ELSEVIER

Information and Software Technology 41 (1999) 319–329

INFORMATION AND SOFTWARE TECHNOLOGY

Of maps and scripts
The status of formal constructs in cooperative work

Kjeld Schmidt*

Centre for Tele-Information, Technical University of Denmark, DK-2800 Lyngby, Denmark

Abstract

The received understanding of the status of formal organizational constructs in cooperative work is problematic. This paper shows that the empirical evidence is not as strong as we may have believed and that there is evidence from other studies that contradicts what we may have taken for granted for years. This indicates that the role of formal constructs is more differentiated than generally taken for granted. They not only serve as 'maps' but also as 'scripts'. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Cooperative work; Coordination; Coordinative artifacts; Formal constructs; Procedures

Thanks to impressive computer-supported cooperative work (CSCW) systems such as TeamWorkStation [1], GroupDesk [2], wOrlds [3], and TeamRoom [4], to name but a few, it is by now widely accepted that computer artifacts can provide effective support for cooperative work by offering a 'shared space' through which actors can interact directly, i.e., by means of generic competencies such as talking, gesturing, pointing, monitoring etc., without other restraints than the constraints of limited bandwidth and so on.

There is considerably less certainty and consensus, however, as to whether computer systems can be successfully designed to support cooperative work by providing representations of formal organizational constructs—procedures, workflows, process models, etc.—so as to regulate routine coordinative activities and thereby enable cooperative ensembles to perform more reliably and efficiently. In fact, there are strong concerns about the status of such formal constructs.

In a way CSCW can be said to have been born with these concerns. The office automation movement had already given way to disillusionment, and artificial intelligence was increasingly being confronted with unfulfilled promises. At the same time, a number of critical studies had demonstrated that the problems were deep rooted: office procedures were of a different nature than presumed by the protagonists of office automation (e.g. [5–7]). The general conclusion of these studies were that such constructs, instead of determining action causally, serve as 'maps' which responsible and competent actors may consult to accomplish their work ([8], p. 188 f.; [9], p. 114). Thus, Lucy Suchman's radical critique of cognitive science [8] and the ''situated action'' perspective she proposed has played a significant role in defining the CSCW agenda and has become a shared frame of reference to many, perhaps most, of us. For good reasons, then, designers of CSCW systems have been advised to treat them with great caution (cf. for example [10]).

Thus, the issue of how computer systems can be successfully used to regulate or govern routine coordinative activities has been surprisingly marginal on the CSCW agenda and one can detect a pronounced reluctance to design systems which regulate coordinative activities in the work of many eminent CSCW researchers who instead pursue different 'minimalist' design strategies (e.g. [11–14]). This is quite legitimate and reflects serious and well-founded concerns about the status of formal organizational constructs.

However, the role of formal constructs in cooperative work is still far from understood. Although Suchman explicitly submits the ''situated action'' perspective as a research approach ([8], p. 178 f.), it often seems as if the issue is presumed to have been settled. Only few CSCW researchers have attempted to address this issue [15,16].

Perhaps, therefore, it is not surprising that CSCW has had little influence on the development of workflow technologies [17]. These technologies have not benefited from CSCW insights (e.g., the crucial role of mutual awareness and shared artifacts) while CSCW has become similarly

* *E-mail address:* schmidt@tele.dtu.dk (K. Schmidt)

0950-5849/99/$ - see front matter
PII: S0950-5849(98)00065-2

marginalized with respect to the needs of large-scale cooperative work arrangements where 'shared spaces' typically are of only marginal relevance.

In other words, it is time to face the spectre of 'formal constructs' again. Firstly, I will argue that determining whether particular observable work activities are in accord with standard procedures or not raises fundamental methodological problems. Next, I will revisit some of the empirical evidence of the status of formal constructs such as office procedures and will argue that these studies do not investigate the use of procedures under routine conditions and, hence, that the way in which the findings from these studies have been generalized is problematic. As a contrast, I will offer contradictory evidence which suggests that formal constructs sometimes serve more like scripts than maps and that the role of formal constructs is more differentiated than generally taken for granted in CSCW. Finally, I will argue that in order to understand the role of formal constructs in cooperative work we need to take into account the fact that such constructs, to be effective, are inscribed upon textual artifacts and that we therefore must investigate thoroughly how such objectified formal constructs are used in the coordination of cooperative work.

The purpose of this discussion is not to suggest that the 'situated action' perspective as such is problematic. The paper is a critique in the Kantian sense, i.e., an attempt to determine the proper domain of this approach, so as to unburden it of the popular misunderstandings and unwarranted generalizations and suggest some nuanced conceptualizations for further research. Thus, if the following discussion again and again takes issue with some of Lucy Suchman's propositions, it is merely an indication of the significance of her contribution to CSCW and of my own intellectual debt to her work.

1. Determining the meaning of formal constructs

In a large body of sociological literature, the commonsense presumption that pre-defined organizational constructs (formal structures, procedures, methods, plans) somehow determine action has been subjected to critical examination. For years, study after study have demonstrated, unambiguously and beyond any doubt, that the status of these formal organizational constructs in the actual course of work is problematic in that these constructs are abstract idealizations when taken as representations of actually unfolding activities. In the words of Philip Selznick's classic summary of this line of sociological investigation:

> The formal administrative design can never adequately or fully reflect the concrete organization to which it refers, for the obvious reasons that no abstract plan or pattern can—or may, if it is to be useful—exhaustively describe an empirical totality. At the same time, that which is not included in the abstract design (as reflected, for example, in a staff-and-line organization chart) is vitally relevant to the maintenance and development of the formal system itself. ([18], p. 25).

Years later, in the context of examining the notion of office procedures underlying office automation, Suchman and Wynn raised the same question: ''how adequately do these accounts describe how office work gets done?'' and made a quite similar point: ''The problems involved in accomplishing office tasks, while central to work practices, are ignored in procedural formulations of how the work gets done. The point of this observation is not to critique procedural formulations, but to indicate *another domain of the work*, in which those formulations are brought to bear on the practical contingencies of actual tasks'' ([7], p. 139).

This conception of the status of formal constructs has been highly influential in that, as observed by Egon Bittner in a classic paper, it has ''furnished the necessary theoretical argument for an entire field of sociological investigations by directing attention to a sphere of adaptive and cooperative manipulations, and to the tensions typically found in it.'' ([19], p. 240).

