IMPLEMENTING INFORMATION SYSTEMS TO SUPPORT KNOWLEDGE WORK: AN EXPLORATION OF WORK MOTIFS

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Abstract

The research presented in this paper is part of a larger study of the organizational impacts of information systems on knowledge work. The phase of the research reported in the paper explores current understanding of information systems implementation issues and asks whether it is adequate to effectively manage the wide range of IS that support knowledge work. Studies that have focused on systems that automate core business functions such as manufacturing, logistics, inventory management, and accounting have improved our understanding of both the range of issues involved and the factors most often associated with successful implementation. However this research questions whether such understanding is sufficient to optimize the use of knowledge assets in the modern economy. As organizations turn their attention to automating knowledge work, it makes sense to reexamine what we know about systems implementation and ask ourselves what new challenges this particular class of systems poses for organizational managers.

The paper demonstrates the existence and significance of shared cognitive schemas or work motifs that influence the way knowledge workers respond to information systems designed to automate their work. Findings from the study of a forensic information system show how these work motifs were used to reduce the level of uncertainty during the implementation of the information system and improve the effectiveness of the knowledge management processes it supported. The paper suggests a number of avenues for future KMS implementation research.

Keywords: restructuring expertise; work motifs; shared cognitive schemas; conversational technology.

1 INTRODUCTION

For many decades, information systems researchers have investigated a host of issues that affect the success or failure of large scale implementation projects. A majority of those studies have focused on systems that automate core business functions such as manufacturing, logistics, inventory management, and accounting. Through these efforts, our discipline has come to better understand both the range of issues involved and the factors most often associated with successful implementations. As organizations now turn their attention to automating knowledge work, it makes sense to reexamine what we know about systems implementation and ask ourselves what new challenges this particular class of systems poses for organizational managers.

This research focuses on the implementation of a forensic information system in an effort to understand how knowledge workers experience and react to significant changes in their task environment. The data discussed here arise from a longitudinal study involving the implementation of an automated fingerprint identification system in the U.K. This study incorporated multiple methods including Repertory Grid Analysis, which was used to elicit and refine a set of overarching constructs or "work motifs" that could be understood and discussed across organizational levels.

The aim of this paper is to demonstrate the existence and importance of these shared cognitive schemas or work motifs that influence the way knowledge workers interpret and respond to information systems designed to automate their work. Also provided is evidence of how these work motifs were used by project participants -- managers, developers, and users -- to stimulate meaningful discussion of the changes faced by fingerprint experts and to probe more deeply into the issues of greatest concern to these knowledge workers.

The preliminary results of this investigation suggest that understanding the subjective experiences of knowledge workers as they adapt to altered work flows and changes in their work environment is crucial to the successful implementation of new systems and tools to support knowledge workers. Furthermore, the identification of shared cognitive schemas suggests new ways of eliciting and analyzing these experiences to gain a deeper insight into the process and organization of knowledge work and the criteria used to judge it.

2 THEORETICAL DEVELOPMENT

This research builds on theories of situated learning (McLellan, 1996) which treat organizational knowledge as a critical resource that is embedded in and inseparable from the specific social context in which it occurs. This social context exerts a powerful influence on the ways in which specific knowledge is developed, transformed, shared, and applied (Nidumolu, Subramani et al. 2001; Postrel 2002). From a situated learning perspective, implementation cannot be studied in isolation. To gain a deep understanding of the issues that affect both knowledge workers' responses to the implementation process and the eventual outcomes of that process, we need to tap into "the social meanings that emerge from the process of designing and using information technology" (Sahay and Robey 1996, p258).

Prior research in the interpretivist tradition suggests that social meanings are intimately connected to the ways in which people within a community of practice communicate. Thus, what people say in the context of work has "situational significance" and can only be appreciated in the particular milieu in which they speak (Suchman 1987). The social meanings associated with knowledge work can be especially difficult to study because the people who do this work often develop a unique technical language to describe the essence of their work activities (Barley 1996; Bechky 2003). Researchers and managers who are not conversant in this technical language can easily overlook or misinterpret important issues, or may fail to recognize the true significance of the knowledge workers' concerns.

Furthermore, because work-related knowledge is largely tacit, identifying the criteria subject matter experts use to judge their own work and their work tools can be an especially challenging task.

