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Title:

Steps across the border –

Cooperation, knowledge production and systems design

Abstract

The computer support of cooperation and knowledge production across socially distributed activity systems has become an important topic in the context of the discourse on "knowledge management". The present article will draw on concepts of cultural-historical activity theory to discuss the problem of how the notion of "knowledge" is conceptualized and implicitly implemented in computer systems to support knowledge management, often neglecting the social embeddedness of knowledge production in everyday work practices. From the point of view of cultural-historical activity theory we would propose to look upon the generation of knowledge as a process embedded in socially distributed activities that are constantly being reproduced and transformed in and between specific communities of practice. We will present a model of cooperation that relates processual and structural aspects of joint activity. Methodologically, it draws on the analysis of unexpected events in the course of joint activity. Our model also proposes to use forums for co-construction to make visible different perspectives in the process of software design. The concept of cooperative model production is highlighted as a means to mediate, not to eliminate, differences of perspectives involved in the course of systems design. An empirical example will be given in which the repertory-grid technique is used to visualize similarities and differences of potential users' viewpoints and requirements in early stages of systems design.

Keywords

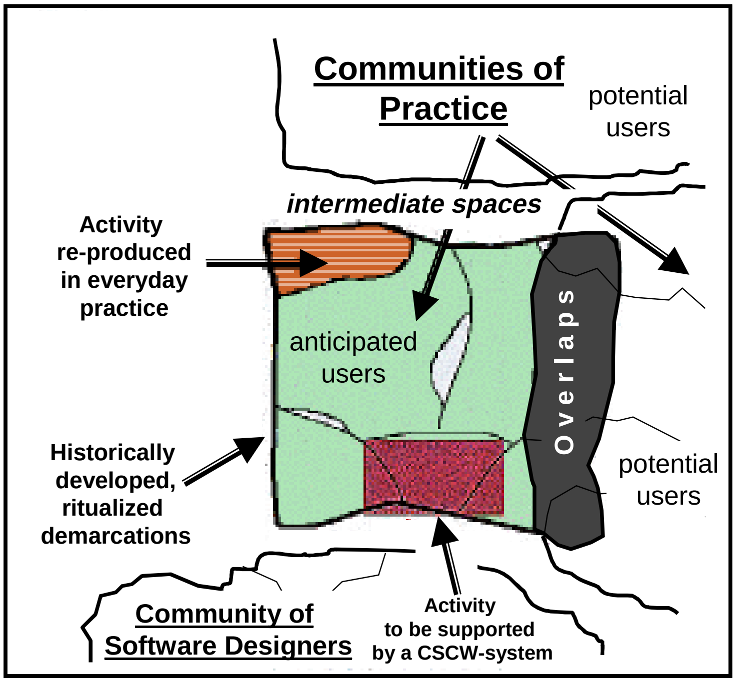
activity theory, cscw, methodology, unexpected events, cooperation, co-construction, difference, knowledge, work psychology

1. Introduction

The present paper represents a step across the border in various respects; it is an attempt to cross disciplinary borders on a theoretical level and boundaries of situated perspectives in systems design on a practical level. First of all, we would like to cross the border between the research fields of work psychology and CSCW. In doing so we will be proposing cultural-historical approaches to activity theory as a frame of reference to base the discussion on common theoretical and methodological premises.

In the course of software development, actors representing different communities of practice (Lave and Wenger, 1991) are interrelated in a division of labor. These actors are contributing different kinds of expertise: in software design and development on the one hand and in knowledge of local established work practices which are to be supported on the other hand. These different kinds of "interactive expertise" (Engeström, 1992) evoke varying perspectives and anticipations concerning the features of systems to support cooperative work. In figure 1 the need to conceptualize the design of CSCW systems as a joint activity crossing borders of different communities of practice is visualized. The fuzzy borders of each community represent historically developed and ritualized demarcations. Each community may be characterized by various interdependent activities that are being reproduced in everyday practice. The support of work practices by CSCW systems will change the joint activity itself, as the mediating tools are co-constitutive for its characteristics. From this point of view we see the challenge to anticipate possibilities of future work that affiliate to and at the same time transcend the *coordinatedness* (see section 3.2) of already established practices.

