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Computer Applications as Mediators of Design and Use

Susanne Bødker

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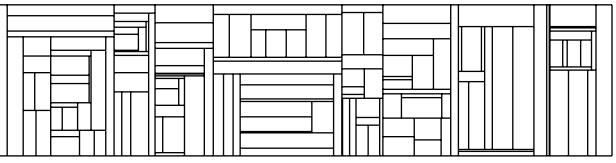
DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF AARHUS
Ny Munkegade, Bldg. 540
DK-8000 Aarhus C, Denmark



Computer applications as mediators of design and use - a developmental perspective

Edb-artifakters mediering af design og brug

-et udviklingsperspektiv

Susanne Bødker

Submitted work/Indleveret arbejde

1. Bødker, S. & Grønbæk, K. (1989). Cooperative Prototyping Studies - Users and Designers Envision a Dental Case Record System. In J. Bowers & S. Benford (Eds.). *Proceedings of the first EC-CSCW '89*. Computer Sciences Company , pp. 343-357. Also in J. Bowers & S. Benford (Eds.). *Studies in Computer Supported Cooperative Work: Theory, Practice and Design,* Amsterdam: Elsevier Science Publishers / North Holland. 1991, pp. 315-332.
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4. Bødker, S. & K. Grønbæk (1996). Users and Designers in Mutual Activity- an analysis of cooperative activities in systems design. In Engeström, Y. & Middleton D. (Eds.). *Cognition and Communication at Work*, Cambridge University Press, pp. 130-158.
5. Trigg, R., Bødker, S. & Grønbæk, K. (1991). A Video-based Analysis of the Cooperative Prototyping Process. *Scandinavian Journal of Information Systems*, vol. 3, pp. 63-86.
6. Bødker, S. (1991). Activity theory as a challenge to systems design. In Nissen, H.E., Klein, H. & Hirschheim, R. (Eds.). *Information Systems Research: Contemporary Approaches and Emergent Traditions*, Amsterdam: North Holland, pp. 551-564.
7. Bødker, S. (1993). Historical analysis and conflicting perspectives - contextualizing HCI. In Bass, L., Gornostaev, J. & Unger, C. (Eds.). *Human-Computer interaction. 3rd International Conference, EWHCI '93,* Springer Lecture Notes in Computer Science vol. 753, pp.1-10.
8. Bødker, S. (1996). Understanding computer applications in use - a human activity analysis. In Bøgh Andersen, P. Holmquist, B., Klein, H. & Posner , R. (Eds.). *Signs at work,* Berlin: de Gruyter, pp. 325-348.
9. Bannon, L. & Bødker, S. (1991). Beyond the Interface, Encountering Artifacts in Use. In Carroll, J. (Ed.). *Designing Interaction: Psychological Theory of the Human-Computer Interface*. Cambridge University Press, pp. 227-253.
10. Bødker, S. (1996). Applying activity theory to video analysis: How to make sense of video data in HCI. In Nardi, B. (Ed.). *Context and consciousness. Activity theory and human computer interaction*, Cambridge: MIT press, pp. 147-174.
11. Bødker, S. (1996). Creating conditions for participation: Conflicts and resources in systems design, *Human Computer Interaction* 11(3), 215-236. An earlier version in Trigg R., Irwing Anderson, S., & Dykstra-Eriksson, E. (Eds.) (1994). *Proceedings of PDC '94*, pp. 13-20.
12. Bødker, S. , Ehn, P., Lindskov Knudsen, J., Kyng, M., K. Halskov Madsen (1988). Computer Support for Cooperative Design. In Tatar, D. (Ed.). *Proceedings of Conference*

on CSCW, Portland, Oregon, September 1988 (pp. 377-394), New York: ACM. Also in Marca, D. & Bock, G. (Eds.). *Groupware.* IEEE Computer society Press, 1992, pp. 82-99.

13. Bødker, S. & Christiansen, E. (1997). Scenarios as springboards in design. In Bowker, G., Gasser, L., Star, S.L. & Turner, W. (Eds.). *Social science research, technical systems and cooperative work*, Mahwah, NJ: Erlbaum pp. 217-234.

14. Bødker, S., Christiansen, E., & Thüring, M. (1995). A conceptual toolbox for designing CSCW applications. In *COOP '95, International Workshop on the Design of Cooperative Systems*, Juan-les-Pins, January 1995, pp. 266-284.

15. Trigg, R, & Bødker, S. (1994). From Implementation to design: Tailoring and the emergence of systematization in CSCW. In Futura, R. & Neuwirth, C. (Eds.). *Proceedings of CSCW 94*, New York: ACM press, pp. 45-54.

16. Bødker, S. (1998). Understanding representation in design. *Human-Computer Interaction* 13(2), 107-125. Earlier version presented at IMPACT workshop and included in the final report of CoTECH workgroup IMPACT.

17. Bødker, S. (in press). *Mediating technical platforms to support the development of shared work practices*, In press for CACM. Earlier version presented at COST 4 workshop: 4th Software Cultures Workshop, Vienna, November, pp. 91-102. Included version available as DAIMI-PB 539.

18. Bødker S. (1997). Computers in mediated human activity. *Mind, Culture and Activity*, 4(3) 149-158.

19. Bannon, L. & Bødker, S. (1997). Constructing Common Information Spaces. In Hughes, J., Prinz, W., Rodden, T. & Schmidt, K. (Eds.). *Proceedings of ECSCW97*, Dordrecht: Kluwer, pp. 81-96.

20. Bødker, S. & Halskov Madsen, K. (1998). Context - an active choice in usability work, *Interactions*, July+August 1998, pp. 17-25.

21. Bødker, S. (1999). Scenarios in user-centred design - setting the stage for reflection and action. *Hawaii International Conference on System Sciences 32*. Version to appear in *Interacting with Computers*, 1999.

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1

Introduction

"Technology is a process you start, not a thing you buy"
Jørn Andersen, local developer AT

The present dissertation summarizes an understanding of computers as the materials that we shape in design, on the one hand, and the artifacts that we use, in work and other everyday activities on the other. The presented work is primarily methodological and design-oriented, i.e. it is concerned with changing computer applications, and with understanding them as changing and as part of change.

My starting point for understanding computer applications in design and use is the classical system perspective that has penetrated computer system design methods and thinking: Methodologically this perspective aims to structure analysis and design of computer applications according to universal principles (Floyd, 1987). It sees problem solving as a matter of stepwise refinement and divide-and-conquer and computer applications as rigid systems, primarily aiming to constrain the human users.

This product-oriented perspective has been challenged by a number of authors, including Floyd (1987), who introduces the alternative of a process-oriented perspective. In my own tradition, Ehn & Kyng (1984) introduced the tools perspective which, along with the rest of the work of the Utopia project (Bødker et al., 1987), brought the shaping of computer applications by ordinary people into focus. Kay's (1984) discussion of the "clay of computing" is a further example of an alternative perspective that made it possible to both think about, and build, computer applications that would emphasize flexibility, where programming-by-example came to be seen as an alternative to structured programming.

Though Floyd (1987) challenges the product-oriented perspective, she argues that both the product- and the process-oriented perspectives are needed in order to benefit from the capabilities of human beings as well as the qualities of computer technology. In reality, the two perspectives have lived side by side with very few attempts to bridge between them. With my present work I propose that it is possible to move beyond these perspectives towards a more fundamental understanding of the materials and artifacts that we, as computer scientists, work with, and provide for others to work with. This is what I would call the clay of computing.

In order to develop such an understanding of computers, we also need to move beyond the static view of the user organization that underlies much systems development literature as well as the kind of task analysis that has come out of cognitive science. The assumption that, once uncovered, the tasks will remain the same throughout design and use is highly insufficient [9][1]. Thus, in my work I propose an alternative, that is based on the ideas that human use of technology develops, and that we cannot design the future totally – use as well as design is an ongoing learning process (see also Bødker, 1993). I have chosen as an overriding perspective of this dissertation that of learning or development in and of use. Seen from the perspective of the clay of computing, the materials of computer scientists, this is an understanding of computer applications in their ongoing transformation in human activity, i.e. in use, in design, and between the two. Learning, with inspiration from Engeström (1987), I take to mean more than just adaptation to technology. It is a matter of development, change, or even expansion of practice of communities in cooperation between participants, struggling with the particular material and cultural conditions of the activity.

1.1 The development of the perspective

The elaboration of this perspective has taken place over the 10-15 year period, since my ph.d. thesis (Bødker, 1987a, 1991) was written to become an important step in establishing activity theory as a useful framework for HCI. Activity theory, I still find, is a useful platform for understanding design and use of computer applications, and I have spent this period of time on extending the framework in various ways - looking at new theoretical challenges, new technology (CSCW, shrink-wrap software), revisiting some old ones (Participatory Design), continuously linking back to fundamental issues in activity theory. I have worked empirically as well as theoretically over the period, and the main direction of my writings has been from rather direct accounts of findings from the empirical research, via primarily theoretical considerations, to practical suggestions for improvement of systems development based on theory and experience. The reader who is interested in the current state of the art of my research is recommended to read the following papers [10, 13, 14, 16, 17, 18, 20, 21].

Where my ph.d. thesis was primarily concerned with use / HCI, at the same time, I worked with a large group of colleagues to formulate an initial perspective on design which, in my present vocabulary goes as follows [12]:

- design of a computer application is design of conditions for the whole use activity,

[1] References marked with [] are to my submitted work as it is listed in the beginning of this note. Other references can be found in Chapter 10.

- users and designers have different backgrounds and belong to different communities of practice,
- the users need to experience the future computer application in order to pose demands for it,
- the practice of the users is the starting point for design. At the same time they need to be confronted with, and to experience new ideas in order to transcend their own practice.

Based on these statements, my previous work in activity theory and in design, [6] went on to propose a research agenda for the 1990's:

1. Understand, and help users change their whole work activity in interaction with understanding and changing the computer application.
2. Grounding design in historical analyses.
3. Working to understand and deal with conflicts as resources in design.

In retrospect, I have worked closely to this agenda, though, as fortunately it always happens, new insights and opportunities have appeared that could not be foreseen. First of all, where the research agenda has a rather piecemeal approach to where activity theory fits in, I find that I am at present more able to see how the pieces fit together, *placing the ever changing computer applications in use as a centerpiece*. Secondly, shrink-wrap software has come to play a greater role, in the world of systems development and use, as well as in my work, than I foresaw. Thirdly, Randi Markussen (1994) did a lot of the ground work of historical analysis in the AT project, and my work was able to nourish from that. I have further had the pleasure of seeing my work picked up, and developed by two ph.d. students: Olav Bertelsen has developed an activity theoretical understanding of design artifacts (Bertelsen 1994, 1996, 1998), and Jakob Bardram (Bardram, 1997, 1998) has worked specifically in the area of design and evaluation of CSCW. Thus the process reflected in my writings has been one of expansion and development, as well as consolidation. This is the case as regards practical design work, conceptual and theoretical work, as well as research methodology. I find the development of our understanding of the computer as material and instrument of work of outmost importance. As illustrated by my work, however, I find it equally important to start from particular instances and work in close interaction with the particular problems of these particular cases.

1.2 Submitted work

The works that I have submitted for this dissertation consist of this summary note and 21 papers, the contribution of which to the overall perspective of the dissertation is outlined below. There is a certain irony to writing a dissertation summary like this in that on the one hand, it is a summary that should be readable without repeating all arguments and points made in the individual papers. On the other, I want the text to be

readable in its own right, bringing out a perspective that is not explicitly spelled out in the individual papers. I hope that I have found a balance where, on the one hand, the reader is certainly better prepared if he or she is familiar with my writings, but where, on the other hand, it is not necessary to have read all more than 20 papers to read the summary.

1. Bødker, S. & Grønbæk, K. (1989). Cooperative Prototyping Studies - Users and Designers Envision a Dental Case Record System. In J. Bowers & S. Benford (Eds.). *Proceedings of the first EC-CSCW '89*. Computer Sciences Company , pp. 343-357. Also in J. Bowers & S. Benford (Eds.). *Studies in Computer Supported Cooperative Work: Theory, Practice and Design,* Amsterdam: Elsevier Science Publishers / North Holland. 1991, pp. 315-332.

   [1] is a very early attempt to crystallize the cooperative prototyping approach developed by Grønbæk and myself as a means of dealing with future use in design. It is primarily reporting practical experiences from a rather limited setting, emphasizing the need to do immediate modifications of prototypes in such situations, but also the limitations of such, and the requirements for tools to support such prototyping. The setting is that of municipal dental clinics where we have worked with nurses, as part of an educational process to make these better actors as regards computer applications at their workplace.

2. Bødker, S. & Grønbæk, K. (1991). Cooperative Prototyping: Users and Designers in Mutual Activity. *International Journal of Man-Machine Studies, 34, Special Issue on CSCW,* pp. 453-478. Also in Greenberg, S. (Ed.) (1991). *Computer Supported Cooperative Work and Groupware*, London: Academic Press, pp. 331-359.