The conception is also a methodological nightmare, however, that systematically confounds analyses of the use of formal constructs in working life. The tradition of critical studies of formal constructs implicitly ascribes an almost ceremonial status to these constructs and it thus falls victim to a dichotomy of the 'formal' and the 'informal,' 'procedure' and 'practice'. The argument implies that members of the organizational settings in question are somehow supposed to take formal constructs literally—as if constructs such as procedural formulations are *supposed* to be exhaustive specifications of how the work gets done.

In addressing this problem from the perspective of ethnomethodology, Bittner makes some very cogent observations:

> While Selznick quite clearly assigns the formal schemes to the domain of sociological data, he does not explore the full range of consequences out of this decision. By retaining Weber's conception of them as normative idealizations, *Selznick avoids having to consider what the constructions of rational conduct mean to, and how they are used by, persons who have to live with them from day to day. It could be, however, that the rational schemes appear as unrealistic normative idealizations only when one considers them literally, i.e., without considering some tacit background assumptions that bureaucrats take for granted.* ([19], p. 242)[1].

Bittner's methodological recommendation is quite pertinent to the issue at hand: the meaning of formal constructs cannot be taken to be immediately obvious to the investigator. To the contrary! Or in Zimmerman's accurate

[1] Emphasis added.

restatement of Bittner's injunction, ''the investigator should not provide his own (essentially commonsense) interpretation of what such rational constructions mean for those charged with their use'' ([19], p. 12). Hence, ''the import or meaning of rational constructions for action is a matter of empirical determination'' ([19], p. 12).

When, for instance, Suchman says ''that situated action turns on local interactions between actor and contingencies that, while they are made accountable to a plan, remain *essentially outside* the plan's scope'' ([8], p. 188 f.),[2] a dichotomy between plan and action is introduced which is methodologically problematic. By contrast and in the words of Zimmerman, ''the observed practices'' should be viewed as ''the 'governing sense' of the existing rules'' [20].[3]

Consider, for example, Louis Bucciarelli's excellent study of design work [9] which is based on several years of ethnographic investigation of design at an engineering firm engaged in making photovoltaic modules for the production of electrical power from sunlight. In his analysis of the findings, Bucciarelli questions the status of the organizational constructs and corresponding artifacts used in that particular setting: ''The milestone chart [· · ·] can be viewed as a snapshot of a month in the life of a participant in design, a picture of how his or her time is to be 'spent' over the next one or several months. [· · ·] The chart suggests that there exists clear and distinct beginnings and ends to design tasks. What can be surer than a 'deadline'?'' ([9], p. 98).

In general, Bucciarelli argues, charts such as the milestone chart and the critical path chart ''suggest that tasks are all of a finite duration and bounded by well-defined starting dates and deadlines'' ([9], p. 104). In Bucciarelli's analysis, it thus offers an 'illusion of definiteness': ''While it suggests the continuous chinking away of a finite number of days to come, from the perspective of the individual whose milestone chart it is, the exercise of its construction has an element of fantasy about it, asking for too high a degree of precision in pacing future, uncertain events. To account for one's future in the terms of the chart engenders an uneasiness, a sense that its format is too confining and disallows any adequate explanation of what it will take to get the job done.'' ([9], p. 107).

The core of Bucciarelli's interpretation is the contention that the chart 'suggests' that there exists clear and distinct beginnings and ends to design tasks and that it thereby offers an 'illusion of definiteness'. While there is no reason to doubt the veracity and accuracy of Bucciarelli's observations, this interpretation is methodologically dubious: to whom does the chart make such illusionary suggestions? Are the constructs indeed ''misleading'' ([9], p. 106) to competent members? Has anybody been mislead by them? How? Is the 'fantasy' being enforced? Or, to put it the other way round, have any of the engineers been admonished for not subscribing to the notion that ''tasks are all of a finite duration and bounded by well-defined starting dates and deadlines''? Bucciarelli does not present any evidence to that effect and one is thus led to surmise that the putative contradiction between the formal constructs and the actual practice of the engineers may be the investigator's own construction and that the design of these constructs presumes the observed practice.

2. The problem of generalization

On the basis of which kind of evidence can we make well-founded statements about the status and use of formal constructs in cooperative work settings? Or rather, what can be learned from which kind of evidence?

First of all, there is reason to assume that formal constructs are used in radically different ways in small ensembles and in large-scale cooperative settings. That is, we need to be cautious as to how and to which extent we generalize from studies of the use of formal constructs in small groups, perhaps co-located, where activities can be articulated seamlessly, as opposed to large-scale cooperative work arrangements. This issue has, for instance, been raised by Dubinskas in an interesting comment to Bucciarelli's study of the solar energy panel project [21]. Comparing Bucciarelli's findings to his own observations from the automobile industry, Dubinskas notes that the temporal and design flexibility observed by Bucciarelli is not to be expected in automobile design settings: ''[In the solar energy panel project, the] number of people and components was lower, the range of expertise was much narrower in scope, and the design process took place in a largely face-to-face environment. Schedule building was intimately tied to the progressive emergence of the artifact—the panel—and the project direction was perhaps less clearly defined (or constrained) technically than new car development is. One result was that schedule formation became a regularized forum for negotiations about the order of work and the character of the artifact'' ([21], p. 18). That is, due to the special conditions of the solar energy panel project the participants were presumably able to articulate their various activities without, for instance, unceasingly relying on the stipulations of the milestone chart which, thus, could remain in the desk drawer or on the bulletin board for reference.

Dubinskas's point can be illustrated by the case of the S4000 project which shows in detail how formal constructs are invented and introduced to handle the increased complexity experienced when the scale of cooperative work is increased [22–24]. Foss Electric is a Danish manufacturing company that produces advanced equipment for analytical measurement of quality parameters of agricultural products, e.g., the compositional quality of milk in terms of fat content

[2] Emphasis added.

[3] This does not mean that the distinction between following a rule and breaking a rule is obliterated. ''To do so would be to violate an essential feature of a rule; i.e., that it be possible to determine whether or not the rule was correctly applied. [This] determination is left to persons whose task it is to decide such matters.'' ([20], p. 155).

and the count of protein, lactose, somatic cells, bacteria, etc. At the time of the field study, the company was engaged in a large design project called S4000 which aimed at building a new instrument for analytical testing of raw milk. It was the first attempt to build an integrated instrument which would offer a range of functionalities that previously had been offered by a number of specialized instruments and the S4000 would be the first Foss instrument to incorporate a personal computer to control the instrument. On the whole, the project was significantly more complex than previous projects at Foss.