3 STUDY BACKGROUND AND RESEARCH CHALLENGE

Forensic information systems have evolved rapidly to exploit scientific breakthroughs such as DNA profiling, facial recognition and psychological profiling. A key factor in the success of these systems is the extent to which they extend and exploit the knowledge of the forensic experts who use them. Fingerprints represent unique knowledge assets in forensic investigation because they can provide positive identification of a criminal directly from material left at the crime scene. Like the majority of knowledge work, fingerprint work is complex and time consuming. It must be conducted with the utmost care in order to avoid mistakes. Because this work is highly technical, it takes 5 years to gain the expertise required to qualify as a fingerprint expert in the UK. Over the years, technologies such as image comparators, coding schemes and databases have enabled fingerprint experts to adapt their work processes so as to increase the likelihood and speed of identification. Automated Fingerprint Recognition (AFR) represents the latest generation of technology to offer opportunities for change to the process and organization of fingerprint work.

The information system studied for this phase of the research was the National Automated Fingerprint Identification System (NAFIS) which, in the few years since it was implemented, has already had a significant impact on crime investigation and detection (Leith 2000). The research reported here spanned the development, implementation and operational use of NAFIS at eight of the 43 police forces in the UK in order to assess its impact on fingerprint work, fingerprint experts, and their managers.

NAFIS consists of a central system; fingerprint bureau front-end systems for the 43 police forces in England and Wales; an integrated communications system connecting the central system to the bureau systems; two training systems; and a test and development system. NAFIS utilizes the Police National Network (PNN), to carry data between the central site and the police forces. The NAFIS Central Site is co-located with the Police National Computer (PNC). PNC contains the national database of criminal records. NAFIS is one of the largest image storage systems in Europe holding up to 90 million images and 3 million scenes of crime (latent) marks. Its search speed is one million fingerprint comparisons per second. The NAFIS architecture is designed to provide a foundation for future growth and technology insertion.

Investigating the impact of NAFIS on the knowledge work it supports represented a significant research challenge due to the scale of the NAFIS architecture and the multi-site context in which it is used. In addition, the methods chosen for this investigation had to provide a perspective that was both broad and deep to ensure that the results not only captured the essence of this particular type of knowledge work, and were potentially generalizable to other types of knowledge work.

4 RESEARCH METHODS

Recognizing fingerprint work as a form of knowledge work suggested that technologies such as AFR would impact the organization at a number of levels. However, in this phase of the research, the primary focus was the knowledge workers who routinely process, analyze, and evaluate fingerprint evidence. In order to optimize the reliability and validity of the data, three data gathering techniques (observation, interview and Repertory Grid Analysis) were used. These techniques provided complementary data sets that were combined in a substantial data archive (Yin 1993; Davis 2001). Repertory Grid Analysis (RGA) provided a content-free means of gathering data from individuals about their experience of changes to fingerprint work during the implementation of NAFIS.

Three rounds of RGA were conducted with each participant. Using the same protocol each time, participants were asked to explain the repertoire of tasks that comprised their work. The task elements

(typically 12-15) were recorded and used to elicit bi-polar constructs (typically 15-20) that differentiated the tasks. Each participant was then presented with a grid with columns and rows labeled with the element and construct names they had given, and asked to rate each task in relation to each construct. Two dimensional cluster analysis was used to re-order the grid using the values in the grid cells. (for a fuller discussion of the technique, see Fransella and Bannister 1971; Shaw 1994; Stewart 1997; Davis 2001).

The data collected via RGA were analyzed and interpreted by the fingerprint experts themselves via the 'talkback' analysis protocol proposed by Thomas and Harri-Augstein (1985). Talkback involved presenting the final cluster analysis results to the participant who provided the original input and asking that individual to assign labels to each construct. Having the participants themselves explain the significance of the relationship between the tasks and constructs ensures that the researcher's *a priori* theories and hypotheses do not bias the results. The talkback process elicited a number of super-constructs from the RGA data that enabled fingerprint workers to articulate changes to the process and organization of fingerprint work in terms that could be shared with the developer and management communities.

5 RESEARCH FINDINGS

The RGA analyses identified a substantial number of constructs from individuals' experience of changes to their work. Although collectively the grids contain over eight hundred constructs, the need to rely on the participants' own use of language during the RGA and talkback processes means that many are duplicated. The organization corollary to Kelly's (1955) fundamental postulate supports the use of Thomas and Harri-Augstein's (1985) talkback protocol to develop a series of overarching constructs (based on the ordinal relationships in the re-ordered grids) that articulate cognitive schemas shared by the fingerprint experts. These schemas used language that made their concerns about changes to their work understandable by non-experts. To date, nine over-arching constructs have been dawn the research data.