   [2] is the first, and most practically oriented in a series of four papers (out of which three (2, 4 and 5), are included here) about the work that Kaj Grønbæk and I did on cooperative prototyping with municipal workers in Grenå. The paper extends the early work done in [1], practically, and it starts to build a theoretical ground based on activity theory.

3. Bødker, S. & K. Grønbæk (1991). Design in Action: From Prototyping by Demonstration to Cooperative Prototyping. In Greenbaum, J. & Kyng, M. (Eds.). *Design at Work: Cooperative Design of Computer Systems*. Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 197-218.

   [3] is a practical introduction to cooperative prototyping. It uses the example from [1] as well as an example from my earlier work in order to give recommendations for tools, techniques and conditions for cooperative prototyping.

4. Bødker, S. & K. Grønbæk (1996). Users and Designers in Mutual Activity- an analysis of cooperative activities in systems design. In Engeström, Y. & Middleton D. (Eds.). *Cognition and Communication at Work*, Cambridge University Press, pp. 130-158.

   The bulk of the empirical work of [4] is the same as that of [2]. [4], however, relates to the background in the Scandinavian research tradition,

and discusses actors, conditions and artifacts of cooperative design activities. Furthermore, the paper develops a very specific set of questions to be used in the analysis of cooperative prototyping situations.

5. Trigg, R., Bødker, S. & Grønbæk, K. (1991). A Video-based Analysis of the Cooperative Prototyping Process. *Scandinavian Journal of Information Systems*, vol. 3, pp. 63-86.

   [5] presents a detailed analysis of one prototyping. Following along the line of analysis of [2 and 4] it looks at focus shifts, initiative, story telling, and recurring patterns of foci/focus shifts among the participants in cooperative prototyping situations. This leads to conclusions pointing out how cooperative prototyping sessions contain a richness of many different kinds of "conversations" mediated by the prototype.

6. Bødker, S. (1991). Activity theory as a challenge to systems design. In Nissen, H.E., Klein, H. & Hirschheim, R. (Eds.). *Information Systems Research: Contemporary Approaches and Emergent Traditions*, Amsterdam: North Holland, pp. 551-564.

   [6] is a programmatic paper discussing how a more profound anchoring in activity theory may change our research as well as practical agenda in systems development. Activity theory is seen as a framework for understanding the area as such, as well as for particular systems development projects.

7. Bødker, S. (1993). Historical analysis and conflicting perspectives - contextualizing HCI. In Bass, L., Gornostaev, J. & Unger, C. (Eds.). *Human-Computer interaction. 3rd International Conference, EWHCI '93,* Springer Lecture Notes in Computer Science vol. 753, pp.1-10.

   Based in activity theory, [7] develops and applies two techniques for analyzing human computer interaction, i.e. use, in context. The example used for the analysis is the VIRK system at AT, the National Labor Inspection, and the two techniques are 'historical analysis' and 'conflicting perspectives analysis' based on metaphors. The further development of the use of VIRK is considered in order to understand how the development of a computer application in use may be directed.

8. Bødker, S. (1996). Understanding computer applications in use - a human activity analysis. In Bøgh Andersen, P. Holmquist, B., Klein, H. & Posner , R. (Eds.). *Signs at work,* Berlin: de Gruyter, pp. 325-348.

   [8] is written for a book about understanding work (the semiotics of the workplace), thus emphasizing analysis of computer applications in use rather than designing them. Applying activity theory in this context is very much in line with how Wertsch (1988) uses one of the founding fathers of activity theory, Vygotsky. However, as the paper emphasizes, I see such an analysis as action-oriented, causing changes to the phenomenon studied, i.e. the computer application in use, rather than analysis "from the side-line" assuming to leave the phenomenon unchanged.

9. Bannon, L. & Bødker, S. (1991). Beyond the Interface, Encountering Artifacts in Use. In Carroll, J. (Ed.). *Designing Interaction: Psychological Theory of the Human-Computer Interface*. Cambridge University Press, pp. 227-253.

   In [9] Liam Bannon and I discuss the prospects of activity theory from the outset of breaking with the cognitivist paradigm in HCI as well as with the classical product-oriented approach (See Floyd, 1987) to systems development. We argue that in both cases the divide and conquer strategies result in a disembedding of the problems studied. Instead we see activity theory as a useful means of understanding and designing computer applications in use.

10. Bødker, S. (1996). Applying activity theory to video analysis: How to make sense of video data in HCI. In Nardi, B. (Ed.). *Context and consciousness. Activity theory and human computer interaction*, Cambridge: MIT press, pp. 147-174.

    [10] presents the accumulated analysis techniques developed in [7] and [8], and even [2], [4] and [5], aimed at an audience without deep insight into activity theory. The paper is part of a book collection on activity theory and HCI and should be seen in this context.

11. Bødker, S. (1996). Creating conditions for participation: Conflicts and resources in systems design, *Human Computer Interaction* 11(3), 215-236. An earlier version in Trigg R., Irwing Anderson, S., & Dykstra-Eriksson, E. (Eds.) (1994). *Proceedings of PDC '94*, pp. 13-20.

    [11] presents research theoretical reflections on what it means to do participatory design (research) in the 1990's. The paper looks back on the Scandinavian collective research tradition and discusses the actors, conditions and methods of the next generation of cooperative design and cooperative design research.

12. Bødker, S. , Ehn, P., Lindskov Knudsen, J., Kyng, M., K. Halskov Madsen (1988). Computer Support for Cooperative Design. In Tatar, D. (Ed.). *Proceedings of Conference on CSCW, Portland, Oregon, September 1988* (pp. 377-394), New York: ACM. Also in Marca, D. & Bock, G. (Eds.). *Groupware*. IEEE Computer society Press, 1992, pp. 82-99.

    [12] is a programmatic paper that set the agenda for our approach the then newly founded area of CSCW from our collective resource approach. The paper develops some rather interesting perspectives on what CSCW may be and on cooperative work in general. Some of these perspectives are developed further elsewhere, and some not. The paper presents a first vision of a systems development environment, based on participatory design experiences and on object orientation. This vision, called APLEX has lived on (mainly as a vision) to the EuroCODE project, where it has been realized in parts.

13. Bødker, S. & Christiansen, E. (1997). Scenarios as springboards in design. In Bowker, G., Gasser, L., Star, S.L. & Turner, W. (Eds.). *Social*

science research, technical systems and cooperative work, Mahwah, NJ: Erlbaum pp. 217-234.

[13] outlines an approach to the design of computer support for cooperative work (CSCW), where change is addressed in terms of expansion of the work practice associated with technological change. The framework was developed as part of the EuroCODE project and brings together experiences and theoretical reflections from this project and a number of earlier papers by myself and others. It introduces checklists and scenarios as parts of a new approach to a systematic design toolbox for CSCW. This toolbox aims to support learning by designers and users so as to facilitate the development of a cooperative design practice.

14. Bødker, S., Christiansen, E., & Thüring, M. (1995). A conceptual toolbox for designing CSCW applications. In *COOP '95, International Workshop on the Design of Cooperative Systems*, Juan-les-Pins, January 1995, pp. 266-284.

    [14] gives a presentation of the EuroCODE framework intended for a broad audience in need for a CSCW design method. The intent was to do this without letting go of some of our own reservations against methods. For this reason, the paper emphasizes the use of different combinations of tools from the toolbox, rather than a "linear" approach. It further emphasizes contradictions, and the insights coming out of contradictory statements, namely that of creative thinking.

15. Trigg, R, & Bødker, S. (1994). From Implementation to design: Tailoring and the emergence of systematization in CSCW. In Futura, R. & Neuwirth, C. (Eds.). *Proceedings of CSCW 94*, New York: ACM press, pp. 45-54.

    [15] discusses the process of adapting Word Perfect to shared use in a case study from the AT project. The main conclusion is that such as adaptation is in itself a process that takes form to manage the sharing and tailoring of the shared environment.

16. Bødker, S. (1998). Understanding representation in design. *Human-Computer Interaction* 13(2) 107-125. Earlier version presented at IMPACT workshop and included in the final report of CoTECH workgroup IMPACT.

    [16] is mainly a theoretical contribution to how we may understand design artifacts as mediators of design work in general, or as they are called here, representations. Based on the perspective that use / work is changing rather than stable, the paper discusses the constitution of representations as mediators of design and use.

17. Bødker, S. (in press). *Mediating technical platforms to support the development of shared work practices*, In press for CACM. Earlier version presented at COST 4 workshop: 4th Software Cultures Workshop, Vienna, November, pp. 91-102. Included version available as DAIMI-PB 539.

[17] follows on top of (Bødker, submitted for publication) and [15] in exploring the roles of human mediators in the development of computer applications in use; in one case in a Word Perfect environment and in the other an object-oriented systems development environment. In both cases, the human mediation of sharing and distribution is important.

18. Bødker S. (1997). Computers in mediated human activity. *Mind, Culture and Activity*, 4(3) 149-158.

    [18] explores a role of the computer not as a model for human cognition but through various ways in which it mediates human activity. It relies heavily on [10] in its example analysis.

19. Bannon, L. & Bødker, S. (1997). Constructing Common Information Spaces. In Hughes, J., Prinz, W., Rodden, T. & Schmidt, K. (Eds.). *Proceedings of ECSCW97*, Dordrecht: Kluwer, pp. 81-96.

    [19] focuses on the interplay between design and use of a particular kind of computer-based artifacts, common information spaces. As indicated by the title, the paper is in particular concerned with the emergent co-construction of such spaces by a variety of users in partly overlapping activities.

20. Bødker, S. & Halskov Madsen, K. (1998). Context - an active choice in usability work, *Interactions*, July+August 1998, pp. 17-25.

    [20] takes the starting point in how traditional usability work often tends to look at artifacts in isolation, and discusses ways in which the work practices of usability, as well as the quality of the products benefit from a focus on artifacts-in-use. The paper is based on the empirical work of the BIDI project.

21. Bødker, S. (1999). Scenarios in user-centred design - setting the stage for reflection and action. *Hawaii International Conference on System Sciences 32*. Version to appear in *Interacting with Computers*, 1999.

    [21] builds on the ideas about scenarios coming out of [13] and [14], and unites these with experiences from BIDI regarding how scenarios may be used to anchor cooperative design in real use situations, and explore future use.

1.3 Research context

My work has come out of the Scandinavian tradition of research in systems development. For me this means a concern for action research, organizational conflicts and human resources as discussed in [11]. In a way, the time period that is accounted for in this work, is the period where this tradition internationalized and confronted itself with both North-American and European research traditions. As reflected in my own work as well as that of many other researchers from this tradition, e.g. Kyng (1995c), this

confrontation has meant a diversification in terms of research theme labels that could be attached to our work. Participatory design is one label that I happily identify with. The present identity of participatory design it has from the confrontation between Scandinavian research and North-American ditto. The forming of the USA-based Participatory design conferences started in 1990. Not only did these conferences establish the name. They also forced Scandinavian (and other European) researchers to formulate their ideas in English to a wider audience and relating them to non-Scandinavian societal conditions, and as such they have been important for the development.

Through the UTOPIA project it became necessary for me to understand more of the, then, fairly young tradition of Human-Computer Interaction (HCI). I attended my first CHI (Computer-Human Interaction) conference in 1985, around the time when I decided explore this area further for my ph.d. thesis. At the same time, I worked to establish teaching in my department in this area, which meant a series of visits from researchers with insight into the American cognitive science-based HCI tradition as well as the German equivalent. This means that HCI is part of my general background and that cognitive science in many ways have served as a counter image to what I have wanted to achieve.

Partly out of HCI emerged the field of Computer Supported Cooperative Work (CSCW), a field that I have contributed to from the start, both through papers, participation in program committees and European task forces. CSCW is interesting in the way it unites a number of concerns that we had worked with [12], e.g. studying computer applications in real use settings and viewing use and work not as individual activities but as co-operation. CSCW further became an inter-disciplinary meeting place for a number of interesting research traditions focusing on the role of computer technology in use in real work settings, and design of such. Figure 1 gives a coarse-grained overview of how these research areas have been represented in the submitted work.

