaviors. Only a minor portion of an organization's information was on-line, technology was not networked to the degree that it could easily cross organizational boundaries, information systems were not available to all users, and when they were, it was often only through intermediaries (e.g., secretaries and clerks). As outlined previously, the current generation of Intranets are designed to be on everyone's desktop and have to the ability to store and retrieve the majority of business information.

Communication to users

Though managers have built in (organizational) structural abilities to communicate information concerning new technologies, there are others in the organization who also have the ability to sway opinion. In many cases, the individuals with the most direct knowledge about current technological trends are not the mid to high level managers, but lower level staff. These individuals retain high referent power and have opinions held in high regard by others concerning technical issues. Similarly, some personnel have job roles that allow them to travel between a wide variety of groups within an organization and are able to influence opinions over a broad spread of an organization. Both these types of individuals who could be considered 'Key Communicators' within an organization and hold a special role in influencing attitudes about new technology (Contractor & Eisenberg, 1990).

Management still has the responsibility for communicating both the short-term and long-term goals of new technology and to establish a timeline for milestones along the way. They also have the responsibility of clarifying management intentions for introducing new technologies. A constant concern among workers is new technologies are meant as a vehicle for downsizing the workforce. In fact, the introduction of office technology such as CAD systems seems to have rarely been the root cause of workforce reductions (Majchrzak & Klein, 1991). On the other hand, management has to be up front about the fact that successful integration will probably entail changes in job design and work responsibility.

New intranet-based communication technologies such as email and/or CAD/PDM may be considered at a company specifically because of difficulty in communicating with workers at remote sites. During the transition period, older more established communication channels may provide a more reliable method of communicating with the majority of individuals affected by the change. Yet, not using the new technology to communicate with users may both send an inappropriate symbolic message. These problems can be especially acute with users at more remote locations; users who both can stand to benefit greatly from improved communication technologies but who may be the hardest to reach out to gain their support.

Training/User support

New technology often brings a dramatic increase in the need for training; a need that often goes unmet (Majchrzak & Klein, 1991). How a training program is designed and implemented can have a significant impact on the implementation of new technology such as CAD/PDM (Klein, Hall & Laliberte, 1990). To begin with, a training program is often the employee's first introduction to the new technology. This will especially true if the employee was not part of choosing and designing the implementation of the new system. Employees will inevitably approach the new technology with certain preconceived notions about the new technology. It can be very important for those involved in the training to have some idea the general level of support there is among those undergoing training for the new technology. The level of interest and commitment on the part of the trainees will determine the level of self motivation to master the technology, how the reward system for successfully completing training should be structured, and the level of expectations among management as to the pace of mastery.

Training programs can roughly be divided along the dimensions of formal versus informal, and in-house versus out-of-house. Larger companies training on general productivity software such as word processing often have in-house trainers who hold regular, formal workshops on the software. The user's training is usually filled out through informal self-study and question asking of co-workers. CAD software is usually specialized enough that more formal training is done by outside contractors either in-house or out-of-house. There is also typically a lot of on-the-job informal training that often depends on the help of the resident expert: either a long time user, or a particularly aggressive self-starter. A PDM system, like many intranet tools, may be a hybrid of these two types of software tools. It may require both specialized training for a small group of individuals entering and modifying the bulk of data in the system and then more widespread generalized training for larger groups of users who need to query and view, but not modify the data.

There are no clear indications that there is a single correct approach to training other than careful planning and listening to the users' needs. Often where trouble arises with sophisticated software tools like CAD is that there is poor follow-up analysis of training effectiveness and coordinated remediation and advanced training. It is not uncommon for a company to buy a new CAD system, send employees off for a week of formal, off-site training, and then not have the software implemented back at the company for another three to six months. By this time, the users' knowledge of the system has atrophied, requiring re-climbing the initial learning curve, but this time on their own. This becomes a double-jeopardy situation: not only is the software user not being productive, but also feels not supported by their organization; meanwhile their manager, having paid the bill for training, cannot understand why the users aren't more productive.