The project posed the most dramatic challenge to the software designers who had, until then, been working individually or, occasionally, in teams of two. In the S4000 project, however, eleven programmers were involved in the design of an integrated software system which ultimately amounted to some 200,000 lines of code.

Traditional measures such as shared office spaces to support mutual awareness and ad hoc interaction as well as the usual design meetings were soon experienced as insufficient. The software designers felt that were pretty much in the dark with respect to the state of the project and that much more effective coordination was required. At the height of the crisis the software design goals were almost abandoned. To overcome the crisis, the software designers developed a repertoire of procedures and artifacts to ensure the monitoring and control of the integration of software components and modules. Thus, a 'bug report form' with corresponding procedures for reporting, classifying, and correcting faults were introduced to ensure that bugs were properly registered, that corrected bugs were duly reported, and to make the allocation of responsibilities clear and visible to all members. As a complementary measure, copies of bug forms were collected in a publicly available repository in the form of a simple binder. (For details, see [23,24]).

The software designers thus realized that it was impossible to handle the distributed testing and bug registration activities of some twenty testers and designers without, inter alia, a bug report form and its associated procedures. By devising and introducing these constructs they managed to alleviate the coordination crisis in the project.

The case is particularly valuable because we here witness the introduction of formal constructs for coordination purposes in response to overwhelming problems encountered in coping with the complexities of articulating cooperative work under conditions that are typical for contemporary industry. However, while daunting to the participants, the complexity of the S4000 project is not exceptional. Such complexities are an everyday occurrence in modern industrial, service, and administrative settings.

In our effort to understand the use of formal constructs in cooperative work we should thus bear in mind that it may be problematic to generalize from cooperative work on a small scale where activities can be articulated largely or entirely by means of direct interaction.

Another major problem of generalization is the extent to which we can learn of the use of formal constructs from studies of work in non-routine situations.

Consider, for instance, Suchman's study of the accounting office [6]. This office was responsible for the orderly payment to outside organizations which supplied goods and services to the company. Orderly payment was documented through record-keeping, and accuracy was monitored by the auditing of invoices against records of requisition and receipt. According to the standard procedure, items on a given purchase order could be received and billed in separate installments over an extended period. Again, if all went smoothly, the items marked off on the receiving report from Shipping or Receiving would correspond to those on the invoice from the vendor. The purchase order, receiver, and invoice would be matched and audited. The payment for the items received would be recorded by margin notes on the purchase order, which would then be returned to the temporary file to wait for the next shipment and billing. Only after all bills had been received and paid would the completed purchase order be filed permanently in the paid file.

In the episode described by Suchman, however, the record of what had happened was incomplete: the original purchase order was missing. A completed receiving document was found with eight items listed on it, all of which had been marked as received. The two invoices found in the paid file, however, showed only two items as paid; there was no invoice or record of payment for the other items, yet the vendor reported that the transaction would be completed with payment of the past due invoice for only two of those items that seemingly had not yet been paid. The study then shows how the two actors, the accounting clerk and the auditing clerk, step by step solved the 'mystery'. Of the invoice for one of the items, only page two was on file; page one was missing. It thus transpired that four other items were invoiced with this item and had already been paid.

Suchman's interpretation of the case is cogent and succinct:

> Standard procedure is constituted by the generation of orderly records. This does not necessarily mean, however, that orderly records are the result, or outcome, of some prescribed sequence of steps. [· · ·] In this case, once the legitimate history of the past due invoice is established, payment is made by acting as though the record[s] were complete and then filling in the documentation where necessary. The practice of completing a record or pieces of it after the fact of actions taken is central to the work of record-keeping. ([6], p. 326).

The case thus provides a graphic impression of the massive heuristic use of standard procedures even in a seemingly abnormal situation. The two actors were able to solve the problem because of their ''knowledge of the accounts payable procedure'' ([6], p. 322). Standard

procedures have a heuristic function in the sense that they ''are formulated in the interest of what things should come to, and not necessarily how they should arrive there'' ([6], p. 326). The case thus gives us an insight into the crucial role of prescribed procedures even in the handling of contingencies; it shows that prescribed procedures convey heuristic information for the handling of errors as well as for routine tasks.

However, in several places, Suchman suggests more general and radical interpretations of the case. She introduces the study by stating, without reservation, that ''the case suggests that the procedural structure of organizational activities is the *product* of the orderly work of the office, rather than the reflection of some enduring structure that stands behind that work'' ([6], p. 321). And she concludes with similar general formulations: ''It is the assembly of orderly records out of the practical contingencies of actual cases that produces evidence of action in accordance with routine procedure'' ([6], p. 327). Because the argumentation in other passages is carefully guarded, the reader is left with the impression that the general interpretations are deliberate, that is, that office procedures are the *product* of the orderly work of the office and that they do not in some way or at some level determine the course of action. And this reading is how the study has been generally understood. For instance, in his review of Suchman's *Plans and Situated Action*, Phil Agre summarized the study of the accounting office as follows:

> She discovered [· · ·] that the actual role of the prescribed office procedures was *not* to specify how their work should proceed. Instead, the procedures provided a criterion for judging how their work should turn out at the end of the day. The office workers used the office procedures as resources in figuring out what their work should come to, but they based their decisions about how to achieve this end on the particulars of each next case that came along. ([25], p. 375).

This interpretation of the case is not supported by the published data. The study presents an analysis of a recovery from breakdown. It does not attempt to demonstrate that prescribed procedures do not—in some form and to some extent—determine the handling of routine cases; it does not even attempt to give an analysis of how prescribed procedures are used in routine cases. The study thus provides little insight into how standard procedures, defined as pre-defined written stipulations, are applied in routine daily work.[4]

While this and other studies have contributed substantially to our understanding of the articulation of cooperative activities and have been highly influential in dissipating the simplistic notion of the 'office automation' movement, they are problematic in that the evidence does not warrant the general conclusions the authors seem to draw. In their analyses of the status of formal constructs such as procedures, the authors do not take into account the fact that the situations studied are beyond the 'jurisdiction' of these constructs, that is, beyond the operational conditions for which they had presumably been designed. The point I am trying to make is that, contrary to what seems to be claimed by the general conclusions of these studies and how they have been interpreted and received, *the use of procedures under everyday routine conditions* for which such procedures are designed, *is not investigated* in these studies.

Instead of merely observing in case study after case study that procedures are impoverished abstractions when confronted with the multifarious and contingent nature of practical action, it is necessary to investigate precisely *how* they stipulate the articulation of cooperative work, *how* they are interpreted and used, designed and adapted by competent actors 'who have to live with them from day to day'.