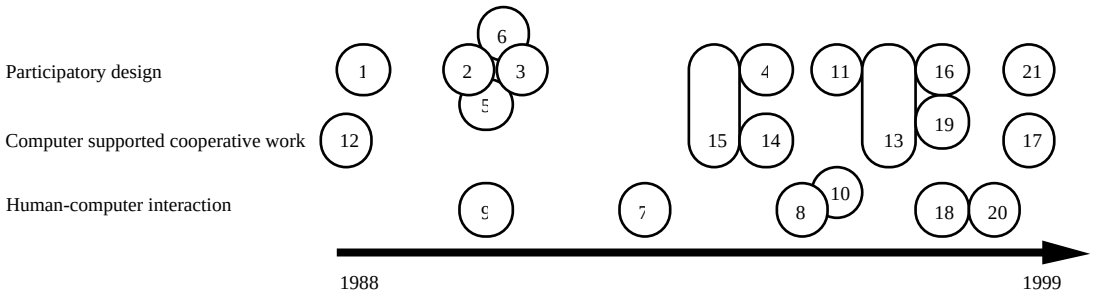

Figure 1. Submitted papers distributed over research area and time

	Computer applications in use	History	Tailorability	Design represen-tations	Proto-typing	Design activity
1					x	
2	x			x	x	
3					x	
4				x	x	x
5				x	x	x
6						x
7	x	x				
8	x	x				
9	x					
10	x					x
11	x					x
12	x			x	x	x
13	x	x		x	x	x
14	x	x		x	x	x
15	x		x			
16				x	x	x
17	x		x			
18	x					
19	x					
20	x					
21				x		

Figure 2. Recurrent research topics distributed over papers and time

Out of, and across these research areas have grown a number of themes that have been recurrent in my work in the past decade as part of the overall focus on the integration of design and use:

- computer artifacts in use,
- the historical development of computer artifacts and use, and the relation between the past, the present and the future that mutually shape each other,
- tailorability or understanding use as emergent organizational activity with structures, conditions and actors that goes beyond the individual,

- design representations, in particular scenarios and other kinds of work/use descriptions and the ways they mediate design,
- understanding and constituting of future use as part of design, e.g. through cooperative prototyping,
- issues of design that pertain to organization, resources and actors, and the situation of design in webs of activities.

These issues and insights have constituted the back-bone of what has come to be the perspective presented here and Figure 2 summarizes how they are dealt with in the submitted papers.

1.4 The development of research and design

My work and research approach are grounded in the action-oriented research tradition that is well-established in my department as well as internationally (see e.g. Kyng, 1995c). Adding to this is the grounding in activity theoretical approaches to understanding work and the interaction between human beings and computers in the widest sense. The activity theoretical research that I mainly identify with (e.g. Engeström, 1990, Engeström et al. 1996) shares the aim to be practically useful through action orientation with my own tradition.

Being action-oriented, my research tradition often proposes that elements of research method can and ought to be used as practical design method as well, though with due concern for purpose, available resources, etc. In each of the projects that are part of my work, we have used and developed a number of methods that are accounted for in my writings. The main projects are with Grenå Municipal office [2, 4, 5, 16]; AT, the Danish National Labor Inspection Services, Aarhus Branch [7, 8, 9, 10, 11, 15, 16, 17, 18]; EuroCODE [13, 14, 16, 21]; and BIDI [20, 21]. The methods applied and developed in these projects run on a number of different levels, some dealing with an overall research strategy, and some with a rather specific research problem. Thus, a total overview makes little sense, and I have instead chosen to summarize important activities and mediating methods of these main projects. These summaries will be used as a basis for further discussions in Chapter 6.

The Grenå Municipal project was laid out to investigate tools and methods to support cooperative prototyping, in particular hands-on experience with future use. It was a small project comprising of two researchers, 5-6 users, and a group of students and ran for the short time period of approximately one half year. On top of providing further insight into prototyping and hands-on experiences, we worked in the project with extended interviews, future workshops, and with video-based analysis of, and reflections on, a wider range of cooperative prototyping situations, introducing activity theory into the analysis (Figure 3).

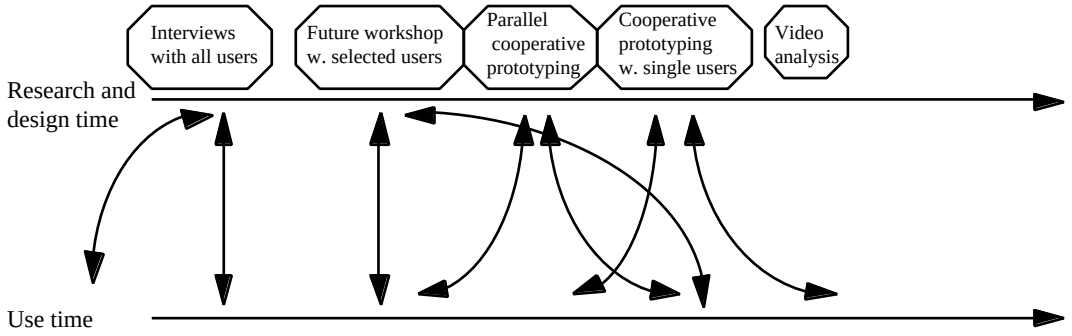

Figure 3. The Grenå Municipal project activities. The arrows indicate how the activities were concerned with present, past and future use, relative to research/design time.

The AT project was a much more large-scale effort with 6 researchers of different disciplinary backgrounds, active collaboration with a large user community lasting for more than 2 years with varying intensity (Bødker et al. 1993c). The project developed a number of types of workshops such as organizational games (Ehn & Sjögren, 1991, Mogensen & Trigg, 1992) and dilemma games (Mogensen, 1994). It worked with historical analyses, video analysis, re-framing of use through education, tailoring and design strategies related to the introduction of standard technology in organizations, to mention some of the important aspects (Figure 4).

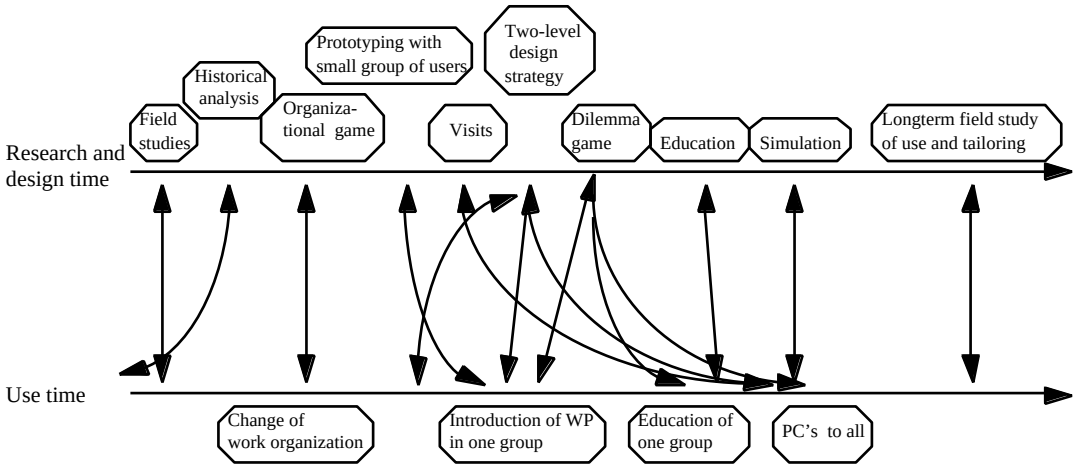

Figure 4. The AT project. The arrows indicate how research and design activities were concerned with present, past and future use, and how activities to directly implement change of use were undertaken along the way.

Both Grenå Municipal and AT developed a combination of activities where we worked with smaller groups of users, with wider activities, comprising larger groups or whole organizations, in some cases including management.

My participation in EuroCODE, a large-scale Esprit project (see e.g. Grønbæk et al. 1997) aiming to build CSCW in cooperation with future users at the Great Belt Bridge construction, was focused on two particular tasks, namely the evaluation of one particular prototype, and what was

called the CSCW framework. The latter is what I have published on, and the former in this connection served to link the particular empirical case with general knowledge of design and CSCW. From this particular angle, EuroCODE was a project where we worked to develop a CSCW framework in close interaction with the designers in EuroCODE who provided prototypes for the end-users. The interaction with designers took place through workshops aiming to make designers experience the use of the framework, and was partly based on our access to video recordings of previous design meetings (Bødker 1995, Bødker et al., 1993a).

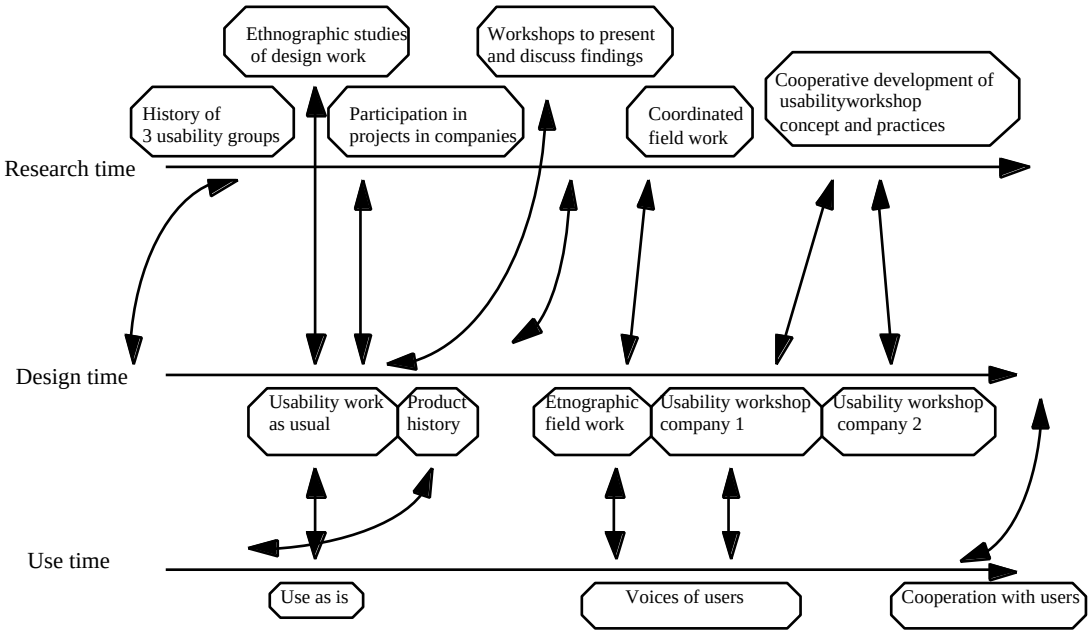

Figure 5. BIDI a multi-layered research effort aiming to study and to change design activities as well as use. The use time line in this figure indicate how usability people in various parts of the BIDI project have related to use: first by looking at use as it takes place and extracting test situations from that. Then by doing more thorough fieldwork, and by bringing the voices of the users into the design process, e.g. through video, and finally by cooperating with users.

BIDI is, just like my work in EuroCODE, a multi-layered research effort. In BIDI we work with designers / usability people in three companies, and these designers / usability people in turn cooperate with their users in designing and evaluating usable products in the domains of computer systems, mechatronics and HI-FI equipment. BIDI is a three-year-research project that we are half way through. At any point in time, 4 researchers have worked in the project together with participants from the three companies. The main emphasis of BIDI was initially to make the voice of the users better heard in design, and in this vain ethnographic field work and video analysis was important for the project ([20, 21], Nielsen 1998). In the next step, the focus was on cooperation within design groups, across disciplines and competencies, and in this the notion of usability workshops started to form, through a number of workshops carried out in the project ([21], Madsen & Petersen (in press)). The third step is to introduce real user

participation into the usability workshops. The BIDI project makes use of a double-reflection in the multi-layered strategy: We mainly experiment with and develop the same kind of approaches both in our joint investigations in the project and in the design and the usability work that the companies do with their users (Figure 5).

Use is indeed not static and independent of how research and design proceed. This problem or asset is part of the challenges of the perspective introduced in this summary.

1.5 The perspective

An initial formulation of the particular perspective of this dissertation is to understand computer application in use *and* design: Computer applications are very central artifacts of work in our world today, as *mediators* of our everyday activity. Activity theory gives a useful handle for understanding these mediators, and how they are shaped, in a dialectical relationship with the changing practice of the work in which they are used. Understanding in this vocabulary is primarily methodological: ways and means of framing, probing, working with, and constructing. My interest in the computer applications or artifacts is *design*-oriented, i.e. directed towards changing them, and understanding them as changing and as part of change. I am seeing the computer application (even when built) as a source of changing practice. This is indeed a way of viewing *learning as fundamental to our everyday existence with computer technology, an existence that consist of use as well as of design*.

This perspective makes it necessary to see design as *co-construction* of the future use activity. This co-construction goes on between designers and users, even in situations where there is no apparent cooperation between them: Designers cannot predetermine and prescribe users' actions anymore than users can apply a particular piece of technology exactly as they like. Activity theory offers help in understanding how this co-construction happens, as well as how it may be improved and supported by various artifacts, to understand work and envision the future. *Hands-on* experience is important as a particular way of getting to grips with a future computer application and its use.

Looking at design as co-construction further underlines that design is a multi-practical activity, where the experiences, resources, tools, etc. of designers meet, and sometimes clash, with those of the users, and with other involved parties in a number of inter-linked, and partly overlapping activities. In [3 and 4] we see how this co-construction unfolds “in the small” between situations that are truly cooperative, and those where designers and users have their different motives, purposes, instruments and agendas in design. Figure 6, adapted from [4], shows where the computer application, as material, instrument of design and use, and as product is involved in this.