Training programs that are not sensitive to the dynamics of the organization can end up exacerbating negative elements that existed in the organization before the planned implementation and/or came about because of other aspects of the implementation process. Klein, et al. (1990) outline a case study of the implementation of a 3-D CAD system in an engineering firm. Klein identified a number of problems in the design of the training. Among them, employees were expected to complete the 60-hour training program for the software on their own time, sending mixed signals to the future users as to the companies' commitment to the system. In addition, only the primary users of the system, the designer/drafters, were trained on the system; managers were not. Where before the engineers managing a project could both review drafted drawings of projects under development and make corrections directly on the drawings, the 3-D CAD system placed a barrier between them and the work in progress. The engineers, always concerned about the quality of the design work, now felt that they were no longer able to monitor the design process. The CAD system users, in turn, felt that the managers did not have a good understanding of the difficulties of implementing and using the system. Even with these problems, neither management nor the end users wanted to return to using manual drafting to do the design and documentation work.

In summary, training individuals on complex software systems is a continual process and will be received differently by each user based on basic aptitude, initial biases, and level of perceived support. Not only must the dynamics between the end user and the system be taken into account, but the organizational dynamics which interact with the training program must also be accounted for.

Organizational /Technology Interaction at the Group Level

Increasingly, software is being designed for use in coordinated group activity. Whereas 2-D CAD was typically used as a single-user tool for automating drafting, the full benefits of 3-D CAD/PDM systems are found when the product database is used to coordinate group, division, and organizational-level activities. The need to assess social and organizational factors become even more acute when 'groupware' systems are being integrated into an organization (Ellis, Gibbs & Rein, 1991). A particularly potent source of influence of one's perceptions of new technology is one's peer group within the organization (Fulk et al., 1990). This peer group will typically consist both of those you interact with regularly over the course of the work day, but also those who hold similar positions within the company. Those within the peer group who have special expertise and/or knowledge about the new technology will hold special sway since they are members of the peer group and they also hold special referent power.

In addition to the previously discussed social and organizational dynamics, groupware systems such as CAD/PDM bring a new set if issues to bear (Grudin, 1994). To begin with, the success of a groupware system is no longer dependent on the acceptance of a single individual, but on a group of users. The issue of critical mass now becomes an important factor in system success (Markus, 1990). As an example, if a new word processor is offered for use within an organization, and 50% of the users switch to it, it would probably be considered a successful introduction. On the other hand, if email is introduced and only 50% adopt it (with the remaining continuing to communicate via written messages), it would be a complete failure as a company-wide messaging system. Management is often faced with the quandary of mandating the new system's use and risk the new users' resentment or not reaching critical mass due to lack of adoption. With this dynamic, support of early adopters becomes critical. New users face special hurdles in adopting new group technology: they do not have the support of their peer group, they often do not have informal support nearby, and they are unable to gain full functionality out of the system due to lack of widespread use. Yet, without these early adopters to lead the way, critical mass is unlikely to be met; they represent an import initial percentage towards the goal and can act as evangelists and informal trainers to later adopters.

One of the first steps in introducing a groupware system is to defining what will be the user population(s) making use of the system. With most sophisticated groupware systems, such as CAD/PDM, there may be many levels of user populations. What this means is that the system can be implemented in stages with an initial subset of features implemented in the system specifically for a strategic group of users. The choice of this initial group of users will be based on a number of factors, including: 1) high degree of acceptance/enthusiasm of the new technology by the group, 2) the meeting of immediate business needs, 3) the visibility of the group within the organization, 4) the scalability of the system from this group to the next level of use. Staging the introduction of the groupware allows for diffusion of knowledge of the system within the organization. The initial users are able to both troubleshoot issues pertaining to the use of the system and to present a realistic profile of system capabilities to future users. This dissemination can take place both through more formal show-and-tell sessions and through informal demonstrations.

Another implementation issue that gets magnified when put in the context of groupware is issues of job design. With any shared database, there is a greater need for standardization of how information is entered and maintained within the system. At the same time, the wide the user population, the greater the variety of work habits and needs. There is the often conflicting need to keep data in a standard format that is communicated to all users of the system and the need to make the information universally accessible by presenting and formatting the information in ways most useful to the various users. What this often entails is not altering the fundamental content of the information in the databases, but altering the way the information is presented to the users. This entails careful task analyses of future users of the system and designing interfaces to the groupware system that meet their needs. Luckily, a new generation of intranet-based software tools allows for flexible design of interfaces to data sources and the integration of existing software tools. Often the integration of an intranet-based groupware system is composed of integrating both new and old software tools with server-based information systems. This means that often new job skills involving new software can be introduced beside existing software tools over a transitional period.