Figure 1: Joint Activity between Communities of Practice



We hold that *different perspectives* (between software designers as well as between software designers and anticipated or actual actors at work) involved in design should not only looked upon as barriers but may become potential driving factors for the development of CSCW systems. Thus we are in need of methodological approaches and practical methods to make these different viewpoints – as situated constructive critiques towards the anticipated use and benefit of CSCW systems – explicit in the course of software development. This holds especially when a participatory design strategy (Muller and Kuhn, 1993; Trigg and Anderson, 1996) is pursued as software development represents a field of negotiation in different settings and political arenas (Gärtner and Wagner, 1996).

As work psychologists inspired by the cultural-historical tradition in activity theory (Vygotsky, 1962, 1978; Luria, 1976, Engeström, 1987; Cole, 1996) we have developed a model of cooperation (Wehner et al., 1998, 2000) that may be helpful as a theoretical background for the design of CSCW systems. The concept of "cooperative model production" (Raeithel and Velichkovsky, 1995; Raeithel, 1998) will be related to our model as a methodological framework to identify methods and means helping to inform software designers and users in stages of co-construction (see section 3.4) about possibilities to visualize, i.e., to symbolically objectify, and communicate similarities as well as differences in perspectives involved in the process of software design (see section 4).

2. The context: CSCW in knowledge management

In order to put our discussion of the relationship of activity theory and CSCW systems design into perspective, we would like to focus on the development of software supporting the generation and the exchange of knowledge. In our research concerned with issues of knowledge management we apply our model of cooperation when developing evaluation criteria and requirements for systems design in that field.

2.1. Some issues related to knowledge management in the CSCW discourse

Knowledge management in recent years has become a popular topic in organization sciences (Nonaka, 1994; Davenport and Prusak, 1998; Tuomi, 1999).

In this discourse "knowledge" is often not only identified as the new dominant production factor in post-fordistic societies but as a product on its own. Thus - from an economic perspective – knowledge needs to be *located and estimated* in order to determine its exchange value. From this perspective, "knowledge" may easily become reified as an isolated entity abstracted from its practical, process- or problem-driven actualization in situated actions (Suchman, 1987).

Linked to the discussion on systems support for knowledge management an interesting discourse about the creation of "organizational memory information systems" (Stein and Zwass, 1995) has been going on in the last decade. "A Corporate or Organizational Memory can be characterized as a comprehensive computer system which captures a company's accumulated know-how and other knowledge assets and makes them available to enhance the efficiency and effectiveness of knowledge-intensive work processes" (Kühn and Abecker, 1997, p. 929). In the context of CSCW a much more modest approach is proposed, i.e. to *augment* organizational memory by the design of CSCW systems. Ackerman (1994a) argues in favor of a perspective on organizational memory that keeps in mind organizational, technical, and *definitional* constraints that are of relevance for the development of software tools. In a further critique it has been proposed to shift the perspective on "organizational memory" towards processes of "active remembering" (Bannon and Kuuti, 1996). The authors here refer to literature in which the predominant use of the metaphor of organizational memory reflects an understanding of memory as a passive storage space for information and knowledge.

From the point of view of work psychology, we argue against a technology driven, functionalistic approach to knowledge management and in favor of an understanding of everyday activities. We promote a process oriented approach to knowledge management, taking into account micro political implications and tensions brought about by different actors, perspectives, goals and motives involved.

2.2. The conceptualization of "knowledge" – implications for systems design

A way to make clear our conception of knowledge is to oppose it to still dominant approaches in the cognitive sciences, based on the physical symbol systems hypothesis (Newell and Simon, 1972) focusing on symbolic representations of the "outside" world "in the head", i.e. in cognitive structures of individuals, and leading to the dichotomies that reproduce the Cartesian gap between mind and body, between cognition and world. These dichotomies have been widely criticized, especially because of the separation of culturally embedded social practices from cognitive processes.