3. Maps and scripts

Suchman's analysis of office procedures as the *product* of the orderly work of the office, rather than the reflection of some enduring structure that stands behind that work, has been generalized in her book on *Plans and Situated Action:* ''plans are resources for situated action, but do not in any strong sense determine its course. While plans presuppose the embodied practices and changing circumstances of situated action, the efficiency of plans as representations comes precisely from the fact that they do not represent those practices and circumstances in all of their concrete detail'' ([8], p. 52).

Suchman's proposition that ''plans are resources for situated action'' is of fundamental importance to CSCW systems design and has served me and my colleagues as a guiding principle in the development of the concept of malleable 'coordination mechanisms' (e.g., [26,27]), but it also leaves a number of questions unanswered: what is it that makes plans such as production schedules, office procedures, classification schemes, etc., useful in the first place? What makes them 'resources'? Furthermore, is it merely the fact that plans are underspecified compared to the rich multiplicity of actual action that makes them 'resources'? Is that really all there is to it? What, then, makes one procedure or form or schedule more useful than another for a certain purpose in a specific setting?

Later in the book, Suchman returns to these issues and suggests a rather apt metaphor for the role of plans, namely that of a ''map'':

> Just as it would seem absurd to claim that a map in some strong sense controlled the traveller's movements through the world, it is wrong to imagine plans as controlling actions. On the other hand, the question of how a map is produced for specific

[4] Standard operating procedures are, of course, instrumental in defining what constitutes an 'error' in a particular setting and how to detect whether or not there is an error and what kind of error it might be. The point I want to make here, however, is that a procedure may work quite differently under routine conditions and under breakdowns.

> purposes, how in any actual instance it is interpreted *vis-à-vis* the world, and how its use is a resource for traversing the world, is a reasonable and productive one. ([8], p. 188 f.).

While the same irksome questions arise here as well, the 'map' analogy is a fitting condensation of the role of procedures as understood in Suchman's study of the accounting office: procedures were found to be ''formulated in the interest of what things should come to, and not necessarily how they should arrive there'' and were used as a general reference for orientation purposes, not as a prescribed sequence of actions.

Other studies, however, lead to quite different conclusions as to how formal constructs are used by actors in everyday work activities.

Consider the relatively simple case of the normal checklist. A checklist is basically a list used to organize tasks whenever it is essential that a set of actions *all* be performed, typically where it is essential that the actions of the performance also be taken in a particular order, to ensure a high level of operational safety. For example, the normal aircraft flight-deck checklist indicates a set of different tasks the pilot must perform or verify during all flight segments in order to configure the aircraft and prepare the flight crew for certain 'macro-tasks' such as ENGINE START, TAXI, TAKEOFF, APPROACH, LANDING, etc. For each one of these macro-tasks there are several 'items' to be accomplished and verified by the crew (for a study of the design and use of flight-deck checklists, see [28]).

Like any other formal construct, the checklist does not describe the prescribed action exhaustively. Indeed, no linguistic construct can describe any action exhaustively [29]. That said, it is clear that the flight-deck checklist does not serve in as weak a role as that of the traveller's map. The use of such checklists requires the actor to employ a strategy for sequential execution which permits him or her to ensure that the steps are done in the correct order and that each step is done once and only once. In fact, the checklist can be conceived of as a construct that has been deliberately and carefully designed to reduce local control, typically in safety-critical environments. The flight-deck checklist thus provides a 'precomputed' selection of safety-critical tasks which all need to be performed at the particular flight segment as well as a 'precomputed' sequence for their execution ([30], p. 21).

Consider another example which is more complex than the checklist but which is also far more pertinent to the use of formal constructs for coordinative purposes under routine as well as non-routine conditions, namely the study of the *kanban* system at Repro Equipment. The study has been described and discussed at length elsewhere [27] but a brief recapitulation is unavoidable.

A manufacturing operation involves myriad discrete parts and processes that are complexly interdependent. Each product consists of many component parts, in some cases thousands of components, and their production may require a number of different processes in a specific sequence. The different processes require specialized tools and skills which are allocated to different workstations and require hugely different set-up times. This is compounded by the fact that, at any given time, a large number of products and their components coexist in the production process at different stages of completion, which means that different parts for the same or for different products compete for the same workstations.

To deal with this complexity, Repro Equipment had introduced a *kanban* system to coordinate processes in the production of cabinets. *Kanban* is a Japanese word for 'card' which it is widely used to denote a just-in-time production control protocol[5] where a set of cards acts as the carrier of information about the state of affairs *as well as* production orders conveying instructions to initiate certain activities. The basic idea is that loosely interdependent activities can be coordinated by exchanging cards between actors. When a new batch of parts or sub-assemblies has been produced and the batch is to be transported 'down-stream' from the present work station to the station where it is to be used, e.g., as components for various sub-assemblies, a specific card is attached to the container used for the transportation. The card specifies the part number, the number of parts to be produced per batch and other relevant information. When the operator at the work station down-stream has processed this batch of parts, the accompanying card is sent back to the operator who produces these parts. To the operator, receiving the card means that he or she has now been issued a production order.

The basic rules of a *kanban* protocol are as follows: (1) no part may be made unless there is a *kanban* authorizing it; (2) there is precisely one card for each container; (3) only standard containers may be used; and (4) containers should only be filled with the prescribed quantity ([31], p. 224).

Setting up a *kanban* system requires a careful configuration of the number of containers per part number and the quantity per container. This configuration, in effect, amounts to a precomputation of task interdependencies in terms of batch size per part number, task allocation in terms of work stations for different part numbers, and task sequences.

However, Repro Equipment was faced with extreme differences and fluctuations in demand for different models and variants, but a *kanban* system is not adequate for coordinating manufacturing operations when faced with such fluctuations; it can only handle small deviations in the demand ([31], p. 227). Accordingly, operators recurrently experienced that the configuration of the system was inadequate. For instance, in a situation where all parts of a particular part number which was only used for a special product variant had all been used, the protocol would automatically generate a production order for this part number,

[5] The term 'protocol' is used here to denote a formal organizational construct which regulates the *coordination* of cooperative work.

although the part in question probably would not be needed for several months. Unmitigated execution of the protocol in this situation would thus absorb production facilities that would be requested for other, more pressing orders.