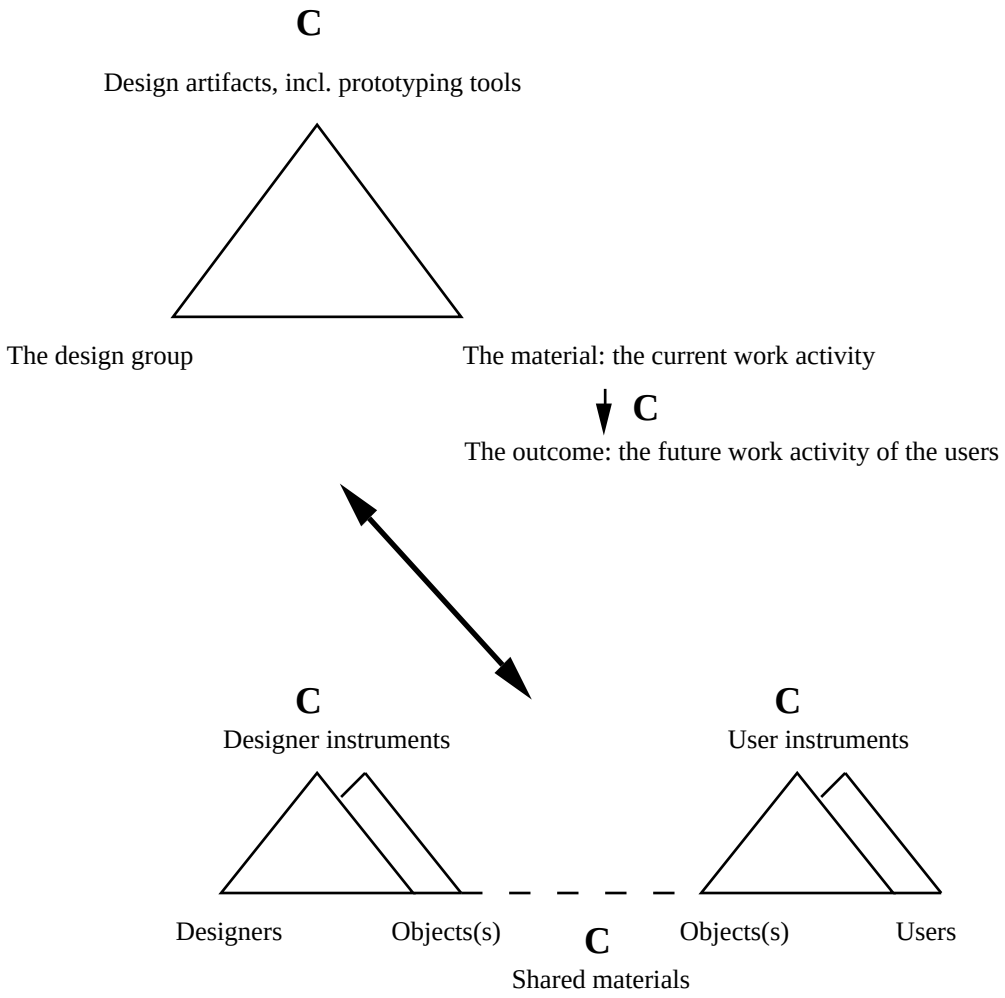

Figure 6. Co-construction between truly cooperative situations and situations where designers and users have their different purposes, instruments and agendas in design. In [4] this analysis is used to reflect on the practice of researchers/designers in their meeting with users in cooperative prototyping. The point is that sometimes the designers and the users share purpose and instruments of the activity. In other parts of the unfolding course of events, the users do their things (such as actually doing their work) whereas the designers do theirs (such as being concerned with timing of the prototyping session, or changing of the prototype). I have added C's in order to indicate where the computer artifact, as material, as instrument of design and use, and as product, is potentially involved in this.

Generalizing this picture is rather complicated, though never the less at the core of this dissertation. As illustrated, e.g. by [3, 4 and 10], activity theory is useful in reflecting on such multi-practical encounters in the web of activities of design and use of computer applications.

Overall, I see the main contribution of this dissertation as the crystallization of this action-oriented perception of computer applications in use. This means that the contribution is mainly methodological, as ways of working with computer applications as they are developing in design and use, and setting up technical, organizational and other resources to sup-

port this development of use. In other words, *the dissertation is mainly concerned with design artifacts in their widest sense: theories, techniques and tools, which can be applied when working with integrated design and use*.

The kind of learning and development that the perspective supports is not only a matter of "small" communities of practice changing their artifacts within an organization. Brown & Duguid argues that organizations which are capable of developing are the ones which are able to bridge the gab between their actual practice, and their "espoused practice" - the rules, regulations and norms that the organization claim to live according to. This kind of bridging is exactly what the developmental perspective is about.

1.6 Structure of the summary

The remainder of this summary is structured as three chapters that go deeper into the perspective. The first of these chapters (Chapter 2) discuss how the underlying activity theoretical concerns are used to establish and extend our understanding of computer applications in design and use. In Chapter 3 I choose a number of more specific topics as starting points for a further, deeper summary. These topics reflect the recurrent issues outlined in Figure 2, shaped and expressed in the theoretical terms used in this summary. These topics relate to different activities in the web of activities of design and use of computer applications. They reflect areas where I have worked most substantially. Chapter 4 discusses the practical design implications of the perspective. Chapter 5 and 6 relate my work to writings of other researchers, and discuss research method. Chapter 7 discusses future work.

1.7 Acknowledgments

I have used examples and data from a number of larger and smaller projects conducted over the years, chiefly the dental assistants [1, 3], Grenå Municipal office [2, 4, 5, 16], AT, the Danish National Labor Inspection Services, Aarhus Branch [7, 8, 9, 10, 11, 15, 16, 17, 18], EuroCODE [13, 14, 16, 21], and BIDI [20, 21]. These projects are a very important part of my research and of my working life, and they are most often what make it all worth while.

Whereas writing my ph.d. thesis was a lonely task, I have, for this work had the opportunity and pleasure of working with 9 co-authors most of whom are present or former colleagues from Aarhus University. Adding to this are several more, with whom I have worked, without the work making it directly into the list of submissions and references here. Together with the rest of what is now known as the DEVISE center, they have been a great source of inspiration, discussion, and hard work. Too

many to mention individually, I am grateful to all of these people for their cooperation. When writing about my work, I often think in terms of ‘we’ and not of ‘I.’ When writing a summary like this, it is however, for good and for bad, necessary to move beyond these different ‘we’s’ to get at what ‘I’ have contributed. I hope that I have succeeded without loosing the anchoring in these important ‘we’s.’

Funding for the work has been provided by Aarhus University through the Department of Computer Science, and through the Aarhus University Research Fund; by the Danish Research Councils through the PIFT program; by EU through Esprit III (EuroCODE), Human Capital and Mobility (ENACT) and COST action 14, CoTECH (IMPACT); by CIT through BIDI, CIT project 23; and by the Danish National Research Foundation through the Center for Human-Machine Interaction.

Dan Shapiro, Lancaster University is kindly acknowledged for setting up the IMPACT group, and ENACT network. He, and the rest of the two, partly overlapping groups have provided some very inspiring insight and discussions. Through the ENACT network the CSCW Center at the University of Limerick offered an environment to get started on this summary. Liam Bannon, Olav Bertelsen, Ellen Christiansen, Morten Kyng and Preben Mogensen have provided many useful comments and constructive criticism to this summary. Helle Holm-Nielsen has been a great help as regards language improvements and practical matters.

My son Jonas, who was born in 1990, has provided an important counterbalance to work in the years of doing the research that is accounted for here, and I dedicate this summary to him.

2

Computer applications in design and use - a developmental perspective

There is a computer in my laundry machine, my cellular phone, and there is my computer at work. And they only do the same for me at a very abstract level. What they all do, however is to *mediate* my daily activities, whether these are in relation to things or other human beings. Activity theory has been concerned with this kind of mediation by a variety of mundane tools (See Kaptelinin, 1996) and my particular concern has been for the mediators that are constituted by computer technology. My work is concerned with understanding the clay of computing, the materials we are working with, the impacts of the products on use, and vice versa, the importance of use for products.

The original writings of Leontiev (1978, 1981), Vygotsky (1962) and newer work in activity theory such as (Engeström 1987, Wertsch 1991, 1998) provides, I propose, useful perspectives on:

1. artifacts as *mediators* of human work. This perspective was further developed for computer artifacts in (Bødker, 1991),
2. human work, making it possible to develop an understanding of how design and use are *interlinked*, and linked with other activities of importance to our understanding,
3. *learning* mechanisms as driving forces in situating and changing use.

In the following I will summarize how these three components can further a design-oriented perspective on computer applications. Readers who need a definition of the concepts used in my writings are referred to the Vocabulary (p. 85).

2.1 Computer applications as artifacts

Activity theory assumes an asymmetric relation between people and things, in contrast to the proposal of a symmetric relationship offered by cognitive science or various brands of computer science, where computer programs and human behaviors are modeled using the same language and methods (see further discussion in [9, 18]). Activity theory places com-

puter applications, along with other artifacts as *mediators* of human activity (See Bødker (1991) [7, 8, 9, 10]). Through a set of dynamic concepts (activity, action, and operation) it makes important features of human endeavors stand out, and makes us focus on the context of use, instead of seeing computer use in isolation.

Any (use) activity is social and motivated. Since artifacts most often mediate several activities, computer applications and other artifacts are situated in a web of activities as discussed further below. Each activity is conducted through *actions* of individuals, directed towards an object or another subject. Activity is what gives meaning to our actions, though actions have their own goals, and the same actions can appear in different activities.

Each action that a human being conducts is implemented through a series of *operations*. Each operation is connected to the concrete physical or social conditions for conducting the action, and it is "triggered" by the specific conditions of the situation. These operations are often *transformed actions*, i.e. we conduct them consciously as actions in the beginning. Through learning we transform them into operations, but on encountering changed conditions, we may have to reflect on them consciously again, and thus make former operations once more into conscious actions.

Artifacts, in a human activity framework, have a double character: they are objects in the world around us which we can reflect on, and they mediate our interaction with the world, in which case they are not themselves objects of our activity. This standpoint activity theory is not alone with: Polanyi (1967) talks about focal and subsidiary awareness, Winograd & Flores (1986) (borrowing from Heidegger) talk about ready-to-hand and present-at-hand. In normal use situations our handling of artifacts is done through operations, and is not conscious to us. When we have difficulties with artifacts, the world does not come to a stand-still: Breakdowns lead to "new" operations that "work around" the problems, so that we can carry on.

This perspective on the nature of artifacts leads us to study *artifacts-in-use*, not in isolation. And we need to study *specific use activities* ([2, 4, 5, 7, 8, 10, 15, 17, 20]. We further need to be concerned with the *division of labor* that historically has caused a separation between the needs of the individual and the purpose of the activity in which the person takes part [10, 15, 17].

Artifacts are seen as historical devices that reflect the state of practice up until the time that they are developed. This practice in turn is shaped by the artifacts used, and so on. Artifacts can be characterized as *crystallized knowledge* which means that operations which are developed in the use of one generation of technology are later incorporated into the artifact itself in the next. Thus to learn something about the present shape and use of an artifact, a *historical analysis of artifacts* as well as of practice is important.

In (Bødker, 1991) as well as [7, 8] a more detailed understanding of computer-based artifacts-in-use is developed, an understanding that I re-

turn to in Chapters 5 and 6. Though use develops, the analyses such as [7 and 8] point out that it is not any development that can result from use. The computer application constrains or disciplines use through what kinds of operations it allows the user to form, through the kinds of uses that it lends itself to, physically, handlingwise and with regard to the foci that the user is "offered" in or through the computer application.

2.2 Design and use as a web of activities

In my current perspective, design cannot be separated from use, though, in some cases, design activities take place somewhat remote from use. Design is collective and multi-practical. Independent of whether design involves a participatory strategy, designers interact with future users, managers, etc. to understand what the computer application is intended for. A consequence of this is that design is inherently a co-construction process since designers cannot predetermine and prescribe users' actions anymore than users can apply a particular piece of technology exactly as they like. Design creates a new practice, and changes the practices of everyday work, both to the extent that users participate in system development, and because it changes the instruments of work. Bertelsen (1998) discusses how design takes place in a boundary zone where heterogeneous practices meet to create the new, emphasizing the multi-voiced nature of design.

As Ehn (1988) points out, designers work in the space between tradition and transcendence, both regarding the practice of design and the practices of use that design is concerned with. In [13, 14] we seek inspiration in Ricour (1988), talking about the space of experience and the horizon of expectation. Ricour sees expectations always in the light of experience, and experience always from particular expectations. Design deals with both experience and expectation making it essential to locate use, and use-in-design in relation to already known use activities as well as possible future ones (for a specific discussion of use activities in terms of context of artifacts such as computer applications, see [20]).