In the literature on computer support for knowledge management we often find quite inconsistent arguments about the concept of knowledge, however, the implicit effort to *locate* and *fix* units of knowledge (e.g. as propositions related to rule-based production systems) seems to be a common characteristic. If we shift the focus from attempts to spatio-temporarily locate ("ready made") *knowledge* here or there, inside or outside people's heads, to a perspective that is interested in practices of *knowing* (Blackler, 1995) we take a completely different stance to the unit of analysis. Then the process of actualizing, transforming and generating new knowledge could only be understood, when we analyze the situatedness of work practices in a socially distributed activity system in which practices of knowing are embedded (see figure 2).

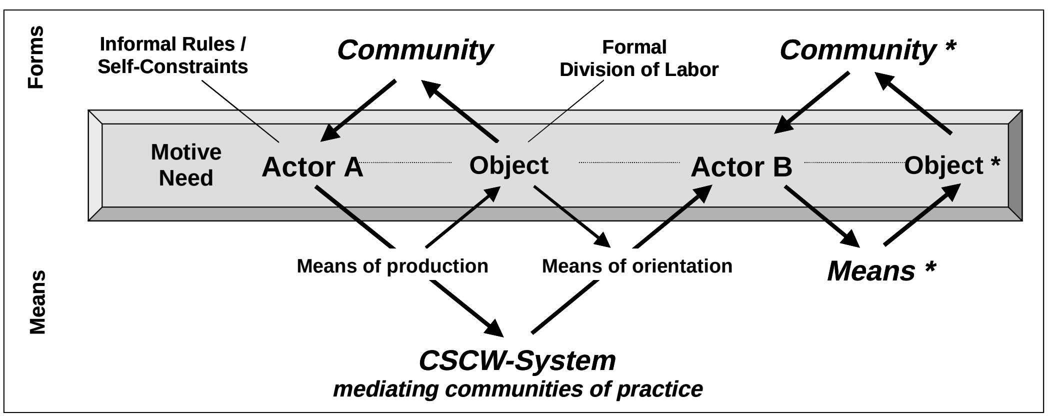
The implications for the design of computer support for knowledge management connected to the tradition criticized above are quite far-reaching. If those premises are referred to as the design of "organizational memory information systems", organizational memory becomes a repository in which knowledge is "stored" and from which knowledge may be "retrieved" – across different contexts – when needed in the very same condition as it has been produced, i.e. has been "transferred" (better transformed into information) into a database. In this case the most significant tasks for the computer support of knowledge management would be to acquire knowledge entities and to optimize the storage, navigation and distribution of these separable units of knowledge in databases. The critique here is not that some of these systems (expert systems, intelligent agents, etc.) would not fulfill certain useful purposes, however, if they are taken as the "whole story" the embodied, contextual, socially distributed and process-related character of knowledge and cognition is being neglected.

2.3. Socially distributed activity systems and the production of knowledge

From the point of view of activity theory we would propose to look upon the generation of knowledge as a process embedded in socially distributed activities that are constantly being reproduced and transformed in and between specific communities of practice. Thus, the generation as well as the actualization of knowledge would be bounded to specific contexts and strongly depend on shared understandings that emerge from the practice in which joint activities are embedded.

Engeström (1987, p. 78) and Raeithel (1992, p. 407) have proposed similar schemes to represent Leont'ev's (1978) basic differentiation between activity, action, and operation in a conceptual framework modeling a *socially distributed activity system*, which is proposed to be used as the key unit for analysis of work practices. One of the core ideas of activity theory is that human activity is *mediated* by societal forms as well as operative means. Figure 2 is based on these schemes and visualizes CSCW systems as mediating the joint activity in or between different communities of practice.