In such situations, where the *kanban* system was 'beyond its bounds', operators would tamper with the *kanban* protocol. For example, having heard of a new rush order from the girl in the order office, the fork lift operator might put the card for a rarely used part for another model in his back pocket or leave it on the fork-lift truck for a while. Similarly, in order to rush an order, operators would occasionally order a new batch of parts for this order *before* the container had actually been emptied and the card had been released, or they would deviate from batch sizes as specified on the card, etc. Of course, in doing that they deviated from the lexical statement of the rules; but when management was later informed of these practices, the reaction was an enthusiastic endorsement. In breaking the literal rules of the protocol they acted in accordance with management's reasons for adopting the *kanban* system in the first place. In the words of the CEO, ''if it weren't for these guys we'd have gone bust a long time ago.''

It is crucial to notice that instead of abandoning the *kanban* system altogether, or at least suspend it temporarily, the operators *changed the configuration* of the system. That is, when an operator pocketed a card, he or she was *modifying* the protocol, not switching it off, and when the card was put back in circulation again, the default configuration was in force again. The reason for this is that the *kanban* system incorporates (implicitly, in the configuration of the system) a precomputed model of crucial interdependencies of the manufacturing process (routing schemes for different parts, setup-times for different processes, etc.). Thus, even though Repro often experienced situations where the *kanban* system was 'beyond its bounds', it was neither discarded, nor suspended, but merely modified locally and temporarily according to the requirements of the situation.

The *kanban* system illuminates several important points.

Suchman's contention that the function of abstract representations such as plans ''is not to serve as specifications for the local interactions, but rather to orient or position us in a way that will allow us, through local interactions, to exploit some contingencies of our environment, and to avoid others.'' ([8], p. 188) is not accurate as far as the *kanban* system is concerned. When an operator receives a card, he or she will produce the batch as specified by the card, in accordance with the general rules of the protocol, without actively searching for reasons not to do so and without deliberating or negotiating whether to do so or not. The *kanban* protocol does not exhaustively describe and prescribe action—no linguistic construct does—but it nonetheless generates specifications for the local interactions. Workers at Repro Equipment rely on the *kanban* protocol to issue valid and sensible production orders, unless they have strong reasons to believe that its unmitigated execution in a particular situation will have undesirable results. Even then they do not discard or suspend the system but alter its behaviour by reconfiguring it, after which the system is allowed to 'switch back' to the default configuration.

The *kanban* system thus determines action in a far stronger sense than the map of a traveller determines the traveller's movements ([8], p. 188 f.; [9], p. 114). In the *kanban* case the protocol conveys a *specific* stipulation in the form of a production order to a particular actor instructing the actor, under the conditions of social accountability, to take the particular actions specified by the card according to the general rules laid down in the protocol. It is more like a *script* than a *map.* In fact, the *kanban* system works well even though it does not provide a 'map' in the form of a visible overview of interdependencies among processes.

The point is that the *kanban* protocol under normal conditions of operation relieves actors of the otherwise forbidding task of computing myriad—partly interdependent, partly competing—production orders and negotiating their priority. They can as competent members, for all practical purposes, rely on the precomputed protocol to issue valid production orders; they take it for granted. Though the relation of plan to action, according to Suchman, can be construed as ''enormously contingent'' ([8], p. 38), this is not necessarily so to competent members. Thus, for a worker at Repro Equipment to contemplate the meaning and rationality of the protocol at every step in every situation would be an utter waste of effort, and it does not happen. In Wittgenstein's words: ''When I obey a rule, I do not choose. I obey the rule *blindly*.'' ([32], p. 219).[6]

But the relationship between the formal construct serving as a script (in this case, the general *kanban* protocol as it was instantiated in a particular configuration and distribution of cards) and actual observable practice is not *causal*: the operators deviated from the lexical statement of the rules when they found that to be appropriate and such putatively illicit practices were actually deemed to be competent and responsible. So, while contradicting Suchman's contention that the function of plans is merely ''to orient or position us in a way that will allow us, through local interactions, to exploit some contingencies of our environment, and to avoid others'', the case does not contradict Suchman's more general observation that formal organizational constructs such as procedures are of a different nature than computational procedures and algorithms ([6], p. 322).

Formal organizational constructs in the form of scripts are not *causal schemes* but should rather be thought of as *normative constructs* based on a precomputation of interdependencies. A script offers a limited selection of safe, secure, legal, valid, advisable, efficient or otherwise prescribed 'moves' while excluding 'moves' that generally would be considered unsafe, etc. Whether or not a particular option is actually deemed feasible or not feasible in a particular situation under certain practical circumstances is a

[6] For discussions of Wittgenstein's analysis of the use of rules, cf. [33,34].

discretionary matter. But such discretion is not exercised in each and every situation. Actors are not endlessly reflexive ([35], p. 118). Under conditions of limited resources, practical exigencies, and social accountability they rely on the stipulations of the script, when one is at hand, in order to get the job done, unless they have good reasons not to do so.

The contradictory findings thus indicate that protocols play very different roles in cooperative work. They may, on one hand, as suggested by Suchman and others, play the weak role of the 'map' of the traveller that offers a codified representation of salient features of past and future actions which actors may consult as a referent. On the other hand, however, they may play the strong role of a 'script' that offers a precomputation of interdependencies among activities (options, required actions, sequential and temporal constraints, etc.) which, at critical points, provides instructions to actors of possible or required next steps. The characteristics of formal constructs, be it maps or scripts, can be summarized as follows:

(1) Both maps and scripts represent constraints and affordances. As pointed out by Suchman, the ''emergent properties of action'' do not mean that action is ''random''. In order to understand the observable regularities in action, she argues, one should investigate the ''relationship between structures of action and the resources and constraints afforded by physical and social circumstances'' ([8], p. 179). We can here add formal organizational constructs as representations of 'the resources and constraints afforded by physical and social circumstances'. That is, formal constructs—maps as well as scripts—stand proxy for the affordances and constraints of the physical and social environment. For all practical purposes, they thereby circumscribe action in the same way as the physical and social circumstances. More specifically, as far as coordinative protocols are concerned, such protocols convey a precomputation of task interdependencies which assists actors in reducing the complexity of coordinating their activities.

(2) Whether weak or strong, a protocol only conveys stipulations within a certain social context, within a certain community, in which it has a satisfactorily certain and agreed meaning and it only does so under conditions of social accountability.