In design we need to hold on to something not-yet-known, the future product, which is also the future instrument of work as seen from the point of view of use (Bødker, 1991). Various kinds of design artifacts, or as they are called in [16], representations play an important role in this endeavor. One kind of design artifacts that I have been particularly concerned with is scenarios [13, 14, 21] another is prototypes [1, 2, 3, 4, 5]. They are shared between system developers, and to some extent with other communities of practice, e.g. that (those) of future use. Bertelsen (1998) proposes to view design artifacts as clusters of primary, secondary and tertiary artifacts that lend themselves to different uses (primary artifacts) at the same time as they are, or contains, models or explanations of these uses (secondary artifacts), and tertiary artifacts that points towards the new. This points to three important purposes of design artifacts: to support trial use or hands on experience, to support conceptual understanding of them

and their use, and to support their innovation. As pointed out in a number of my writings [2, 3, 4], it is important that design artifacts lend themselves to trial use, i.e. to various sorts of hands-on experience be it in real or simulated use settings. The secondary level, its possibilities and limitations are discussed in [13 and 16], along with the capabilities of such representations of supporting creation of something new.

When we distinguish between a computer artifact as material and as the mediating instrument, we see that these two sides are profoundly intertwined: Design actions are continuously taking place in use and in breakdowns leading to a changed use (Bødker 1991). When doing prototyping where hands-on experience is provided for the users (e.g. [2, 4]) use become part of design. [2] discusses in general how prototyping moves back and forth between these two kinds of actions, and how these clusters of actions may at times be little different from activities (see Figure 6). The paper introduces, for the purpose of studying these moves or transformations, the notion of a web of activities.

Using Engeström's (1987) notion of an activity system it is possible to summarize how a computer artifact may have positions in a variety of activities in the web of design / use activities. As discussed by Engeström (1987) as well as by Mathiassen (1981) it is the tensions or contradictions between these positions that are the source of change.

- Computer artifacts are mediators of the human endeavor to create a product from materials, but not only that, they often mediate the cooperation and coordination of the activity as well (Figure 7).

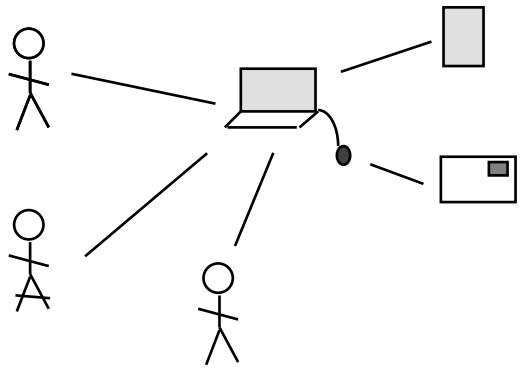

Figure 7. The computer artifact as mediating both cooperation between people, and between people and their materials, that get turned into products.

- The computer artifact is material and outcome of design, though there may be other materials and outcomes as well (Figure 8).

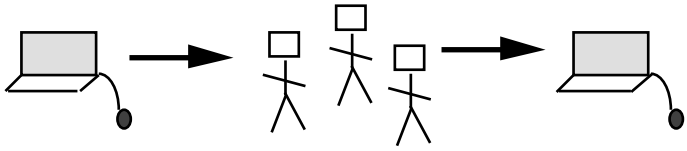

Figure 8. The computer artifact as material and outcome of design. The arrows indicate the transformation from material to outcome.

- The computer artifact may be adapted to, and used in a variety of different work activities (Figure 9).

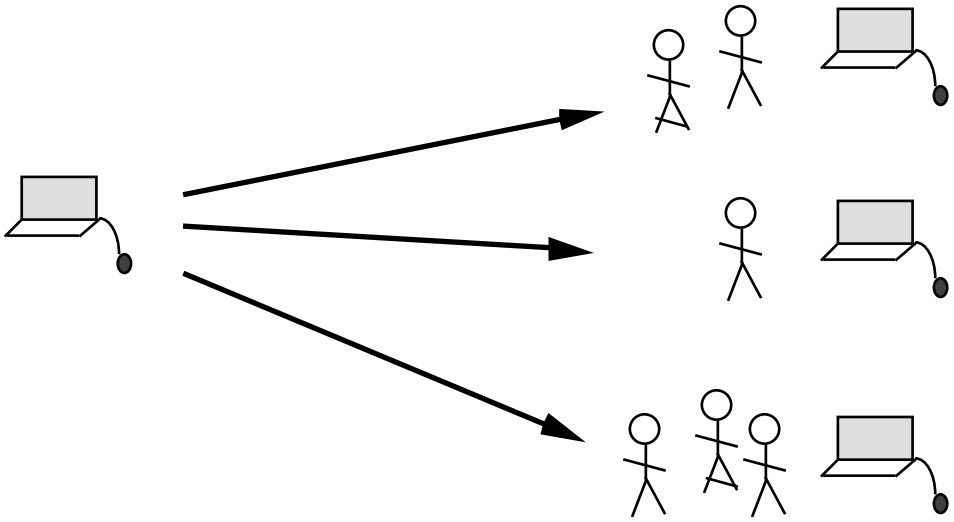

Figure 9. A computer artifact developed into mediation of several activities

- In design as well as in use, computer artifacts that are somewhat more advanced or different in interesting ways are important guiding lights and causes of tension. The heterogeneous developments of a computer artifact in a variety of different settings are further sources of inspiration for users and designers (Figure 10).
- Where learning in use is essential to the understanding of use and design, separate activities of education and training of designers and of users are an equally important concern regarding the location of the computer artifact in the web of activities (Figure 11). An example from the AT project (Bødker et al., 1993c), illustrates how education of users change the computer application, VIRK-in-use.

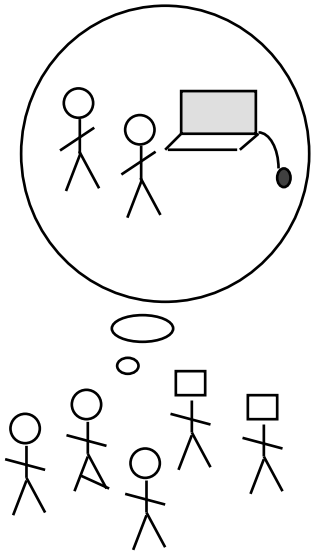

Figure 10. A different use activity as guiding light for design and changed use

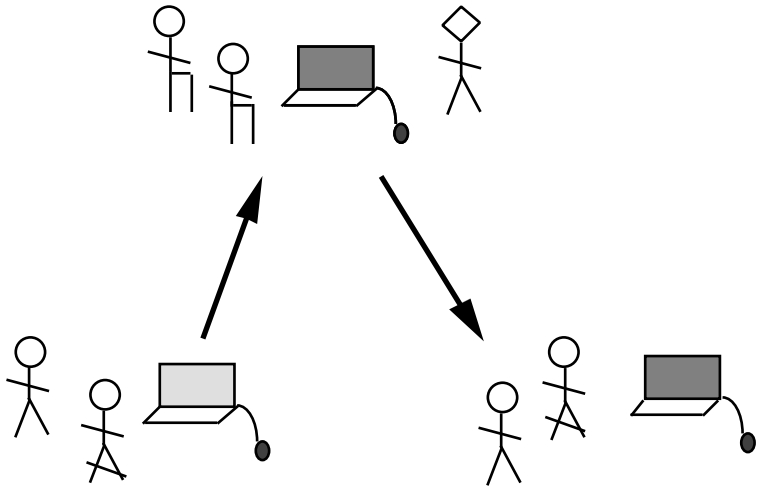

Figure 11. Education as a means of changing the computer artifact-in-use

- Activities that are producing tools, rules, language, and materials for design are often based on, and results in computer artifacts as well (Figure 12). In Bødker & Bertelsen (1998) we were e.g. concerned with the development of an object-oriented debugger, Valhalla – a computer-based design tool, that is built for the BETA- language. The constructors of Valhalla used the BETA environment as their material and artifact as well.

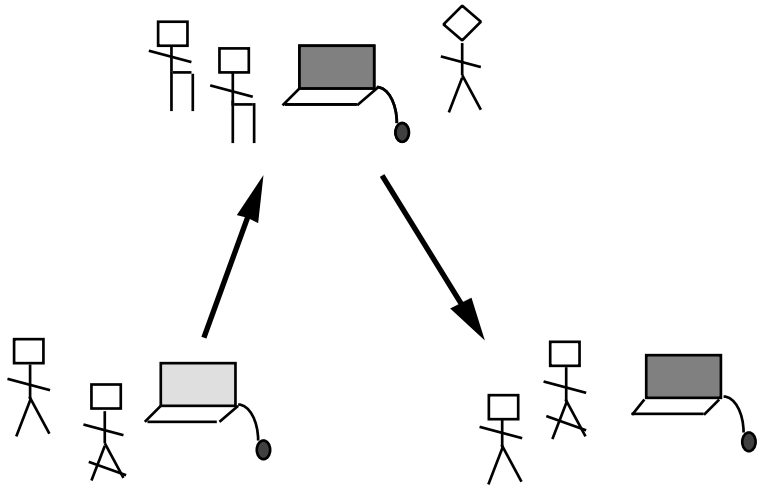

Figure 12. The designer education activity change computer artifacts-in-use in design

Looking at design and use as parts of webs of activities is a basis that can be contrasted to, or supplemented with analyzing the specific actions that take place, through which design as well as use is carried out (sometimes in separate activities, sometimes not). This more process-oriented view emphasizes the continuously ongoing development and constraining, and thus the continuous transformation of the computer artifact. Studying a particular computer application in all or some of the activities in a web, or studying the actual design / use processes through the transformations between these positions, allows for focus on conflicts and tensions between positions. These tensions may eventually lead to the change of the computer application in one way or other (Figure 13, see also (Mathiassen, 1981)).

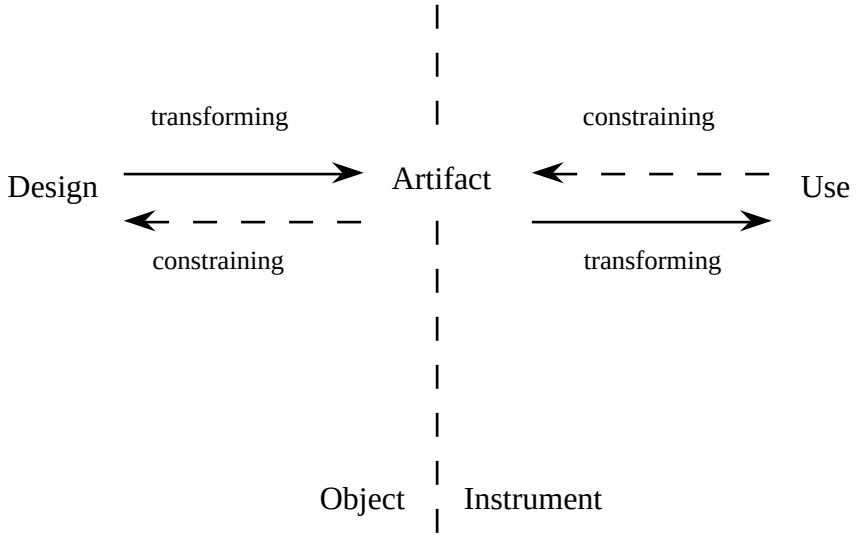

Figure 13. The computer artifact as object and instrument in the ongoing transformations of design and use.

Several of the activities in the web of activities of design and use are multi-practical in that at least users and designers participate. The computer artifact thus not only crosses borders between these practices, it often is the main mediation between the two.

2.3 Design and use as learning

When we use a computer artifact it is a development process in which the computer artifact changes. Gasser (1986) has documented how the use of what is often perceived as rather rigid computer applications develops beyond pure adaptation by the user, through what he calls workarounds. This means that even such computer applications that strongly constrain use, and where technical reconstruction or tailoring is difficult, get transformed in use. Learning is essential because what Gasser talks about are complicated operations developed through use. Such observations form the basis for proposing that systems development is a continuous learning and re-design process [6], integrating design and use, based on an understanding of the interplay between technological and social change [13, 10].

Learning in terms of operations that get formed and break down is one aspect of learning seen from the point of view of activity theory. In a way the essence of Bødker (1991) is how computer applications may be shaped to support such smooth forming of operations, hinder breakdowns, and when they happen after all, support the recovery from breakdown situations. The transparency of handling the computer artifact thus achieved, is certainly important. As pointed out, e.g. by Bardram & Pedersen (1994), this view is mainly considering the level of actions and operations of use, whereas similar moves happen between the levels of actions and activity, having to do with the motives of what we do. Use of the artifact, as described by Bødker (1991) is a process where the use of the artifact looses its own meaning and become integrated in a variety of “real” work activities, in some cases carried out by the same people, in other cases by different ones. In an attempt to extend beyond the handling of artifacts, [13] brings together a theoretical framework making it possible to outline an approach to the design of computer support for cooperative work (CSCW), where change is addressed in terms of *expansion of the work practice* associated with technological change.