Figure 2: CSCW systems mediating between socially distributed activity systems of different communities of practice (based on Engeström, 1987; Raeithel, 1992)



The figure shows that the joint activity evolving between different actors is mediated – on the level of societal *forms* – by informal rules, self-constraints and a certain division of labor that historically evolve in communities of practice. On the other hand, the interaction between actors in computer-supported work places is being structured – on the level of operative *means* – by the characteristics of the specific CSCW system in use. The CSCW system will provide actor A with *means of production*, i.e. features to generate certain *objects*, which will then be represented for Actor B by the use of the system providing *means of orientation*. The artifacts produced by means of CSCW systems may be looked upon as symbolic externalizations of a specific practice. Therefore, when using a CSCW system, Actor A has to transform his experiences made and *knowledge* gained into a certain document. For Actor B, this externalization of a specific practice in the first case appears as *codified knowledge,* i.e. *information* that *might be useful* in another context. Depending on the way in which the context of generating the information is presented, Actor B will be more or less able to put it into perspective. In other words: Knowledge may not immediately be "transferred" but is *transformed* by processes of codification and interpretation. Thus, knowledge may not be fixed once and for all. A design philosophy that is committed to the insights of activity theory should take into account the diversity of meanings across socially distributed activity systems "providing technical support for their ongoing, local negotiation" (Agre, 1995, p. 188).

3. Our model of cooperation and implications on systems design

3.1. Methodological considerations: Cooperation and unexpected events

As an important focus or sensitizing concept for our empirical research on interorganizational relations in German automobile industry, we identified the dynamics of *unexpected events* in everyday work processes (Wehner et al., 2000). Technical breakdowns, errors, and misunderstandings serve as discontinuations of everyday activity and interrupt the anticipated patterns of interaction. The analysis of unexpected events thus may also be looked upon as revealing important *differences among perspectives* of actors involved in the course joint activity. Based on our empirical findings from in-depth field studies we were able to show ways for designing inter-organizational development that take into account the dynamics of unexpected events and turn the notion of failure into a positive and productive direction (Wehner, 1992; Endres and Wehner, 1995). From our point of view differences of perspectives in and between communities of practice should not primarily be looked upon as disturbance variable or barriers, but also – when negotiated – as chances for the development of joint activity.

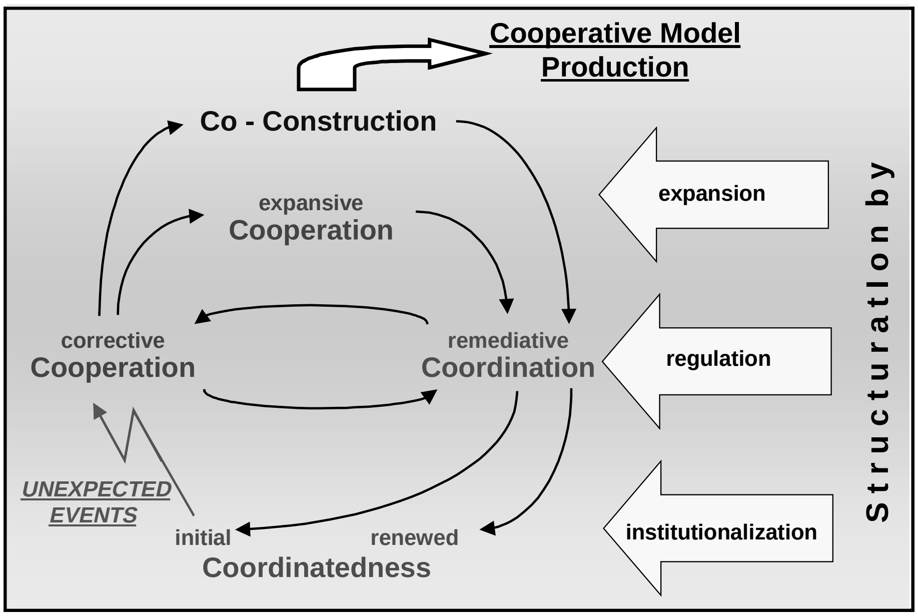
This perspective on the role of unexpected events in joint activity could have interesting implications for the design of CSCW systems to support knowledge production in at least a twofold way. First, the joint activity among systems designers themselves will produce unexpected events in cooperation that may, for example, be used to inform designers about the degree of mutual understanding of the tasks at hand. Second, the interaction between system designers and actual or anticipated users of a CSCW system representing various communities of practice in process of systems design will produce varying expectations, objectives and visions.