(3) Whether a formal construct serves as a map or a script depends on the extent to which it is possible to identify, analyse, and model interdependencies in advance. Moreover, the role of a particular protocol may vary according to the situation. Thus, in a situation where a standard operating procedure does not apply, the procedure may merely serve in its weak default capacity as a vehicle for conveying heuristics (as, for instance, in the recovery from error in the accounting office). In other cases, however, such as that of the *kanban*, the role of the protocol does not vary in the face of contingencies; rather, because of the complexity of the interdependencies of discrete parts production, the *kanban* protocol is not discarded, suspended, or 'weakened' but merely temporarily reconfigured by the operators to accommodate the passing disturbance.

(4) Protocols and other formal constructs cannot exhaustively describe action. As pointed out by Suchman, procedures are characterized by ''inherent and necessary underspecification [· · ·] with respect to the circumstances of particular cases'' ([36], p. 411). Furthermore, Suchman observes, ''the vagueness of plans'' is ''ideally suited to the fact that the detail of intent and action must be contingent on the circumstantial and interactional particulars of actual situations'' ([8], p. 185 f.). In fact, the degree of vagueness of specific plans is itself contingent ([8], p. 188). Thus, not only is a protocol, as a linguistic construction, inherently vague compared to the infinitely rich details of actually unfolding activities, and not only is it inherently decontextualized, but it is deliberately under-specified with respect to (a) factors that are immaterial for the purpose of the given protocol or (b) factors that can more efficiently and effectively be left unspecified, typically until a later stage. The protocol must be defined at ''an appropriate level of ambiguity'' ([37], p. 77).

(5) ''No representation of the world is either complete or permanent'' ([38], p. 257–258). That is, weak or strong, the protocol will, inevitably, encounter situations where it is beyond its bounds, its inherent vagueness and appropriate ambiguity notwithstanding.

4. The crucial role of artifacts

Formal constructs would be of only marginal utility if they were not *inscribed upon artifacts.* In the coordination of cooperative work (to stick to my main concern here) the role of the artifact is, fundamentally, to give permanence to the protocol for which it stands proxy in the sense that it conveys the stipulations of the protocol in a situation-independent manner. As observed by Jack Goody, ''The written language [reaches] back in time'' ([39], p. 280). Written artifacts can at any time be mobilized as a referential for clarifying ambiguities and settling disputes: ''while interpretations vary, the word itself remains as it always was'' ([40], p. 6). They are, for all practical purposes, unceasingly publicly accessible.

Due to these characteristics of the written language, symbolic artifacts play a crucial role as mediators of the coordination of cooperative work. In the case of a standard operating procedure or a checklist, the state of the artifact is completely static, irrespective of the state of the execution of the protocol it prescribes. Even when the protocol is used as a script (actors are following the instructions of the procedure or the items of the checklist step by step), it is entirely up to the actor to produce and maintain the required dynamic representation of the state of the protocol with respect to the unfolding cooperative activities.

In other cases, however, the state of the artifact changes according to the changing state of the protocol. Consider the

case of the bug report form mentioned briefly above [23,24]. As an artifact, it is a simple paper form. The agreed-to protocol dictates that when a new bug is detected by anyone involved in testing the software, a new bug report is initiated and filled-in. The originator of the bug report also provides a preliminary description and diagnosis of the problem. Three designers acting as a so-called 'spec-team' then determine which module might be culpable; they specify the date when the bug should be corrected, and classify the bug according to its perceived severity. The bug report is then passed on to the relevant designer who is then responsible for correcting 'his' or 'her' bugs and for reporting back to the designer who will be responsible for verifying and integrating the many software modules.

This mundane example shows how a protocol and the corresponding artifact supplement each other: firstly, the form is transferred from one actor to another and this *change of location* of the artifact in itself conveys, to the recipient, the stipulations of the protocol in a specified form, that is, the change of location transfers to the particular actor the specific responsibility of taking such actions on this particular bug that are appropriate according to the agreed-to protocol and other taken-for-granted conventions. Secondly, at each step in the execution of the protocol, *the form is annotated* and the updated form retains and conveys this change to the state of the protocol to the other actors—the state of each reported bug is thus reflected in the successive inscriptions on the form made by different actors. That is, a change to the state of the protocol induced by one actor (a tester reporting a bug, for example) is conveyed to other actors by means of a visible and durable change to the artifact. The artifact can thus be said to provide a 'shared space', albeit a space with a structure that reflects salient features of the protocol. Furthermore, the change is propagated within the ensemble according to the stipulations of the protocol, and the state of the total population of reported bugs is publicly visible in a public repository of bug forms.

In such cases, the artifact not only stipulates articulation work (like a standard operating procedure) but *mediates* articulation work as well in the sense that the artifact acts as an intermediary between actors which conveys information about state changes to the protocol. Because the artifact mediates the changing state of the protocol among the actors, it not only conveys the general stipulations of the protocol but *specifies the stipulations* in the sense that the individual actor is instructed that it is he or she that has to take this or that specific action at this particular point in time.

An artifact is, of course, not 'just an empty space', as the song goes. It has a specific *material format* which is formed to serve the purpose of conveying the specific stipulations of the protocol within a particular context. For example, consider the simple checklist again. As noted, the use of the checklist requires the actor to employ a strategy for sequential execution which permits him or her to ensure that the steps are done in the correct order and that each step is done once and only once. The material format of the checklist may be of assistance to the actor in ensuring this: ''The fixed linear structure of the checklist permits the user to accomplish this by simply keeping track of an index that indicates the first unexecuted (or last executed) item. Real checklists often provide additional features to aid in the maintenance of this index: boxes to tick when steps are completed, a window that moves across the checklist, etc.'' ([41], p. 47 f.; cf. also [42], p. 9). In a similar vein, Goody, in a discussion of the specific affordances provided by the material format of written text, observes that writing introduces certain spatio-graphic devices such as lists, tables, matrices by means of which linguistic items can be organized in abstraction from the context of the sentence and points out that the spatio-graphic format of an artifact can stipulate behaviour by reminding an actor of items to do and directing attention to missing items: ''The table abhors a vacuum'' ([39], p. 276; cf. also [43,44]).

These comments are far from conclusive, and are not intended to be. They are rather meant to indicate a crucial and fertile area of CSCW research. There have been several attempts at investigating the use of artifacts for coordinative purposes in CSCW (e.g., [24,27,43–50]). But we are far from a grounded understanding of the role of formal constructs in cooperative work that can serve as a conceptual foundation for the design of CSCW systems that support the regulation of cooperative work. To get there, it is essential to investigate how artifacts are used as objectifications of coordinative protocols and how the material format of such artifacts support that role.