In Bødker & Graves Petersen (submitted for publication) we discuss the issue of learning in use or development of use of artifacts such as computer applications. We are particularly interested in how the artifacts support or prevent learning in use, an issue that was also discussed for particular user interface mechanisms in Bødker (1991). We make use of the understanding of transparent interaction introduced by Bardram & Bertelsen (1995) for an activity theoretical perspective on how learning in use of computer applications may be supported by the artifacts themselves, and extends this perspective both methodologically and practically. The proposal is to base learning of use on a condensed version of the

design / learning which resulted in the shaping of the artifact. This idea was originally developed by Engeström (1987) in interconnecting his proposed learning cycle with the part of the methodological cycle that aims to spread expansive learning from a micro-cosmos to larger groups.

Design is characterized by moves from operation to action, from action to activity: When operations break down new ways of working get formed, helped or hindered by the artifact. As described in [15] this is not only an individual process, it is a process of collaborative tailoring; of designing "in the small". In other cases, design includes re-conceptualization of the work / use activity as such in order to deal with the possible anticipation of the new. Future use cannot be derived from an understanding of the old, nor can it in other ways be fully anticipated. Yet, we want to be able to think about, reflect on, and to some extent direct the future. In Engeström's (1987) development cycle, he builds on the idea that to transcend the present it is necessary to think creatively about the new, at the same time as one can never fully predict this. This means to move beyond the immediate learning in use / work on top of this basis of learning in use. Engeström works with four level of learning in work, where the top one is what he works for, and have a vision of, development of work. Engeström, and along with him Bertelsen (1998), seeks inspiration from the work of Wartofsky's (1979) tertiary level, where he talks about "imaginative" artifact or "springboards", as artifacts of such development. He further talks about heteroglossia, or multi-voicedness as a way of letting different voices participate in the creation of the new. In [13] we use these concepts in developing actual springboards for design. These thoughts are in some ways quite similar to Madsen's (1987, 1994) Schön-inspired talking about metaphors. Bertelsen (1998) develops further ideas and understanding of tertiary artifacts based on Engeström (1996), where these are seen as a basic concept in understanding creativity and innovation as material phenomena, thus transcending the heritage of activity theory of being destined for one path towards something better.

2.4 An initial stance

Use as well as design transform or develop the computer application, at the same time as the computer application constrains or disciplines use and design. First of all, in normal work / use of e.g. a text editor, we use the menus, functions, etc. as more or less intended by the designers, and the constraining is much stronger than the development. Secondly, as illustrated by Gasser (ibid.) and my own material [15, 17], the use of rather rigid computer applications develops beyond pure adaptation by the users. I propose to use these empirical facts actively in understanding and designing computer applications: By insisting on focusing directly on transforming and developing the computer application it is possible, and desirable to focus on *the developmental character of a computer application in use*. However, this activity is also constrained and disciplined by the computer

in various ways, through the actual, available "clay" or materials as such (see e.g. Bødker et al. 1987, [9]), through the past experiences of designers and users ([2, 15, 3]), etc. The constraining from design material is described by Schön (1983) as "backtalk".

In this discussion, design is inherent in the use of any particular computer application. Certainly much everyday use has very little development character, and may immediately be understood best as rather static. However, *it is a main point of this summary that it is exactly the tension between design and use, between transformation and constraining, where the human users learn and develop the computer application, that is the driving force of developing computer technology*.

Here we find an interesting problem - is "the same" computer application involved in all of these activities? On the one hand, the computer application is different seen from each of its different positions as artifact / tool (Figures 7-12). On the other hand it is an important concern how experiences with the computer application, as tool or material transfers between activities, and what happens when activities overlap such as in cooperative prototyping. Between and within these various activities, there are tensions, as described by Engeström (1987), which heavily influence our understanding of computer application. It is, however, exactly this malleable nature of the computer application that we wish to get to, in order to understand how it is constituted.

The computer application is constituted in the field of tension between use and design, as well as in the field of tension between *uses*. It is positioned as instrument and as object (Figure 13) of these various activities. *The tensions between the various uses are an equally important driving force that we must be concerned with when developing computer artifacts*.

3

Computer materials and artifacts and the activities that shape them

This chapter presents a summary of the contributions of the dissertation that adds deeper insight and more substance to the overall understanding presented in the last chapter. The presentation will be structured based on the web of activities of design and use (that are crystallized in figures 7-12). However, it will run orthogonal to the headlines of Chapter 2 in that it will emphasize the mediating, multi-purpose and developmental nature of the computer application. The structure does not reflect separate activities of my research as such, rather they present different analytical foci on a fairly large empirical and theoretical material. Though the web of activities of design and use are used as an overall structuration principle, I have never worked systematically and with even weight on all activities, and thus it is not possible, or desirable, to create that balance in the presentation.

Mediation of work (Figure 7) is in focus in both 3.1 and 3.2. 3.1 focuses on the computer application as tool for producing an outcome, whereas 3.2 focuses on the particular aspects pertaining to cooperation in work, in particular in work settings that are distributed over time and space. In a different vocabulary, 3.1 deals with typical human-computer interaction matters whereas 3.2 is about computer supported cooperative work. 3.3 is concerned with development of, and in, use. This includes the activities and actions that go into tailoring computer applications for particular settings (Figure 9) along with e.g. educational activities that take place to shape use (Figure 11).

Section 3.4 moves to a more design-oriented focus, looking at the interplay between design and future use (Figure 10) through cooperative prototyping. Section 3.5 deals with a particular activity in support of design (Figure 12), namely that of creating design artifacts. Creating design artifacts is interesting for the summary both because of the overlap between what is computer-based design artifacts and what is computer-based artifacts of use, and because design is heavily dependent on good design artifacts. I will delimit myself from discussing design education, and even use education in general, because I have not written about these topics. I will end with section 3.6, which looks at computers as materials and outcome of

design (analogous to Figure 8) in order to substantiate the stance of this summary further.

3.1 Mediation of human work

In (Bødker, 1989, 1991) I went fairly directly for creating an alternative to traditional HCI, based on activity theory. The book provided a theoretical frame for understanding user interfaces, as seen from the point of view of use. In [9], Liam Bannon and I discuss the prospects of activity theory from the outset of breaking with the cognitivist paradigm in HCI as well as with the classical product-oriented approach to systems development (See Floyd, 1987). Fundamental for our choice of activity theory as a candidate for improving HCI theory and practice is the critique of the cognitive paradigm. We argue that the paradigm has a static perspective on the use of computer applications and that it avoids dealing with how computer applications change practice of use, with how users develop their use of the computer application and their whole work practice. Insisting that all human activity is mediated, leads to a useful understanding of the basic relation between a human being and a computer, namely computer applications as mediators of human work. This perspective makes it possible to emphasize context and development, two areas that I laid the ground work for in (Bødker, 1991). As discussed in [18], it leads to an understanding of the prototypical things that computers can do for us, and, in particular, how they do these things for us, when they mediate our daily activities.

[2, 4, 7, 8, 10, 11] develop activity theoretical instruments of design and analysis of use as mediators of human work, in particular human-computer interaction. These instruments and their underlying understanding of computer applications can be summarized as follows:

Computer applications mediate a web of activities, actions and operations as well as shifts between them. This web may be identified by asking why, what and how of the foci of activities. The focus points - being involved with different objects and subjects through, or in the artifact is partly determined by the purpose of the activity, and partly by the "intrusion" in breakdown situations.

The tracing and mapping of foci and focus shifts [7, 8, 10], apply the questions of why, what and how to distinguish between breakdowns interrupting use and other kinds of focus shifts. Such tracing may be carried out to analyze use, as well as a variety of use-in-design situations. E.g. [8] discusses the application of this mapping technique for analysis of real work situations as well as for e.g. demonstrations of applications by a user to a researcher, and points out that such sessions may well provide short-cuts for understanding problems of real work situations.

Artifacts are historical devises that crystallize the work practices of the time they were developed. This crystallization makes historical analyses of

work activity and artifacts essential for understanding the present and the future artifacts [7, 10].

The analyses such as [7 and 8] point how the development of use is directed by the artifact. The computer artifact constrains or disciplines use through what kinds of operations it allows the user to form, through the recurrent breakdowns that appear, through the conceptual understanding that it offers to the user - through the kinds of uses that it lends itself to, physically, handlingwise and with respect to the foci that the user is "offered" in or through the computer application (Bødker 1991) and [10].

The core of the analysis outlined here has been used, and further developed in the small, by a number of master thesis projects over the last years, and as such it has found an operational form as research / design approach (such as it is presented in [10]). Many of these have touched upon the shaping of the computer application for particular examples, and as such they have all helped seed an understanding of the clay of computing in terms of particular configurations of menus, scroll-bars, windows, etc.

3.2 Mediation of shared and distributed settings

According to the activity theoretical framework, use is not individual. In my attempt to look beyond individual use, the area of computer supported cooperative work has been of particular relevance. This is both because of the domain of CSCW, groups of people cooperating through computer applications, and because of its research methods. [12] was one of the first papers discussing the (often implicit) small group ideal of early CSCW: the assumption that for all work, the ideal form of cooperation was that of a small research group without hierarchy and resource shortage. This ideal has later been further discussed by e.g. Bannon & Schmidt (1992) and in Bødker & Mogensen (1993). The main points that [12] makes include the following:

1. It is important to understand the practice of cooperative work, rather than its ideal (in an abstracted / abstract sense) - "cooperative work is many folded and domain dependent".
2. CSCW should be looked at as a process rather than an ideal (this is developed further in (Bødker & Mogensen, 1993)).

Where Bannon & Schmidt (1992), and later work of Schmidt (1993, 1994) moves the discussion away from the small group ideal and into the world of real cooperation, they still make definitions of what is cooperative work and what is not. Bødker & Mogensen (1993) discuss how it makes more sense to look at cooperation as taking place in all kinds of work, seeing CSCW as an attempt to improve the mediation of cooperation in work (See also Raeithel 1992, Kaptelinin, 1996, and Bardram 1998). Whereas much CSCW literature considers more or less simultaneous (though not necessarily real-time) cooperation, [15, 17] point at problems caused by long-term cooperation.

From this perspective, in particular participatory design and prototyping becomes significant for design of CSCW. My own work has aimed to establish an understanding and design practice that is concerned with the shared development in use of computer applications [15]. I have in particular worked with prototypes and other design representations in cooperation in systems development [16, 17). I have extended the analysis of computer applications in use to encompass cooperation, and brought back experiences from empirical studies of CSCW into the realm of systems development [13, 14]. [13] brings together experiences and theoretical reflections from a number of earlier papers by myself and others, but it is also new in its approach to a systematic design toolbox for CSCW. [15, 17, 19] look at the work in terms of tailoring and structuring of tailoring as well as use that goes into sharing computer applications.

In order to understand more about how artifacts are formed in, and take form from, practice, several researchers from the activity theoretical tradition, among them myself [16], have found inspiration from CSCW. Brown & Duguid (1994) introduced the term 'portable contexts' in order to discuss how a variety of artifacts such computers may or may not 'travel' between use contexts. In doing this, they are indirectly normative in pointing out that computer applications rarely carry with them their context or practice of use, and that they are not secondary artifacts to any significant extent because they are not mediating explanations of the role of the primary artifact in particular activities. [20] discusses the issue of contexts of artifacts as important for design and not only for use, [16] discusses the notion of portable contexts in relation to design artifacts, and [19] picks up some related issues in relation also to the concept of boundary objects (Star, 1989, [13, 16]), a concept used in order to identify the capabilities of artifacts, in particular representations within and between activities. In [19] we discuss a particular kind of boundary objects, common information spaces (CIS). The paper illustrates their dialectical nature, emphasizing on the one hand the open and malleable role of a CIS within a community of practice, and, on the other, the role of CISes as boundary objects, packaged and immutable for being shared across contexts and communities of practice. It discusses the tension between frontstage and backstage needs (in the sense which Giddens (1990) uses Goffman's (1963) terms) as an important force in shaping the CIS. Common information spaces are in some cases constituted for collaborators that are co-present in time and space, whereas in other situations they are constituted across time and space boundaries, and the mechanisms used to support 'holding in common' the information varies accordingly. This type of analysis may be elaborated on a variety of levels, and in short, it requires added work to place items in common, work that would not be required if it was not for the CIS.

When looking beyond one user-one computer situations, my activity theory-based work has helped enrich our understanding of computer applications. This is made possible through: reflection on artifacts in their multitude of positions in the web of activities, their position as secondary artifacts dealing with the meaning of the actual doing of work, and as tertiary artifacts providing starting points for the development of the use ac-

tivity. Boundary-crossing between activities provides interesting challenges to the malleable nature of computer applications, because boundary-crossing gives rise to a need for the creation of closures. The discussion illustrates some very practical as well as theoretical consequences of the multi-purpose nature of computer applications: How to understand and to design for all their capacities, and the transitions between them. Transformation and constraining of and by the computer artifact, and thus learning by the human users, is challenged by the notion of common information spaces in that we are dealing with use activities that are so obviously not hierarchically structured, but heterogeneous and partly overlapping. As regards the creation of qualitatively new design in the border zone, some of these issues have been taken much further by Bertelsen (1998).