3.2. Institutionalized patterns of joint activity:

The initial coordinatedness of actors

As basic modes of joint activity in and between communities of practice we emphasize the structural difference between *cooperation*, *coordination* and *co-construction* at work.

Figure 3: Model of cooperation (based on Wehner et al., 2000)



In our model of cooperation as visualized in figure 3 we proceed from the assumption that the design and the courses of joint activity between communities of practice follow a *dialectic of continuity and change*. This dialectic develops in respect to the already established and institutionalized forms of interaction, which we call initial *coordinatedness*. We hold that the coordinatedness of actors is an *integral part of joint activity* – as its pre-condition as well as its product. Using the model, different paths and trajectories of joint activity may be described. In this respect the model is not prescriptive, but provides an analytical framework to conduct field research in CSCW.

A reflection of the specific coordinatedness within a socially distributed activity system (see figure 2) may be found in explicitly formulated regulations as to the division of labor, in certain habits or rules of interaction that evolve locally, or in unquestioned routine activities. With respect to the computer support of knowledge management, the coordinatedness of actors will also be structured through specific means of production and orientation, e.g., to access and use a jointly structured database to augment organizational memory.

Even if new forms of joint activity are to be established, the actors involved (designers and users) will have more or less concrete expectations of the ways in which joint activity should be designed or organized, e.g., between designers and anticipated users or within the community of practitioners to be supported by a CSCW system.

3.3. Local regulation of cooperation and coordination in joint activity

As triggering factors for the dynamics in cooperation and coordination we identify the discontinuities brought into the smooth flow of events due to *unexpected events*. The planned division of labor in work and the anticipated patterns of interaction are necessarily vague and underdetermined when compared to the concrete work practices. Unexpected events reveal the abstractions of formal regulations in respect to unique, so far unknown constellations or developments that trigger cooperation. In the case of unexpected events, the challenge is to develop a common understanding of the problem and common strategies to cope with the situation.

In *corrective cooperation* we identify a mode of joint activity that is focused around a common problem, a triggering incident – generally speaking: an unexpected event – that interrupts the smooth flow of events. In the course of searching for ways to cope with the event new forms of interaction may evolve here. Thus, cooperation brought about by unexpected events represents an important link between patterns that have been shaped by everyday practice in the past and possibilities for transforming and transcending to a *renewed coordinatedness* in the future. Experiences locally gained in cooperation broaden the scope of anticipation for actors practically involved and may change informal rules (see figure 2), e.g. in the ways in which certain features of a computer system are used. However, if the circumstances and outcomes of corrective cooperation in everyday practice are often not reflected upon on a level transcending the single case certain troubles in the everyday use of a CSCW system may not become obvious to designers as actors locally develop viable work-arounds. If there are no feedback forums available for evaluating these experiences and to relate them to the principle underlying structure of the coordinatedness of actors, even larger gaps between formal regulations and actual practice may arise which further block structural changes in the organization of joint activity between communities of practice.

3.4. Co-construction: Ways to expand joint activity

In *co-construction*, a more detached perspective towards the work processes within which problems occur may be taken. Co-construction – as a specific form of expansive cooperation – differs in its underlying structure from coordination and cooperation, because the focus of attention now lies on *the common redefinition of roles, work objectives, and patterns of interaction*. Thus, in co-construction the structural aspects of joint activity themselves – i.e. the different actor-specific redefinitions of the coordinatedness – are in focus in order to generate solutions that transcend the single case. Co-construction may take place in different forums as, for example, future workshops and interorganizational workshop circles. These forums have in common the fact that they take place apart from everyday practice in order to exchange experiences and interpretations as to mutual dependencies of activities.

Based on practical experience, new visions and scenarios for modifying the current coordinatedness may be worked out. Scenarios worked out in co-construction, e.g. for the design of CSCW systems to support knowledge management practices, will have to be remediated to everyday practice of systems design. This process is what we call *remediated coordination*. A successful remediation of possibilities worked out in co-construction would then result in a *renewed coordinatedness*, a changed structural basis on which the dialectics of cooperation and coordination may unfold again.