5. Conclusions

I have tried to demonstrate that the prevalent understanding in CSCW of the status of formal constructs in cooperative work is problematic. The empirical evidence for the received understanding is not as robust as we may have believed and there is evidence from other studies that indicates that formal constructs are not always as feeble and ephemeral as we may have taken for granted. There are good reasons to believe that formal constructs incorporated in computer artifacts may be quite helpful in reducing the complexity of coordinating cooperative activities and thus serve as genuine 'resources for situated action'. We are thus in a situation in which a reconsideration of the premises of much of the research in CSCW is called for. Most importantly, we need to investigate—thoroughly, systematically, and critically—the actual use of formal constructs and the artifacts in which they are objectified. In short, we have got a lot of work to do.

Acknowledgements

The research has been supported by the European Union's ESPRIT Basic Research (COMIC), by The Danish

Natural Science Research Council, and by the European Union's HCM program (ENACT) and TMR program (COTCOS). I am indebted to the anonymous referees and to Liam Bannon, John Bowers, Christian Heath, John Hughes, Dave Randall, Wes Sharrock, and Carla Simone for critical comments—and, occasionally, also an encouraging word or two. Special thanks are due to Peter Carstensen and Bjarne Kaavé for generously sharing their field study findings with me.

References

[1] Hiroshi Ishii, TeamWorkStation: towards a seamless shared workspace, in: CSCW '90. Proceedings of the Conference on Computer-Supported Cooperative Work, Los Angeles, CA, 7–10 October 1990, ACM Press, New York, 1990, pp. 13–26.

[2] Ludwin Fuchs, Uta Pankoke-Babatz, Wolfgang Prinz, Supporting cooperative awareness with local event mechanisms: the GroupDesk system, in: (Eds.) H. Marmolin, Y. Sundblad, K. Schmidt, ECSCW '95. Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work, 10–14 September 1995, Stockholm, Sweden, Kluwer Academic Publishers, Dordrecht, 1995, pp. 245–260.

[3] Geraldine Fitzpatrick, Simon Kaplan, Tim Mansfield, Physical spaces, virtual places and social worlds: a study of work in the virtual, in: (Ed.) M.S. Ackerman, CSCW '96. Proceedings of the Conference on Computer-Supported Cooperative Work, Boston, MA, November 16–20, 1996, ACM press, New York, NY, 1996, pp. 334–343.

[4] Mark Roseman, Saul Greenberg, TeamRooms: network places for collaboration, in: (Ed.) M.S. Ackerman, CSCW '96. Proceedings of the Conference on Computer-Supported Cooperative Work, Boston, MA, November 16–20, 1996, ACM press, New York, NY, 1996, pp. 325–333.

[5] Eleanor H. Wynn, Office conversation as an information medium, Ph.D. dissertation, University of California, Berkeley, 1979.

[6] Lucy A. Suchman, Office procedures as practical action: models of work and system design, ACM Transactions on Office Information Systems 1 (4) (1983) 320–328.

[7] Lucy A. Suchman, Eleanor Wynn, Procedures and problems in the office, Office: Technology and People 2 (1984) 133–154.

[8] Lucy A. Suchman, Plans and Situated Actions: The Problem of Human-Machine Communication, Cambridge University Press, Cambridge, 1987.

[9] Louis L. Bucciarelli, Engineering design process, in: (Ed.) F.A. Dubinskas, Making Time. Ethnographies of High-Technology Organizations, Temple University Press, Philadelphia, 1988, pp. 92–122.

[10] Mike Robinson, Liam Bannon, Questioning representations, in: (Eds.) L. Bannon, M. Robinson, K. Schmidt, ECSCW '91. Proceedings of the Second European Conference on Computer-Supported Cooperative Work, Amsterdam, 24–27 September 1991, Kluwer Academic Publishers, Dordrecht, 1991, pp. 219–233.

[11] Thomas Kreifelts, Elke Hinrichs, Gerd Woetzel, Sharing to-do lists with a distributed task manager, in: (Eds.) G. De Michelis, C. Simone, K. Schmidt, ECSCW '93. Proceedings of the Third European Conference on Computer-Supported Cooperative Work, 13–17 September 1993, Milan, Italy, Kluwer Academic Publishers, Dordrecht, 1993, pp. 31–46.

[12] Jonathan Trevor, Tom Rodden, Gordon Blair, COLA: a lightweight platform for CSCW, in: (Eds.) G. De Michelis, C. Simone, K. Schmidt, ECSCW '93. Proceedings of the Third European Conference on Computer-Supported Cooperative Work, 13–17 September 1993, Milan, Italy, Kluwer Academic Publishers, Dordrecht, 1993, pp. 15–30.

[13] Richard Bentley, Paul Dourish, Medium versus mechanism: supporting collaboration through customization, in: H. Marmolin, Y. Sundblad, K. Schmidt (Eds.), ECSCW '95, Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work, 10–14 September 1995, Stockholm, Sweden, Kluwer Academic Publishers, Dordrecht, 1995, pp. 133–148.

[14] Paul Dourish, Jim Holmes, Allan MacLean, Pernille Marqvardsen, Alex Zbyslaw, Freeflow: mediating between representation and action in workflow systems, in: (Ed.) M.S. Ackerman, CSCW '96. Proceedings of the Conference on Computer-Supported Cooperative Work, Boston, MA, November 16–20, 1996, ACM press, New York, NY, 1996, pp. 190–198.

[15] John Bowers, The politics of formalism, in: M. Lea (Ed.), Contexts of Computer Mediated Communication, Harvester, New York, 1992, pp. 232–261.

[16] John Bowers, Graham Button, Wes Sharrock, Workflow from within and without: technology and cooperative work on the print industry shopfloor, in: H. Marmolin, Y. Sundblad, and K. Schmidt (Eds.), ECSCW '95. Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work, 10–14 September 1995, Stockholm, Sweden, Kluwer Academic Publishers, Dordrecht, 1995, pp. 51–66.

[17] Kenneth R. Abbott, Sunil K. Sarin, Experiences with workflow management: issues for the next generation, in: T. Malone (Ed.), CSCW '94. Proceedings of the Conference on Computer-Supported Cooperative Work, Chapel Hill, North Carolina, October 24–26, 1994, ACM Press, New York, NY, 1994, pp. 113–120.

[18] Philip Selznick, Foundations of the theory of organization, American Sociological Review 13 (1948) 25–35.

[19] Egon Bittner, The concept of organization, Social Research 32 (1965).