3.3 Co-development in use

Even though activity theory stresses that we cannot fully predict the future, designers (and activity theorists as well) are of course trying to predict the future all the time. Cooperative tailoring has been a particular angle for discussing how computer applications develop in use and what flexibility means in situations of collaborative, emergent use. Tailoring, as it is discussed in [15, 17] is focusing on the activities, instruments, conditions and qualifications of the people who work to adapt and to develop computer applications. The work with the tailors in AT nicely illustrates that even a computer application that may very easily be perceived as wrapped up and complete, Word Perfect, need also to be looked at from a design-oriented perspective, and undergo continuous development.

Thus, we may look at tailoring as a particular kind of development of computer artifacts in use; a kind of development that illustrates the dialectical relationship between design and use. In tailoring, the conditions, actors and politics need to be considered in the same way as they do for design in general. We may further understand more of what it means for designers to know the work practice of the users from looking at the tailors who are part of the work practices of use (see also Greenbaum & Bødker, 1988, Bødker & Greenbaum 1989, 1993). [17] further makes a general comparison of conditions, platforms and human mediation in two cases. This human mediation, tailoring, is in [17] called platform coordination, and in [15] local development.

The central concerns of my work in this area are:

1. To understand and to create better conditions for user participation in continuous development of computer artifacts (Bødker & Mogensen, 1993 and Grønbæk, et al., 1993).
2. To understand and to support the local adaptation and design of computer artifacts in settings where also a central and from-the-top demand for standards and structure exists [11].

3. To understand and to support tailoring, i.e. the ongoing development of the computer artifact-in-use, which is, itself an emerging activity [15, 17].

Activity theory helps focus on local design “close to” use though the view on the computer application as mediating both use and design simultaneously. The emergence of instruments of tailoring, beyond the computer application itself turned out to be important for the understanding of tailoring developed in [17, 15]. The cases nicely illustrate how operations and structures that emerge at one level makes it possible to deal with new problems at other levels, and how these operations and structures thus become resources of the tailoring activity. The computer artifact in use is an important mediator of the tailoring process, both regarding the communication between tailors and between tailors and users, at the same time as sharing of components introduces a new kind of complexity in an organization. A complexity that in turn needs to be dealt with by the organization and in particular by the tailors.

This particular set of studies has illustrated the usefulness of a perspective that encompasses the general development of standard technology, at the same time as it allows for focus on particular use processes of this standard technology, not as individual use only, but as collaboration. Not least, the perspective has emphasized the focus on the emergent mechanisms of design-in-use, and supported a study of why and how these mechanisms develop and consolidate, and of the particular roles of computer artifacts as materials and instruments of these processes.

3.4 Exploring use in design

In (Bødker, 1991), breakdowns were talked about extensively when it came to experiencing use, and analyzing use situations. Furthermore, [12] presented some fairly programmatic statements about how it was necessary to study and work with cooperative design. This gave rise to [1], (Bødker 1987b) and what followed from there. During our empirical work with dental assistants and urban planners [1, 2, 3, 4], Kaj Grønbæk and I came to see breakdowns and focus shifts as rich and useful concepts for understanding a much wider set of design situations than solely those of users experiencing failing future use. We developed the notion of cooperative prototyping both theoretically and practically. [1, 2, 3 and 4] identified a set of situations of cooperative prototyping, where the interaction between designers and future users led to various focus shifts and breakdowns, many of which were useful in understanding the future artifact in use as well as the current work practice of the users. These situations, though shared, were not entirely harmonious, and a framework for understanding and dealing with these contradictions and discrepancies were developed. [5] looked in further detail at the narratives of cooperative prototyping situations, and pointed at anecdotes as important focus points for cooperating designers.

By resituating cooperative prototyping in design, both theoretically and practically, we introduce a new way of using prototypes in what is often called analysis, and not just in design of a future computer application (see also Mogensen, 1994). Furthermore, prototyping sessions are also seen as learning devices for the later parts of systems development, e.g. when a prototype is being implemented in the organization.

The central outcome of the work is:

1. When viewing design and use as closely interlinked it is on the one hand necessary to make use-like situations part of design. One the other hand, use-in-design provides possibilities for a number of activities that are not directly aimed at testing the future use, but where the prototype is an important physical manifestation that a variety of heterogeneous interpretations can be anchored in.
2. That hands-on experience is important for users to be active in design. In order to provide the context for hands-on experience one must be concerned with the prototypes that mediate this experience, whether these are computer-based or not; the use context, such as materials worked on, other artifacts in the environment, the physical setting; etc. The prototyping situation needs not in all of these aspects match the real use setting; rather the importance of such a match depends on the specific purpose of the prototyping situation.
3. Studying cooperative prototyping situations has lead to the conclusion that it is neither the professional designers who design a computer application, nor is it the future users. It is through the active collaboration of these parties that co-construction of the future computer application in use takes place.
4. Focus shifts and breakdowns have been important tools for reflection on the cooperative prototyping situations, but more than that, the work has illustrated how these have a potential as well, for self-reflection within a group of designers.

Theoretically, my work on prototyping has found inspiration many places in and around activity theory. Specifically [2 and 4] develops Engeström's (1987) analysis of activity systems, to also consider actions, and talks about this as a web of activities (see also Kling & Scacchi, 1982), and how computer applications mediate those. Furthermore these papers make use of Engeström & Engeström's (1989) analysis of the mediators, foci, and partly shared objects in a multi-practical situation to understand discrepancies in focus and understanding in cooperative prototyping, and at times conflicting conceptions. This work establishes the notion of computer applications in use as mediators of a web of activities. The understanding of prototyping as learning includes also the learning of designers, and the role of what [12] calls lay-designers in the ongoing change of the work practice of the whole community. [4] uses Vygotsky's (1962) zone of proximal development as a notion to support this, and (Bødker & Graves Petersen, submitted for publication) situates prototyping and the exploration of use as an essential part of design for learnability or learning in use.

[13, 14, 16] use of the insights gained into cooperative prototyping, and re-situate these in the systems development process from a theoretical angle as well as from a practical one. With this work, cooperative prototyping is moved from being an interesting, yet perhaps exotic, participatory design technique. *It is moved to a position where it is central for our understanding of, and actions in, the intertwined field of use and design of computer application*.

3.5 Mediation of design

Design artifacts are often, but not necessarily, computer-based. And just as the carpenter is concerned with innovation of his tools, we, as researchers / designers need to be concerned with how we design new design artifacts. At an even more fundamental level, we get a better understanding of the practices of design, as well as of the materials and outcomes of design, not least the computer artifact, by analyzing design artifacts. And as with all artifacts this analysis cannot be seen in isolation but together with e.g. the historical development of design practice. These artifacts are shaped out of and shape design at the same time. As with all human activity, design is mediated and collective.

I have been particularly concerned with:

1. The contradictory requirements for design artifacts to fulfil their roles in the particular web of activities of design [2, 4, 5, 16].
2. The constraints and possibilities of the languages, formalisms, and materials that go into shaping the artifacts [2, 4, 5, 16].
3. The process of co-constructing the artifact [2, 4, 5, 16].

Programming languages, object-oriented analysis methods, specifications, and prototypes are all examples of artifacts that mediate design in various situations involving a variety of groups of designers and users (for other examples see Bødker & Hammerskov 1984, Bødker & Madsen, 1985). These artifacts share many general characteristics with all other kinds of artifacts, and they are, from the point of view of a research interest in design, particularly interesting because they are artifacts to help create the artifacts that we call computer applications. Some would probably say that making a model of the current objects of work through some OOA diagram is not about the future. However, it is well in line with the activity theoretical framework as well as my practical experience to see them all as constructions rather than mappings (see also Ehn 1988, Mogensen, 1994, and my discussions in [13, 16]). My particular concern has been for how such artifacts capture and change work [16], and how they are co-constructed in a process involving designers, and users to a varying extent [1, 2, 4, 5, 16]. Furthermore, I have worked to understand the particular role of object-orientation in shaping the processes and products of design [17]. Object-orientation, from the perspective of this summary may be seen as a particular kind of "clay" in that object-oriented artifacts and materials

constrain and support the development of use in certain particular ways, whether this use is "real use" or use in design (See also Bertelsen (1998)). As such object-oriented artifacts and materials are examples of the generally rather interesting phenomenon fundamental to the stance of this summary: the same computer application may well be the instrument and material of design as well as of use. It moves back and forth as the web of activities of design and use unfolds (See also Bertelsen & Bødker 1998).

Design from this perspective is an example of cooperative work, and often even of computer supported cooperative work. CSCW concepts have helped characterize design plans, formalization, etc. as resources for, rather than prescription of human action (Suchman, 1987, Star, 1991, Suchman, 1996) - a perspective that has helped in understanding some of our early experiences from design with users. My more recent acquaintance with studies of the role of formalisms and representations in various work practices, in particular scientific work (e.g. Latour, 1990; Star, 1989 and 1991; Lynch, 1990; Goodwin, 1994), has made me want to revisit some of my earlier design research regarding the role of design artifacts, or representations in design ([16] as well as [2], [5], [13], [14]).

I propose that some kind of externalization or representation of a future computer application is necessary [16, 13, 14, 21]. There are, however, certain trade-offs between completeness and openness: Completeness is not only a matter of recreating the computer application and its use, but also of recreating the context of design. We need to understand how design artifacts support or represent the design process [16], the continuously changing design and use contexts, and the cooperation and division of work in design [2, 4, 13, 14, 16].

Design artifacts have a particular role in relating to the context of use and the context of design and in boundary crossing between the two. [20] discusses the need for an improved understanding of context of use for usability and design. In [16] I discuss the general weakness of maintaining the design context in / through most design artifacts. The concept of boundary objects (Star, 1989, [13, 16]) is used in order to identify the capabilities of design artifacts within and between design activities, involving various communities of practice.

In [13] we further develop three major sets of requirements, which design artifacts have to meet: First of all, we need design artifacts that embody ideas and communicate them. Secondly, we need to find ways to let go of old conceptualizations and give way for new ones. And thirdly: there is a need to facilitate a shared understanding between participants coming from different practices. Design artifacts [13] are thus seen as mediators of production and communication within or across different communities of practice, springboards, and not least, they lend themselves to various kinds of hands-on experience by participants.

Design is not a stepwise derivation of the new from the existing, neither is the new coming out of the blue. Design is not a process heading towards a predetermined goal, but a process the vision of which is shaped in con-

tinuous interaction with the use practices that it originates from as well as with other uses, other technologies serving as guiding lights.

Whereas many design methods suggest use of a limited number of general design artifacts throughout design, [13 and 21] suggest that we need to focus more on a variety of design artifacts that support different purposes and perspectives in the design activity. This is because it is difficult to unite demands coming out of such a multitude of demands and purposes, and because creativity is supported through heterogeneity and contradiction.

Methods [13, 16] are seen as ways of emphasizing universal, general, theoretical features of the situations, whereas it is the judgement, or discretionary power of the designers whether they actually say something meaningful in / about the specific situation.

How does the notion of the clay of computing extend across design and use? In order to understand if the qualities of a good design tool are the same as those of other sorts of tools we have been interested in programming environments (Bertelsen & Bødker, 1998, Just 1998). Regarding the understanding of programming and designing programming environments, the study (Bertelsen & Bødker, 1998) demonstrates that programming cannot be understood in fragmented terms structured according to the artifacts used (e.g. debugging as being the same as debugger use). It further illustrates how in real-world programming the notion of context and border between, e.g. the code worked on and basic library code, is important. On the one hand, this illustrates the same kinds of problems and qualities as we get in similar analyses of other computer applications. On the other, the border drawing between the code worked on and the context, illustrates that in programming environments the changes between something being tool and material are very frequent, and the border between tool and material less sharp than in many other cases.

3. 6 Computers as materials and outcome of design - substantiating the stance

I have illustrated how use and design transform or develop the computer application, at the same time as the computer application constrains or disciplines use and design. I have discussed how the mediating role of computer applications in relation to the materials worked with, and the outcomes, is of this developmental nature. I have further discussed how the cooperative nature of human activity adds to this, in terms of how people learn from each other, and develop a shared practice together. Cooperative tailoring is one form that this shared development of computer applications may take, and which may be seen as a resource for design. Cooperative prototyping is a different example of how an improved understanding of the interrelations between design and use and an improved design practice may go hand in hand. As illustrated by Figure 2, many of my papers have contributed to this understanding. With the focus on de-

sign artifacts - the artifacts to create the artifacts, our concern extends into the realms of instrument-producing activities of the design activity system. These are indeed, from the perspective of computer science, of outmost importance - better design artifacts should be based on an understanding of design activities, and develop alongside these, at the same time as the future artifacts and their use should benefit from the design, and so forth. Since research and design, in my work, are heavily interlinked, this is furthermore a question of how to understand activities of research. Instead of being analytically wound up in a never-ending recursion of activity systems, I would much rather see the interest in design artifacts as one of self-reflection, where we, as designers and researchers, are interested in our own artifacts and how they are developed.