As Ackerman (1994b) pointed out, the design of CSCW systems to augment organizational memory faces definitional constraints due to varying redefinitions of what should be considered as a – maybe already existing – system supporting active remembering within a specific company. In the face of our model of cooperation, this would indicate the need to initiate forums of co-construction, in which different experience-based viewpoints and evaluations of what should be considered as a system to augment organizational memory could be exchanged.

When it comes to the design of CSCW systems in order to generate and exchange knowledge, one way to conceptualize an organizational memory is to provide a "common information space" (Bannon and Bodker, 1997) which may serve as a boundary object between different viewpoints resulting from the varying situatedness of work practices. Following Star (1989), boundary objects are: "(..) weakly structured in common use, and become strongly structured in individual site-use. Like the blackboard, a boundary object ‚sits in the middle‘ of a group of actors with divergent viewpoints" (Star, 1989, 46). When using the blackboard as a metaphor, the question arises how to structure the blackboard in order to cope with the necessities of local and common use, and how to make visible and negotiate the requirements for a software system in order to anticipate which chalk would serve as good complement.

4. Co-Construction in Systems Design: Varying perspectives and the challenge to formulate experience based requirements

In the course of explicating our model of cooperation we have argued that different levels of joint activity should be distinguished, each of them representing a specific mode of interaction between people involved. *Co-construction* has been highlighted as a process of questioning well-established practices and negotiating possible new forms of activity. In the remainder of the paper we would like to give an empirical example of how the theoretical framework of our model may be applied in research to encounter concrete practical questions in systems design. In an interventionist project we supported the process of co-constructing the requirements for a new software by drawing on the experiences of its potential users. The objective was to make visible similar as well as different points of view in early stages of the design process.

4.1 The context of research: CSCW support for project documentation

The research project is realized at a scientific institute of a large Swiss technical university. The research has been prompted by an interdisciplinary work group that is concerned with the procurement, administration, and maintenance of software for the institute. Due to their close insight in everyday problems encountered in scientific research projects, the workgroup has come up with the idea to find possibilities to further support project work especially focusing on questions of project documentation. The investigation in the various everyday practices of using artifacts to document experiences made and knowledge generated in research projects seemed to be a promising start. Thus, instead of evaluating the technological promises of available groupware products in the first place, the decision was taken to start the project by taking into account the experiences and perspectives of the employees at the institute. In the course of this ongoing project all members will be interviewed, including scientific, technical and administrative staff as well as the head of the institute.

4.2. The research method: Repertory-Grids

In order to explore system requirements from the point of view of its potential users, the *repertory grid technique* based on personal construct psychology (Kelly, 1955; Scheer and Catina, 1996) has been adapted in an innovative way. The repertory grid may be looked upon as *one* research method that supports the cooperative modeling of subjective viewpoints and thus helps to visualize and communicate varying perspectives on a specific problem domain. In the last decade, scholars in personal construct psychology have repeatedly demonstrated the possibility to make tacit knowledge (Polanyi, 1967) explicit by applying the repertory grid technique (Gaines and Shaw, 1992).

Each repertory grid consists of two important components: elements and constructs. The principal idea is to ask the respondents for their subjectively relevant perceptions – formulated as constructs – in relation to specific elements defining a certain problem domain. In the research reported here, 18 *elements* have been defined in advance representing various artifacts and actors supporting project documentation.[1] The personal *constructs* that have been elicited in the

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[1] We defined the following elements: Email (Email), project database of the institute (P_DB), project files on common server (P_Server), each employees local file system (OwnFileSys), hand-written notes (WritNotes), traditional project files (P_Files), project reports (P_Report), minutes of meetings (Minutes), project planning systems (PPS), the still unknown new system (Sys_X), the respondent herself (Myself), the respondents project team (P_Team), other project teams at the institute (Oth_P_Teams), the institute (The Institute), external scientific partners

course of the interviews consist of conceptual oppositions in the wordings of the interview partners. Thus, each construct comprises two conceptual poles and represents a subjectively relevant differentiations between the elements that define the problem domain.