- Fingerprint comparison scope (macroscopic-microscopic)
- Fingerprint comparison continuity (inclusion-exclusion)
- Fingerprint image utilization (fingerprint/administrative work balance)
- Automation, autonomy and control
- Performance, training and trainability
- Fingerprint expert status and task competence
- Exploration, discovery and confirmation
- Nature of output
- Awareness and integration (fingerprint process)

These super-constructs or work motifs describe the essence of the contextually-based, shared cognitive schemas that provide a basis for the intellectual exchange among participants in the community of practice. Thus, they provide a unique, situation-specific interpretation of the fingerprint workers' perspectives, protocols, and frameworks. From a research perspective, the identification of work motifs enabled issues and concerns articulated through the RGA analyses to be categorized and prioritized. More importantly, however, they provided a deep insight into how these particular knowledge workers judged the value of their work and work processes. Work motifs arise from the transformational process at the heart of knowledge work and represent components in the iterative process of knowledge creation described by Nonaka (1994). They helped to articulate concerns and considerations that were shared between the community of fingerprint experts and the wider organizational community within which they were managed. The following vignette highlights the utility of the fingerprint comparison "scope" and "continuity" motifs.

Fingerprint knowledge and expertise is encapsulated in a series of protocols that ensure integrity and optimize resource usage. The most critical phase of fingerprint work involves comparison of the

detailed characteristics or minutiae within the fingerprint. This is painstaking work. The likelihood of error is reduced by pre-comparison procedures that minimize the number of such direct comparisons needed. For instance, if the fingerprint found at a crime scene displays a loop pattern, suspects whose fingerprints display other patterns would not be subjected to this detailed examination. Fingerprint workers quickly decide to reject a suspect's fingerprints from further examination. This protocol was compromised by a design goal: AFR systems include comprehensive audit trails that help to ensure the integrity of the system and its database.

With accountability and auditability in mind, changes to the process of fingerprint work required all the fingerprints examined in connection with a particular case to be input to NAFIS. This included those fingerprints that the experts would quickly and easily reject as having no value to the investigation. The design goal was ensure that all the decisions made during the investigation and the materials on which they were based could be recorded. However, fingerprints are complex images: these additional scanning and recording activities took a substantial amount of time, which the fingerprint workers begrudged.

Tension between the fingerprint workers, their managers, and the system procurers grew: each group became defensive of their interpretation of the need for the change. This impasse arose from an organizational learning disability which, with hindsight, is easy to diagnose. The sophisticated AFR algorithms propose candidate fingerprints as matches by cumulatively mapping the tiny individual characteristics. The higher the number of matching characteristics or points between two images, the higher its position in the list of respondent fingerprints. The cumulative nature of most AFR algorithms means, in simple terms, that rather than saying 'no' (as fingerprint workers do when they see differing patterns), the algorithm simply fails to say 'yes' (the images are identical). The work motifs thus enabled the restructuring of the decision processes that comprise fingerprint expertise to be explored outside the expert domain. Although worthy in terms of auditabity, the original NAFIS workflow compromised long-standing expert practice that minimized the amount of time spent on detailed comparison of images. Identification of the underlying work motifs enabled fingerprint experts, organizational managers and the system procurers to negotiate adaptation of the workflow. The change that resulted from use of the motifs overcame the fingerprint experts' resistance to what they considered a less optimal workflow involving unnecessary use of the AFR technology.

This brief example shows that it is not sufficient to view technologies such as AFR simply as objective forces with a finite repertoire of causal effects. The effects on forensic investigation derive from and enlist the subjective experiences of NAFIS designers, fingerprint experts, and their managers. Articulation and use of the 'scope' and 'continuity' motifs increased understanding of the impacts of NAFIS on the process and organization of fingerprint work. As NAFIS 'unfolded' into the knowledge-use context of fingerprint work these motifs enabled the ideas and meanings that make sense of that experience to be shared by fingerprint experts, organizational managers and developers.