[20] Don H. Zimmerman, Paper work and people work: a study of a public assistance agency, Ph.D. Dissertation, University of California, Los Angeles, 1966.

[21] Frank A. Dubinskas, Cultural constructions: the many faces of time, in: (Ed.) F.A. Dubinskas, Making Time. Ethnographies of High-Technology Organizations, Temple University Press, Philadelphia, 1988, pp. 3–38.

[22] Peter H. Carstensen, Carsten Sørensen, Tuomo Tuikka, Let's talk about bugs!, Scandinavian Journal Of Information Systems 7 (1) (1995) 33–54.

[23] Peter Carstensen, Computer supported coordination, Risø National Laboratory, P.O. Box 49, DK-4000 Roskilde, Denmark, 1996. [Riso-R-890(EN)].

[24] H. Peter, Carstensen, Carsten Sørensen, From the social to the systematic: mechanisms supporting coordination in design, Computer Supported Cooperative Work, The Journal of Collaborative Computing 5 (4) (1996) 387–413.

[25] Phillip E. Agre, [Review of] L. Suchman, Plans and Situated Action (Cambridge University Press, Cambridge, 1987), Artificial Intelligence 43 (1990) 369–384.

[26] Kjeld Schmidt, Riding a tiger, or computer-supported cooperative work, in: (Eds.) L. Bannon, M. Robinson, and K. Schmidt, ECSCW '91. Proceedings of the Second European Conference on Computer-Supported Cooperative Work, Amsterdam, 24–27 September 1991, Kluwer Academic Publishers, Dordrecht, 1991, pp. 1–16.

[27] Kjeld Schmidt, Carla Simone, Coordination mechanisms: towards a conceptual foundation of CSCW systems design, Computer Supported Cooperative Work. The Journal of Collaborative Computing 5 (2) 3 (1996) 155–200.

[28] Asaf Degani, Earl L. Wiener, Human factors of flight-deck checklists: the normal checklist, National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California, May, 1990. [NASA Contractor Report 177549; Contract NCC2-377].

[29] Harold Garfinkel, 'Good' organizational reasons for 'bad' clinic records, in: Studies in Ethnomethodology, Prentice-Hall, Englewood-Cliffs, NJ, 1967, pp. 186–207.

[30] Donald A. Norman, Cognitive artifacts, in: (Ed.) J.M. Carroll,

Designing Interaction. Psychology at the Human–Computer Interface, Cambridge University Press, Cambridge, 1991, pp. 17–38.
[31] Richard J. Schonberger, Japanese Manufacturing Techniques. Nine Hidden Lessons in Simplicity, Free Press, New York, 1982.
[32] Ludwig Wittgenstein, Philosophical Investigations, Translated by G.E.M. Anscombe, Basil Blackwell Publishers, Oxford, 1958, (Manuscript 1938–46).
[33] Michael Lynch, Extending Wittgenstein: the pivotal move from epistemology to the sociology of science, in: (Ed.) A. Pickering, Science as Practice and Culture, Chicago University Press, Chicago, 1993, pp. 215–265.
[34] S.G. Shanker, Wittgenstein and the Turning-Point in the Philosophy of Mathematics, Croom Helm, London and Sydney, 1987.
[35] John Heritage, Garfinkel and Ethnomethodology, Polity Press, Cambridge, 1984.
[36] Lucy A. Suchman, Systematics of office work: office studies for knowledge-based systems. Digest, Office Automation Conference, San Francisco, April 5–7, 1982, 1982, pp. 409–412.
[37] Geoffrey Bowker, Susan Leigh Star, Situations vs. standards in long-term wide-scale decision-making: the case of the international classification of diseases, in: (Eds.) J.F. Nunamaker, Jr. and R.H. Sprague, Jr., Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences, Kauai, Hawaii, January 7–11, 1991, vol. IV, IEEE Computer Society Press, 1991, pp. 73–81.
[38] Elihu M. Gerson, Susan Leigh Star, Analyzing due process in the workplace, ACM Transactions on Office Information Systems 4 (3) (1986) 257–270.
[39] Jack Goody, The Interface Between the Written and the Oral, Cambridge University Press, Cambridge, 1987.
[40] Jack Goody, The Logic of Writing and the Organization of Society, Cambridge University Press, Cambridge, 1986.
[41] Edwin Hutchins, Mediation and automatization, Quarterly Newsletter of the Laboratory of Comparative Human Cognition [University of California, San Diego] 8 (2) (1986) 47–58.
[42] Donald A. Norman, Edwin L. Hutchins, Computation via direct manipulation, Institute for Cognitive Science, University of California, San Diego, La Jolla, California, 1 August, 1988. [ONR Contract N00014-85-C-0133].
[43] Lucy A. Suchman, Randall H. Trigg, Understanding practice: video as a medium for reflection and design, in: (Eds.) J. Greenbaum and M. Kyng, Design at Work: Cooperative Design of Computer Systems, Lawrence Erlbaum, Hillsdale, NJ, 1991, pp. 65–89.
[44] Lucy Suchman, Technologies of accountability: on lizards and airplanes, in: (Ed.) G. Button, Technology in Working Order. Studies of Work, Interaction, and Technology, Routledge, London and New York, 1993, pp. 113–126.
[45] Richard R. Harper, John A. Hughes, Dan Z. Shapiro, The functionality of flight strips in ATC work. The report for the Civil Aviation Authority, Lancaster Sociotechnics Group, Department of Sociology, Lancaster University, January, 1989.
[46] Yvonne Rogers, Coordinating computer-mediated work, Computer Supported Cooperative Work (SCCW). An International Journal 1 (4) (1993) 295–315.
[47] Karin Schneider, Ina Wagner, Constructing the 'Dossier Representatif', computer-based information-sharing in French hospitals, Computer Supported Cooperative Work (CSCW). An International Journal 1 (4) (1993) 229–253.
[48] Rebecca E. Grinter, Supporting articulation work using software configuration management systems, Computer Supported Cooperative Work. The Journal of Collaborative Computing 5 (4) (1996) 447–465.
[49] Colin Potts, Lara Catledge, Collaborative conceptual design: a large software project case study, Computer Supported Cooperative Work. The Journal of Collaborative Computing 5 (4) (1996) 415–445.
[50] Gillian Symon, Karen Long, Judy Ellis, The coordination of work activities: cooperation and conflict in a hospital context, Computer Supported Cooperative Work. The Journal of Collaborative Computing 5 (1) (1996) 1–31.