The repertory grid is a research method on the border between qualitative and quantitative research methods. On the one hand, repertory grids model the individual perspective of our respondents as the elicited constructs represent the subjective differentiations and evaluations with respect to the elements in question. On the other hand – due to the systematic evaluation of all elements on all constructs leading to a matrix of elements and constructs – the resulting grid structure may also be analyzed in a quantative way. The method is capable of visualizing different subjective perspectives on a common set of elements. In our case we chose different actors and artifacts supporting project documentation and added the *element "Sys_X" representing the expectations towards a new system.*

4.2 Modeling individual perspectives on project documentation

As an example of the cooperative model production of perspectives the point of view of one of our respondents will now briefly be discussed. In the graphical visualization (figure 4) – a biplot based on the computation of a principal component analysis of elements and constructs for the elicited grid – distances and angles between elements (indicated by squares) and constructs (indicated by

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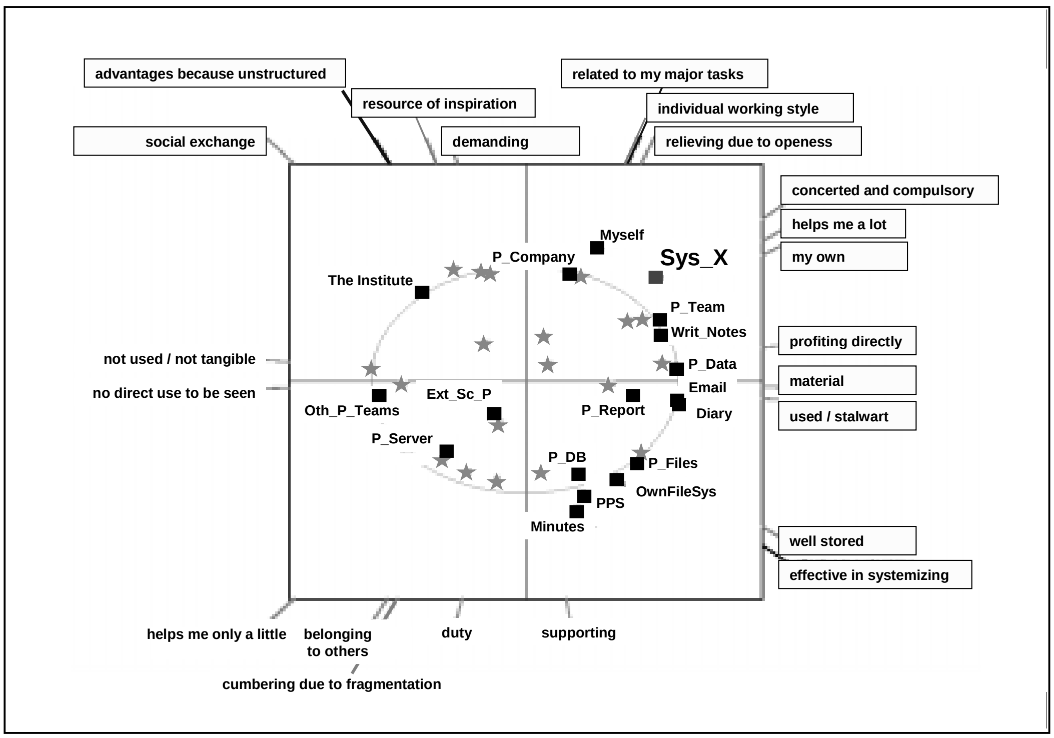
(Ext_Sc_P), companies in which research project work (P_Company), empirical project data (P_Data), and the respondents individual time scheduler (Diary).

stars) may be interpreted. The closer angles and distances between elements and constructs, the closer the statistical correlation. The two statistically most important dimensions explaining the variance in the grid are visualized. Similarities and differences between the elements are due to our respondent's evaluations *based on his personal constructs*. We allowed all respondents to relate both poles of a construct to a specific element in order not to force them to apply a strictly dichotomous way of thinking. The constructs he applied to the element "Sys_X" are highlighted.