Finally, the purchase of groupware systems is typically part of a larger organizational trend away from individual work and towards team oriented work. In the case of furniture and other types of manufacturing, this can be seen in the adoption of cellular-based manufacturing, TQM techniques, and concurrent engineering. With this shift towards team-oriented work must also be a shift in the reward system to tie individual effort to team-oriented goals. As noted, the adoption of new technology is often a process that involves short term stress and productivity loss on the part of the individual. Individuals are likely not to be satisfied strictly with promotions of a new technology as being ‘good for the betterment of the group’. Individuals must feel that there is some personal gain, even if it is long term, in job enhancement and/or status. These desires do not have to be exclusive of group goals and can be tied together.

In summary, companies trying to capitalize on the opportunities of CAD and related computing technologies face challenges in five general domains: organizational procedures, organizational structure, skill base of the organization, implementation strategy, and corporate culture (Adler, 1989). Successful implementation of CAD/PDM technology will require an understanding of: 1) the design and manufacturing process as it currently exists in the company and the roles that different individuals play in the process, 2) individual's job designs, and 3) the information flow during the product development process (Wiebe, 1997). This information, along with knowledge of the skills both the organization as a whole and individuals possess and the attitudes which they hold pertaining to technological change, can be used to help plan an implementation strategy.

Method

The methodology used in surveying the furniture companies was meant to be both descriptive and prescriptive. That is, the results were both meant to capture a snapshot of the current organizational state of the product development divisions of these companies and to help plan for the implementation of CAD and PDM systems. In a broad sense, implementation will involve both technical issues and organizational issues. The focus of this survey work is on the organizational issues: both the structure and the state of the organization. State issues tend to be harder to assess since they involve less tangible elements such as corporate culture and attitudes of individual users. Still, since user and management acceptance is important issue, organization. members attitudes must be surveyed (Bender & Bannecker, 1990)

In an approach supported by Steinfeld & Fulk (1990), the background research has been used to help link specific areas of organizational theory with capabilities of new technology. These theoretical elements are then used to develop propositions as to how new technology will affect organization. These propositions then become the prescriptive component of the research. The goal of most of these prescriptions is to minimize negative aspects of the technology and integration process while still meeting the overarching goals of the organization. Of particular importance is paying attention to the previously identified contingency factors which can blunt the effectiveness of the new technology.

The assessment took advantage of three types of methodologies: surveys, face to face interviews, review of archival documents, and observations of work in progress. Because much of the work done in the product engineering divisions of furniture companies happens over such a long time period, the research approach and framework cannot be based primarily on the registration of observable phenomena (Carstensen, 1995). Though direct observation was a part of the assessment, it captured a small snapshot of a process which was explored more fully in retrospective information from surveys and archival data. The survey instrument used was based on selected and modified questions from Van de Ven & Ferry's (1980) Organizational Assessment Inventory, Hackman & Oldham's (1980) Job Diagnostic Survey, and Pasmore's (1988) Sociotechnical Systems Assessment Survey, as well as Harrison's (1994) text on Diagnosing Organizations. In addition, other questions were developed from the literature on implementing new technology into organizations.

Part of this assessment process was the creation of a graphical chart showing the flow of design and manufacturing information through the company. The initial face-to-face interviews included clarification of job titles and responsibilities and where the employees felt they fit within the organizational structure. This elicitation helped them start thinking about some of the issues they were going to be asked on the survey, formalize their job titles for use in answering questions on the surveys, and assisted in the creation of a flow chart from the survey results. This technique has been used effectively by past researchers (Holtzblatt & Jones, 1993; Johannsen, 1995; Olphert & Poulson, 1990). The survey assessed job design, organizational procedures, organizational structure, organizational flexibility, current level of technology, employee satisfaction and product information flow. The survey used 7-point scales, short option questions, and open-ended questions for: 1) further comments and 2) a request to sketch the product information flow within the company. In addition, archival document review and on-site observation was used to gather supporting information.