6 IMPLICATIONS FOR PRACTITIONERS

The work motifs provided significant insight into the challenges that face organizational managers as knowledge management systems are developed and deployed. The findings problematized implementation. Frequently, implementation is seen as the final stage of a development project. This phase of the research has shown that it is at the point of implementation that knowledge workers' experience of change is most intense, highlighting the need for agile and sensitive management.

Although the work motifs identified in Section 5 are specifically relevant to the specialized context of forensic investigation, the evidence presented here suggests a need for further research into the relationship between the design and application of knowledge management systems and the perceptions and meanings attached to that development by the subject matter experts themselves. Similar work motifs could be articulated in the growing range of knowledge management communities. The research findings suggest that this could increase awareness and understanding of

the nature of the issues and concerns experienced in the workplace, reducing the level of uncertainty about the effects of knowledge management systems and the likelihood of their failure. Such awareness could also enable organizational managers' to better understand and more effectively direct changes to the organization and management of knowledge work.

7 IMPLICATIONS FOR THEORY AND RESEARCH

By demonstrating the existence and utility of work motifs, this phase of the research has identified a number of promising avenues for future research into the implementation of information systems to support knowledge work. Among these is the opportunity to develop a conceptual model that would enable the significance of work motifs in other settings to be explored and tested. Such a model could enable detailed categorization of the impacts of information systems on knowledge work. The development of such a model could reduce dependence on the generic models and metrics that have arisen through the study of core business functions. The development of a model that elaborates a typology of impacts of information systems on knowledge management and organizations as they co-evolve would represent a substantial contribution to our field. Given the specialization of knowledge work, the work motif concept could provide an avenue for exploring emergent, unanticipated implementation issues and concerns. This would complement other work, such as that of DeLone and McLean (2003), which relies on predetermined variables to assess the causality of information systems' effects.

8 CONCLUSION

To date, this research has made two important contributions. Firstly, the immediate local relevance of the findings demonstrated the reliability and relevance of the research design. On-site analysis and discussion of the work motifs helped to initiate and sustain a dialogue between the management, developer and expert user communities. This dialogue prompted management action at a number of levels, from the resolution of operational problems (Davis 2001) to the alignment of business and information technology strategies (Beeson and Davis 1998). Secondly, the findings of the RGA analyses provide proof of concept for the existence of work motifs as higher level constructs that are manifestations of the forces surrounding knowledge work, technology and organization. The motifs increase understanding of the relationship between technological and organizational change as knowledge work and expertise are restructured in response to the opportunities afforded by information systems such as NAFIS.

NAFIS and other AFR systems are typical of knowledge management systems that are becoming more common in the support of experts in a number of fields. Whilst the work motifs identified in the NAFIS study are immediately relevant only to knowledge workers and organizational managers in the criminal justice communities, it is clear from this phase of the research that the work motif concept is relevant to knowledge work in many other organizational settings. The data show how, as they unfold through design, implementation and use over time, technologies such as AFR restructure the expertise they support (Hatchuel and Weil 1995).

The insight gained through the use of RGA as a conversational (Harri-Augstein and Thomas 1991) or interlocutory (Hatchuel and Weil 1995) technology also raises interesting questions regarding our continuing reliance on rational management techniques. These insights gleaned from this study could help us better understand the nature of the techniques used to manage knowledge work and the information systems that support it. This is particularly important insofar as "…the scientific organization of work, operational research, new forms of flow management and expert systems all make over-simplified assumptions on the conditions of collective action and must therefore be called into question" (Hatchuel and Weil 1995, p7).

One aspect of future phases of this research will be to explore the restructuring of expertise during the course of an information systems project and how the relations between actors are transformed. Actor-network theory (Latour 1993; Callon 1997) will be used to explore the metamorphosis of knowledge workers, organizational managers and other actors, including the 'birth' or disappearance of some of them (Hatchuel and Weil 1995, p77). This strand of the research will directly support development of a revised innovation model.

In addition to the utility arising from the identification of a number of shared cognitive schemas and enabling the resolution of management issues, the work motifs identified a phenomenon clearly not unique to fingerprint work. As one of many specialties in forensic investigation, fingerprint work tends to be managed within one of several organizational 'silos' that arise from managerial rationalization of complex task environments. Although it may be argued that few task environments are as complex as forensic investigation, the dissonance between the strategic managers at the top of the organizational hierarchy and the knowledge workers carrying out fingerprint work is found in other work settings. Future work will use work motifs to explore the nature and significance of this 'strategy vacuum' in other fields of knowledge work.

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