Figure 4: Biplot of a repertory grid modeling an individual perspective on project documentation



Our respondent related his evaluations to an interdisciplinary research on organizational development processes in which field studies have been undertaken in small and medium sized companies on a national level. Various scientific partners inside and outside the institute have been involved in this project. The respondent accepted the 18 elements presented as sufficient to cover the range of most important actors and artifacts involved in project documentation.

As to the other elements of the grid, the model shows that the respondent formulated his expectations for a system that supports project documentation ("Sys_X”) close to the constructs he also assigned to human actors in a research project: to himself ("Myself”), his project team ("P_Team”), and the partner company in which the project has been realized ("P_Company”). The written notes ("WritNotes") he uses to document events in the course of a project represent those kinds of artifacts that share constructs with the element "Sys_X".

Interestingly, our respondent perceives the institute's file server ("Pserver") that provides each project with an access restricted space for up- and downloading project specific documents in strong contrast to what he would expect from a new system ("Sys_X") supporting project documentation. For him the file server neither fits his "individual working style" nor does it support him with any features that make it "concerted and compulsory”, he identifies no features that make the tool "demanding" in any way, additionally he sees the file server as something "not touchable", "extrinsic" and "cumbering due to fragmentation".

The *construct poles* that show the best statistical correlation to the element "Sys_X” may be looked upon as those which mostly distinguish the system from the other elements of the grid. The respondent thinks about the system that it should typically be "related to my major tasks” and at the same time should correspond to "my individual working style”. These constructs refer to his needs and motives (figure 2) that drive his anticipations in relation to a new system supporting project documentation.

Furthermore, the construct "concerted and compulsory” is capable of explaining main characteristics of the respondents’ expectations concerning a new software system. This construct pole introduces the collective perspective that is supported by the construct pole "social exchange”, however, at the same time rejected by the construct pole not applied to the system as "belonging to others”.

Interesting clues to ambivalent anticipations become obvious when looking at the constructs "advantages because unstructured – effective in systemizing”, "well stored – resource of inspiration”. When applying these constructs both poles have been highlighted as expected benefits of a new system for project documentation. The other grids elicited in our research so far also show such interesting tensions, which will be further analyzed by a qualitative analysis of the construct poles, an analysis that will reveal differences *and* similarities, tensions *and* synergies related to the perspectives of actors involved. Their expectations as to the new system should be well reflected in the further course of negotiating system requirements in *forums of co-construction*.

5. Conclusions

When summing up the considerations brought forward in this paper we may conclude that in the design of CSCW systems for knowledge management as a work-practice on its own there is the need to take into account

- the coordinatedness of actors – both of designers as well as of users – as the basic structure of their work practice in a socially distributed activity systems,
- unexpected events (misunderstandings, breakdowns, etc.) in triggering cooperation between designers and users,
- chances brought about by these unexpected events to discuss the logic of joint activity in systems design,
- similarities as well as differences in the perspectives of actors, acknowledging the diversity of meanings and contexts especially when crossing boundaries of socially distributed activity systems.

From our point of view the computer support for knowledge management practices should rather help to mediate than to reduce differences between actors' perspectives and locally evolving work practices. Referring to our model of cooperation this would be a question of *co-construction* among designers and users representing different communities of practice trying to commonly produce symbolical externalizations of core aspects of their work practice. This process of cooperative modeling using the expertise of various professions would turn situated knowledge into intersubjectively understandable externalizations.

The design of CSCW systems implies various steps across the border bringing up the necessity to explore the worlds of thought and practice of different actors involved. From our point of view the effort to communicate perspectives of different actors involved does not need to follow the aim of harmonizing and integrating all perspectives involved in a one-best-way. On the contrary, the development and the implementation of tools for cooperative work in joint activity will always induce unpredictable changes in work practices within the overall activity system which will newly trigger the dialectics of cooperation and coordination in a community of practitioners. A newly developed CSCW software for mediating joint activity does not only represent a new means to some specific ends, but always has the potential to set free new ends in its actual, often unforeseen forms of use. Thus far, software development represents an open-ended process, as long as it not conceptually restricted to the laboratories but reaches out in real-world settings by taking into account experiences, perspectives, and knowledge arising from practical use.

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