Survey Results

The survey was completed by members of the product development divisions in three medium-to-large furniture companies: Companies A, B, and C. At Company C these job functions were based at individual factories, so groups at two factories were surveyed. The survey groups at these various companies ranged in size from five to 12 members.

Job design

For the most part the respondents found considerable variety in their jobs but only moderate complexity in the actual tasks. Only at Company A was there a minority group that found little variety in their work.

Organizational procedures

At all three companies there were set procedures for coordinating work activities. On the other hand, the division manager at Company B felt that even with the set procedures, there was poor follow-through on using standardized methods of coding, storing, sharing, and modifying design information.

Organizational structure

There were differences between the three companies concerning perceptions of organizational structure. Company A reported some problems with communication between two of its primary groups: Detailing and Bill-out and only minimal formal communication channels. Quality of coordination and the effectiveness of content and flow of information was moderate. On the other hand, both Companies B and C felt there was a high degree of interaction with formal communication channels being followed. The perceived degree and quality of coordination and cooperation and information was fairly high. In all three companies, there was perception of highly differentiated jobs with only a limited ability to be able to rotate positions with someone else. At companies B and C, workers felt they had a moderate amount of autonomy on the job. At Company A there was lower perceived autonomy in Bill-out than in Detailing.

Organizational flexibility

The degree to which their companies were receptive to technological change ranged from low (Company C) to moderate (Company A) to high (Company B). The one dissenter in Company B was the division manager who felt the company was not receptive to change. It may be he had first hand knowledge at actually selling projects to upper management.

Current level of technology

Overall people perceived their technical skills to be fairly good, though the level of technical skills depended to some degree on the immediate work group. Training was seen as an important issue at all three companies. A large majority of respondents felt that transition to 3-D CAD and/or PDM software was going to be difficult and would need to be supported by training. There was, however no agreement on the best type of training. Respondents at Company A favored an in-house expert while out-of-house training had a slight edge at Company C. Self training was uniformly rated the least desirable.

Employee satisfaction

With some exceptions, respondents felt satisfied with their jobs and saw computer technology as having considerable potential for improving their jobs. Specifically, there was definite interest in implementing 3-D CAD even though — as mentioned above — they thought the transition would be difficult. The notable exception to the majority was the Bill-out group from Company A, which felt less stimulation, challenge, and satisfaction from their jobs and also raised the most concerns about implementing 3-D CAD.

Product information flow

Figures 1 through 3 display the flow charts generated from the survey and interview data. Since all respondents were asked to rate the level of information exchange (on a seven point scale) both to and from other members of their group, comparisons could be made using ratings between pairs of members. Where the 'to' rating by one member of a pair differed by more than one point on the scale from the comparable 'from' rating by the other member, the vector was coded as conflicting. These vectors, along with missing values, were identified for follow-up interviewing.

