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# Emergent CSCW systems: The resolution and bandwidth of workplaces

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ABSTRACT

In any collaborative work settings, people naturally develop physical tools and associated work processes that support the management of the interdependencies in information, materials, and social needs. Field studies of management of operating rooms pointed out that collaborative work is supported by an infrastructure that is composed of mostly non-computerized, physical components. The supporting infrastructure is jointly maintained and exploited, with constantly evolving patterns of usage, in response to complexity of coordination needs and the uncertain environment. To represent status and plans, users seem to invent structures based both on idiosyncratic preferences and on negotiated symbols. The fluidity and ease of restructuring workplaces to support collaborative work may be explained in part by the high resolution and bandwidth of workplaces: a large number of ways in which workers could structure their work and a high capacity to convey rich information and meanings quickly to collaborators. We argue that to support health care workers, designers of computer supported cooperative work (CSCW) systems should learn how the physical and perceptual properties of workplaces are exploited, and that CSCW systems should be designed to allow maximum freedom of restructuring and reconfiguring as part of workplaces to enhance bandwidth and resolution of representation and communication.



## 1. Introduction

Computerized information and communication technology (ICT) has rapidly changed how work is performed and its use has been advocated for a number of reasons (e.g. [1]). How to harness the ever increasing power of the digital world of computing has become a challenge to many, as the introduction of large information systems is not always successful, despite the intuitive appeal of speed, accuracy, and convenience [2]. Healthcare is characterized by the collective nature of work because of demands for specialization of expertise and facilities. Such collective nature results in two, interrelated sides in harnessing ICT. First, collaborative work often means added efforts in the management of interdependencies of information and materials. ICT can potentially facilitate the information flow thus collaborative work. Second, ICT is likely to change and indeed redefine how work is carried out among workers. A simple example would be ICT-adoption related task redistribution of data input, often demanded by information technology. This example was demonstrated in automated air traffic control systems [3]. These two sides of issues could also be stated as how to leverage ICT for its potential beneficial impact and how to minimize its potential negative impact.

In this article, we follow the long tradition of understanding work in its natural context to address questions related to these two sides of information technology. Over the last 4

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years observational studies have been carried out to understand the collaborative work involved in the management of surgical operating rooms. The physical artifacts used and the ways they were exploited in supporting collaborative work were closely examined to appreciate the interaction between people and their workplaces. In this article, we attempt to provide suggestions on important characteristics of artifacts that workers find useful and that should be considered in the design of computer supported cooperative work (CSCW) systems. In particular, we propose the concepts of resolution and bandwidth of workplaces, as a way to provide insight into design of CSCW systems and potential impacts of CSCW on collaborative work.

## 2. Analytical framework

The interactive nature of individual human cognition and environment has been highlighted by the notions of affordance (e.g. [4]) and display-based cognition (e.g. [5]). Similarly, the roles of physical objects in collective work are made significant by observations in work settings, such as navigation (e.g. [6]). Observations in an airline operations room, for example, illustrate how paper forms (complex sheets) are exploited to facilitate production of joint work [7]. Suchman and Trigg [7] reported that complex sheets performed an essential role in getting workers on the same page in terms of understanding intended plans. Furthermore, the researchers discovered that complex forms were being continually modified and were in fact a "medium" for notation of changes.

Studies of "flight strips" provide interesting insights into how seemingly low-tech paper artifacts support collaborative work [3,8,9]. Flight strips are paper cards used to manage flights by individual air traffic controllers. Since flight strips are physical artifacts, their manipulation (such as rearranging, removing, or inserting a new one) would provide visual cues to neighboring controllers. An experimental video system to enable remote visual access to flight strips was shown to be valuable [8]. In control centers where computerized systems were used, Mackay [3] found that various paper artifacts are used. She concluded that "attempts to radically change work practices that have successfully evolved over the past 50 years will almost certainly fail to account for all the embedded, intangible safety factors and are likely to result in dangerous, perhaps fatal, situations" (p. 337). An intriguing yet mundane example of artifacts supporting collaborative work is the "spindle wheel" in the short-order restaurant industry ([10] p. 393), where the spindle wheel holds paper order slips in sequence to coordinate the work between waitresses and the cook. The cook could reorganize work such as materials preparation based on all the pending orders, and the waitresses could view overall workload to their advantage such as information on potential wait time of their orders.

Several other examples on emergency response dispatch centers [11,12], a trading room [13], an underground train control room [14] and medical records [15] have suggested that in nearly all collaborative work settings, an "infrastructure" is in place to support the articulation of individual activities in significant ways, such as providing awareness and facilitating communication. The infrastructure would include physical objects such as computer printouts, paper forms, paper checklists, bulletin boards, whiteboards, or even work objects such as syringes and medications. Along with the physical supporting infrastructure are traditions, formal and informal agreements and a common accepted symbology in interpreting meanings as conveyed by different configuration of physical objects in the infrastructure [16].

In a sense a workplace is an emergent "CSCW" system, which users configure and adapt to meet the demands of collaborative work, the nature of which usually change over time. From this point of view, ICT systems deployed are essentially one component inserted into existing infrastructure that supports collaborative work. In healthcare, very rarely is ICT used in isolation, but rather it is always used in conjunction with other components. We will use this framework to examine how two types of artifacts are used in the management of operating rooms.

## 3. Materials and methods

We based our observational studies in a six-room surgical unit in a dedicated trauma hospital. As in most workplaces, a combination of computerized and manual scheduling systems was used. Management of materials, staff, and operating room access was assisted by a multitude of computerized scheduling and calendar systems installed over time. Printouts were distributed and posted, which were annotated.

Observations and opportunistic short discussions with workers were carried out, with the assistances of photographs and notes. Over 200 photos were taken in more than 60 observation days over the span of 4 years. We encountered many examples of information rich areas in the workplaces, such as the one illustrated by Fig. 1 where the work environment was tailored and configured to provide easy access to information.

**Fig. 1 – A portion of the infrastructure supporting collaborative work. Artifacts, such as list of contact numbers and on-call schedules, are placed near the telephone. Although appearing messy, the artifacts are frequently used and updated.**