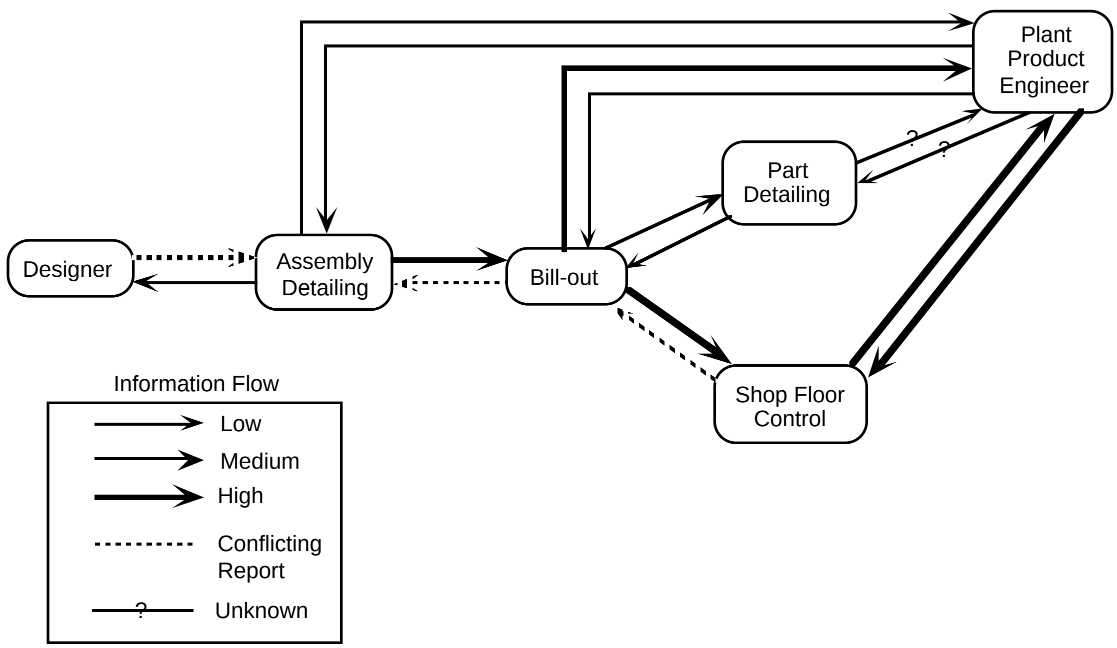

Figure 1 - Product information flow chart for Company A

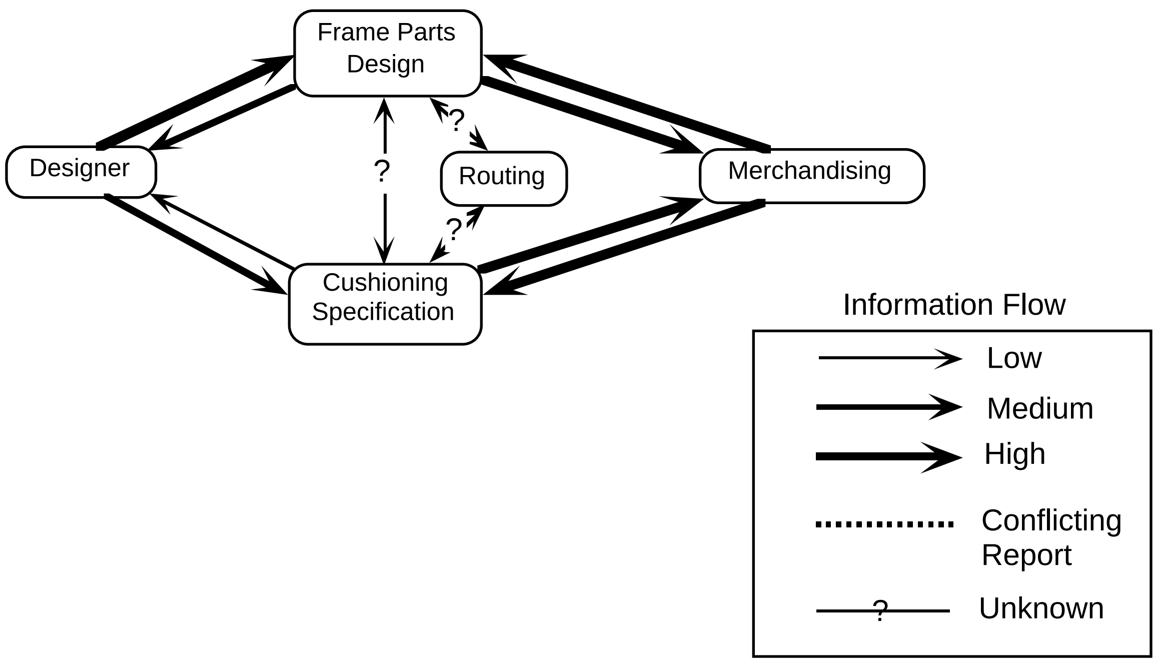

Figure 2 - Product information flow chart for Company B

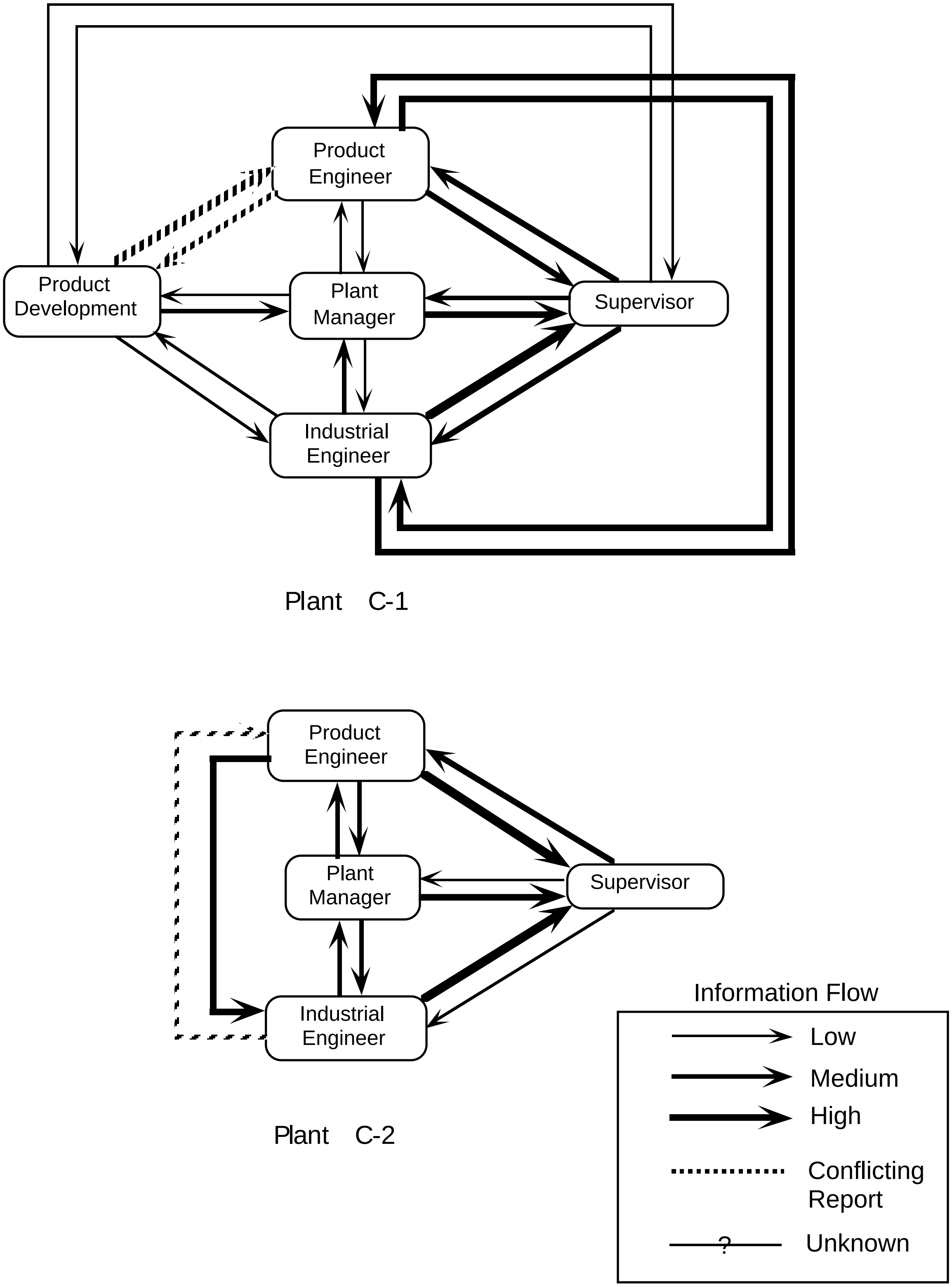

Figure 3 - Product information flow chart for Company C

Specific problems to be addressed

Specific problems mentioned in the final open ended question included such items as: lack of communication with designers, too much 'rework' of completed designs, the need for better part classification systems, the inability of shop floor workers to correctly interpret drawings, and late changes made by designers and marketing staff.

Other findings

Company A had the largest central product engineering groups of the three companies surveyed, yet critical functions of the product development process were still being performed remotely at individual plants, namely the creation of individual parts drawings and the binding of these parts drawings with the route sheet information for the parts. Errors found in the product specification sheets during the process of drawing the parts or piloting the manufacture of the parts were recorded on correction sheets and sent back to central engineering. This process depended on both the individual factories to do good job recording changes and for central engineering to record the changes on the master product specification sheets. The original detail assembly drawings were rarely updated based on these changes. Manual entry of product specification information was also required for entering information into the scheduling/MRP system on the mainframe for generation of the route sheets. As the product specification sheets were updated, this information would have to be manually updated. These two coordination issues were examples of where geographic and technological barriers aggravated the coordination of key information.

Another item that revealed itself in the survey work at Company A was the diversity of age, experience, and motivation of workers to tackle new technology within central engineering. There also seemed to be an interaction between these factors, divisional boundaries, and the differences in job design within central engineering which enhanced the spread between those who were highly motivated to tackle new technology and those who were not. Company B, on the other hand, had a much smaller central engineering group and one that was much more homogeneous in terms of age and experience. They were perceived to function much more as a unified group and were more uniformly excited about the prospect of introducing of new technology. Company C had a clearly evident corporate culture of a tightly knit company that took care of its employees. No one could remember the last time anyone was fired or laid off in engineering. A close association to ‘tradition’ and a high comfort level did not lead to very high motivation for change among the survey participants. In contrast, at Company A, there was also a high level of overall anxiety over job security caused largely by the recent buy-out of the company by a large conglomerate.

Recommendations

Both the specific findings in the three furniture companies surveyed and the organizational and social theory review support the use of pilot groups to be an integral part of the implementation process of a 3-D CAD/PDM system. First, pilot groups offers a means of assessing the impact of the technology on the organization by viewing its impact on a subset of the organization. In this environment, impact on job design, workflow, changes in product information standards can all be evaluated. In addition to this critical assessment, pilot groups directly address some of the key social and organizational contingencies which may blunt the effectiveness of the new system. Pilot groups can act as key communicators of the new technology to others in the organization and provide a transitional period during which future users can familiarize themselves with the technology.

Markus (1990) has cited piloting as a recommended implementation technique when working with enterprise-wide technology such as an intranet-based CAD/PDM system where reaching 'critical mass' is crucial. He notes that choice of participants for the pilot group is an important consideration. The choices for the participants should not only take into account current job description match to proposed system use, but also more social/organizational factors such as: 1) the referent power of the individual (i.e., is he/she thought of as a technology 'guru'), 2) whether they represent a key communicator within the organization, 3) their initial level of enthusiasm and realistic expectations for the technology, and 4) their working relationship with other potential pilot team members. Finally, selection of pilot group members needs to assure that its members form a coherent community able to perform of most of the processes and functions which the final system will perform. This is a micro-level critical mass needed for realistic functioning of groupware systems.

Support for this pilot group will also be a critical issue. Early adopters of any technology face additional hurdles and this is particularly true of adopters of groupware tools. High profile support by management for this pilot group sends a message both to the group and the rest of the organization about the importance of this project, if executed well, this additional support will provide additional status to the group needed to both secure needed resources and cooperation from other divisions and validate the promotion of the system to others. Support for the group can include relieving them of normal day-to-day duties either through a redistribution of the work or through the hiring of temporary replacements. In addition, strategic technical support in the form of consultants or guaranteed time of in-house staff can help the team members focus on higher level implementation issues and avoid frustration and wheel-spinning.

How the pilot group is integrated into the implementation process needs to be planned from the very beginning of the project. Ideally, key members of the pilot group should be part of the group involved with designing and selecting the new system (Holtzblatt & Jones, 1993) (Olson & Olson, 1991). Early involvement will not only speed up the orientation process of the group to the technology, but also help engender commitment to the project from the outset. Once the pilot group begins operation with the new system, where they are physically located and how they interact with future users of the system needs to be carefully planned out. A careful balance needs to be struck between keeping the group in close contact with the eventual operational work the system must perform, and distracting the pilot group members with day-to-day production issues. Though the amount of normal operational work the pilot group performs should be minimized, they still need to keep an open, two-way dialogue going with the remaining staff. For example, the pilot group could develop all the product information for a furniture suite in parallel with its development through traditional channels. This would give the pilot group and production group a chance to compare how individual parts and pieces are developed and managed as they go through their respective processes. At the same time, the pressure to produce usable information for manufacturing would not be on the pilot group.

Dialogue between the pilot group and the future users of the system can both be formal and informal. Regularly scheduled mini presentations can be made of system capabilities and process recommendations to groups through the company. This will allow for a systematic dissemination of knowledge about the new technology throughout the company. A more important dialogue may be more informal discussions and show and tell sessions one-on-one or in small groups. This allows future users to get a close up look at the system through vicarious learning in a non-threatening environment. These demonstrations provide a way of de-mystifying the technology, often a major hurdle with radically new technology. In both these types of dialogues, it is important that they are truly bi-directional: that is, the pilot group both disseminates information about the system as receives feedback and comments from future users. Just as the involvement of the pilot group in selection process helps enhance their commitment, the future users of the system will have their commitment elevated if they feel they have a voice in the implementation process. Key to a healthy dialogue is guarding against isolation of the pilot group. Though the pilot group’s time and efforts must be protected, isolation will allow for them to become alienated from the production group they will eventually have to rejoin, antagonize power or status issues between groups, and encourage an attitudes of elitism.

In addition to the social and organizational advantages of using pilot groups, there are also some very concrete benefits. First, the pilot group — either by itself or with specialized technical support — can act to debug both the software and the system processes before it is fully operational. The pilot period, perhaps a six month market cycle, gives the company time to plan the transition from the old to new system. This initial pilot group, even after they have rejoined their original work teams, can act as technical resources for the operation and evolution of system. Some or all of the pilot group can also act as either formal or informal trainers of system usage to new users.

Future Research

The theoretical development thus far has made it clear that systems analysis approaches that focus purely on the technical or cognitive issues of systems integration or ergonomic approaches that look exclusively at the one person-one machine interaction will fail to take into account many important issues involved in the integration of a group-oriented CAD/PDM system. Designers often concentrate on the technical aspects of developments, leaving the design of work structure and systems to be considered as an afterthought rather than as an integrated part of the project (Olphert & Poulson, 1990).

The methodology applied in this research has been guided by findings similar to other researchers:

> The approach adopted is that technologies are socially shaped both prior to and after their introduction within organizations; that technologies within organizations are part of complex and changing technical systems; that organizations' technical systems are looser and less rule-governed than is often assumed; and that the nature and requirements of technologies are necessarily interpreted within and influenced by the social context in which they are used. (Badham, 1995, p. 81)

Field studies making use of qualitative tools such as surveys become a critical method for obtaining a coherent understanding of how design tools are applied in manufacturing settings (Carstensen, 1995; Good (ed.), 1989; Klein et al., 1990). Though lab-based quantitative studies can be used with more narrowly focused sub-issues in systems integration, they lack the ecological validity to be able to extrapolate to over-arching conclusions of how an integration scenario is likely to proceed. Traditional lab studies may fail to capture the social, motivational, economic, and political dynamics of an organization (Grudin, 1994; Helander, 1994). Even using site-based qualitative tools, it is difficult to extend findings at one site to another. One of the fundamental theoretical underpinnings is that the course of technology integration is contingent on a number of interacting social and organizational factors, factors that will vary from site to site.

Technology integration research should recognize the dynamic and iterative nature of such activity in an operational setting. Ideally rapid prototyping tools can be used to give future users a chance to interact with concrete examples of potential system capabilities and functionality from an early stage in the specification process (Grudin, 1993). Survey work, as was done in the work reported here, can then be matched with the evolving system specification to identify relevant social and organizational variables which are likely to interact with the technical aspects of the system. Future users of the system, such as members of a pilot group, can use both the findings of the survey plus their own knowledge of their organization to help plan an implementation process.

An understanding of the dynamic interaction between the new system and the organization helps prepare the pilot group and researchers for the fact that the initial implementation plan will not account for inevitable evolution of both the system and of the organization over time. Only longitudinal analysis will lead to a truly robust understanding of some of the more critical social and organizational factors of interest (Fulk et al., 1990; McGrath & Hollingshead, 1993). This longitudinal analysis needs to attempt to account for how the system implementation process has altered from its initial proposed direction, and why. Part of this process is to try and understand how many of these changes were for purely technical reasons and how many were from unexpected or evolving social and organizational factors.

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