Computer applications are materials, artifacts and outcomes in a number of different activities, or, in other words, they are multi-purpose artifacts. In their transformation between these use settings, they do maintain an identity, that make them resist their own reshaping, they constrain whatever use activity they become part of, or they are, in Star's (1989) terms, boundary objects, or what may be more appropriate with the present terminology, boundary artifacts. As such they also become a special and particular artifact for each activity that they become part of. Understanding the "clay of computing" from this perspective means that it is necessary to untangle the particulars of each relevant activity in the web of activities where the computer application, *qua* the relevant set of hardware and software, has a role. This is an analysis that moves on a contextual level to understand the general relationships between use activities and artifacts [10]. Where [10] focuses very much on the activity and focus of single users, or at least the level from the activities that one particular user is involved with and "down" towards the actions and operations. Additionally, this summary has been concerned with the total web of activities where a computer application is involved be it in the capacity of material, outcome or instrument. Thus, the present analysis is in a sense complimentary to that of (Bødker 1991) and [10]. The distinctions between the physical aspects of the computer application, the handling aspects and the subject/object directed aspects, developed in (Bødker 1991) are useful also in design-oriented concerns for the entire web of activities. How computer applications get transformed between activities is very much a matter of how they support recovery from breakdowns, and focus shifts between objects of relevance. It is further a matter of how they support conceptualization and re-conceptualization of the artifacts in use. Conceptually as well as practically this analysis gives very precise answers to which activities (or perspectives) to involve e.g. in a cooperative design setting. It stresses a concern for the boundary-crossing capabilities of the computer application and emphasizes the concern for contradictions among activities, and instruments of different activities (such as e.g. developed in [7]). However, it also emphasizes the need for an analytical and design-oriented delimitation of concerns, in that it is impossible to involve the entire, and often indefinite, web of activities. This further entails a concern of normative nature in that computer applications

developed to support tailorability is an option that is well supported by this way of thinking.

A computer application remains “clay” until it is used, i.e. made instrument of certain use / work activities. Design activities need to be concerned with, and somehow anticipate, this use. Use will always differ from what is anticipated, though the instrument constrains use. This is a driving force of the ongoing design of computer applications along with the influence of other activities in the web of activities.

4

Design in use - use in design - practical implications

As already stated, I consider some of my later writings, in particular [13 and 14] as summarizing the practical implications of the present understanding of design and use. However, there is still a need to make such a summary explicit, and there are practical insights to be gained from other of my papers than the ones directly included in [13, 14].

The primary practical implication is that *development in and of design and use needs to be dealt with throughout the existence of a computer application. This development needs to be anticipated as best as we can, despite the unanticipatory nature of computer applications.* "Design for unanticipated use", Robinson (1993) recommends. The question that I hope to provide an answer to in the following is - how? The answer lies both in the products we design, and in how they may be reshaped in the design processes we set up, and in the way use is organized so as to facilitate learning.

The remains of this section will be structured as a series of statements about the integration of use and design, and how this perspective should practically impact our ways of doing design, in general and as to allow for development through design-in-use in particular.

1. design is inherently multi-practical and thus, supporting the cooperation between various groups of users and designers is important
2. design[2] must be carried out in ways that give users possibilities of experiencing the future
3. design must be carried out so as to understand use, both present, past and future, and must seek theoretical as well as empirical inspiration
4. design must be based on an understanding of how use may develop, and how the use activities interact or may interact with other activities
5. design must be based on a use-oriented understanding of the materials worked with, in particular those computer-based

[2] Since design is fundamentally multi-practical, in this formulation "design" indicates that we talk about groups of professional designers and future users.

6. design must be creative and innovative
7. design must be carried out in ways that allow designers to be concerned with their own tools and practice

This section ends with a presentation of a toolbox that I propose will support such design.

4.1 Design is inherently multi-practical and thus, supporting the cooperation between various groups of users and designers is important

Practical design needs to deal with several user groups as well as several different groups of participating designers [21]. These may at times have overlapping, and at times contradictory interests in use and in the design activity as such [11]. Adding to this, a conclusion of [4] is that we need to develop the instruments of design so that the objects of design become shared (between developers, and between developers and users).

In papers from the AT project [11, 14] it is discussed how users may be positioned to better participate in design. It is furthermore discussed how participatory design as such can be shaped as an educational activity that help the organization and its people act more skillfully as regards use and further development of the technology. In situations like the AT where much design is a matter of local tailoring of standard technology a fundamental question is how general support for local participatory design may be set up? First of all, flexible, tailorable standard technology is a necessity [11, 17]. Secondly it is important to rethink the design process to include structures through which ordinary users can participate in tailoring and design.

Connected to this, Engeström's (1987) notion of multi-voicedness deserves mentioning as a perspective on bringing the voices of various groups together, constructively, in design / development of a new work activity. [21] gives various suggestions to how scenarios, anchored in specific use / work situations may be used to support bringing these voices forth. [11] recommends to start in a small group, what Engeström (1987) calls a microcosmos, which in the AT case allowed a real working group to apply a computer-artifact, before it was spread in the entire organization.

Design artifacts are important boundary objects mediating the interaction between various groups involved in the web of activities of design and use. Design artifacts, or representations as they are called in [16], are handed over, they hold on to decisions, on the one hand. On the other hand, even among a fairly small group of designers and users practice change continuously, along with the design. This means that neither the object being designed, the computer application, nor the use context remain the same throughout the process.

[16] summarizes the potentials and problems of design artifacts as follows:

- though they are never complete, they are necessary, and vice versa;
- completeness is not only a matter of recreating the computer application and its use, but also of recreating the context of design;
- the contexts of use as well as of design are continuously changing;
- shared experiences (i.e. participation) are necessary, though everybody cannot do everything.

4.2 Design must be carried out in ways that give users possibilities of experiencing the future

This statement is the practical instantiation of early observations in my work of the users' needs for hands-on experience (Bødker, 1985, Bødker et al., 1987). Experiencing the future needs, however, to be looked at a bit wider than as early hands-on experiences with a tool. [1] points to some of the fundamental ideas behind cooperative design: That designers need access to domain specific objects, and that users need to gain hands-on experience with the future. In various other papers we find a number of suggestions for how to deal with these challenges: In [1, 2, 3, 15, 11] prototypes as well as computer applications from other domains are demonstrated to be valuable means of communication, and valuable springboards for getting new ideas. [13, 14, 21] discuss the use of workshops and scenarios, adding to which (Bødker et al., 1991) presents workplace visits.

4.3 Design must be aimed at understanding use, both present, past and future, and must seek theoretical as well as empirical inspiration

This statement looks into the ways in which a, in system development and HCI practice, classical analysis of the present use, based on preconceived theoretical concepts, is too limited. Creating something new in design is not only a matter of a stepwise refinement of a description of the existing situation, neither is it a matter of a hierarchical decomposition of complex problems into solvable ones.

Field studies of use combined with theoretical analysis, as described in Chapter 3, has been used in my work to understand details of use / work in focus of design [2, 4, 7, 8, 10, 15, 20, 21]. In Bødker (1992) I further discuss the role of ethnographic field studies, and in [7] practical ways of working with the historical dimension are developed. General design suggestions may guide design, but they need to be explored in the particular conditions of the specific setting. These matters are further discussed for practical HCI work in [20, 21].

[8, 10] develop a checklist for understanding use through focus shifts and breakdowns, by asking questions about each particular focus and focus shift of involved users. These questions relate to the purpose of the activity / actions for the user, the objects focused on, the instruments and the causes of focus shift. The mapping technique suggested is one way of putting together an overview of the answers to these questions.

[7] identifies the web of activities through identifying users, objects, activities / purposes and the character of the mediation in terms of tool, medium or system.

The paper further presents the following repertoire of analyses as an appropriate overall approach to understanding use, present, past and future, theoretically as well as empirically:

- situating work and computer application historically,
- situating the computer application in a web of activities where it is used,
- characterizing the use according to the stereotypes of systems, tools and media,
- considering the support needed for the various activities going on around the computer application, and the historical circumstances of the computer application,
- identifying the objects worked on, in or through the computer application,
- considering contradictions with respect to activities where the computer application in used.

Though these analyses have been outlined as having a certain order among them, actual analyses should take place in interaction and iteration.

Adding to these analyses [20] discusses further the need to work with the use context of artifacts in practical HCI design. Bødker & Graves Petersen (submitted for publication) moves on to present questions to be used in focusing on learnability, and the possible development in use of artifacts such as computer applications.

The conceptual framework of EuroCODE (Bødker et al., 1993a, 1995, [13, 14]) utilizes theories, and further empirical findings and theoretical constructs from CSCW to deal with creative idea generation as well as systematic evaluation of ideas. These are made available through checklists. The framework recommends scenario-making as the backbone of design, an approach that is exemplified and developed further in [21]. The toolbox was consciously organized to let different perspectives talk to each other: Theoretical concerns were applied to focus the scenarios through checklists, originally asking questions about a specific work situation and / or a specific CSCW application, thus enabling the designers to find out relevant constraints and key-concerns.

4.4 Design must be based on an understanding of how use may develop, and how the use activities interact or may interact with other activities

This statement looks to the developmental and situated nature of activities, and thus of use. In my work I have worked to provide a practical developmental perspective on use in a number of ways. This perspective leans heavily on understanding and working with contradictions between the different use activities where the computer application is involved, activities that have other important relations to the central use activities, as well as with theoretically and empirically inspired understandings of future use (as outlined above):

Education and design of education are important for changing the computer application and its use [10, 11].

In order to design for development of use, it is necessary that the specific development of use is understood and dealt with in design, e.g. by bringing a microcosmos of users through the development zone as part of design.

Development in use through tailoring of the computer application can be further supported through a flexible and understandable technical platform, and through education, and development of tailoring practice of the platform coordinators [15, 17].

The EuroCODE framework [13, 14] supports further the developmental and situated perspective by suggesting to work on provocation of thoughts and ideas in scenario-construction. This is a matter of triggering ideas that are innovative on the one hand, but realistic and technically feasible on the other, recognizing the social, organizational and technical conditions which constrain a solution.

The AT and BIDI projects used various kinds of workshops in order to confront, and make constructive use of, the variety of use activities and practices in design (see [11, 20], Bødker et al., 1993b, Bødker 1992, Mogensen & Trigg, 1992, Mogensen 1994, Bødker & Graves Petersen, submitted for publication).

4.5 Design must be based on a use-oriented understanding of the materials worked with, in particular those computer-based

This statement looks to the idea that understanding use is not enough. What is important is to understand computer artifacts from the perspective of use, and to provide designers with operational means for such an understanding [13, 14, 20, 21].

In [7, 18], I use the terms system, tool, and medium for stereotypes of important ways of mediating between users and their surroundings. The sys-

tems perspective is the birds-eye, control perspective. The tool perspective emphasizes the human engagement with materials through the computer artifact, and the media perspective, in a similar way, emphasizes the human engagement with other human beings through the computer artifact. Almost no real-life computer application can be understood in terms of only one of these perspectives. Analytically they are applied by tracing and characterizing the web of different activities that takes place around a computer artifact and in particular contradictions among the different uses. A computer artifact is supporting several interwoven activities, which deal with the same or connected objects. While conducting a specific activity, various focus shifts and breakdowns happen by which the object changes. In some cases this may be viewed as a change of activity, in others the overall activity remains the same, but the purposeful actions change. Being involved with different objects and subjects through or in the artifact is partly determined by the purpose of the activity, and partly by the "intrusion" in breakdown situations.

4.6 Design must be creative and innovative

Through this statement I want to emphasize that there is more to design than building computer applications to support an existing practice and hope that they develop from there.

In [13, 14] we use various technical and social/use-oriented constructions as springboards in design, an issue that is discussed also in (Bødker 1997). We need to move away from stepwise derivations to ways of rethinking the whole of the new activity or parts of it in different, yet very concrete, ways. Madsen (1994) proposes the use of metaphors when creating something new (by seeing e.g. a library as a meeting place, etc.). Obviously, such ideas need to be contained and placed in context, similarly to any other ideas, i.e. we need to find ways of making and working with such representations in design. Engeström and collaborators similarly use theoretical models to facilitate innovation (Engeström et al., 1996).

Making scenarios as proposed in [13, 14, 21] is a creative process: they are hypotheses, or qualified guesses about the future computer application and our toolbox cannot be used in a stepwise derivation of scenarios. Rather it serves to open the dialogue about future possibilities and current constraints. The toolbox is intended to guide the process and to get to grips with the shaping of the artifact as well as to anticipate and transcend current use in a planned way and in a specific direction. *The designers need to represent and hypothesize about the computer artifact and its use* and in this endeavor they need to be supported by thinking tools [13].

4.7 Design must be carried out in ways that allow designers to be concerned with their own tools and practice

Self-reflection is very important for the ongoing change of a particular practice, including that of design. Furthermore, the perspective of this summary makes it necessary to view design in the same way as any practice that is developing. Thus, the design artifacts play the same role for design as other artifacts do for other kinds of use activities.

With the integration of design and use, such self-reflection in a sense is the "business" of users-as-designers as well as of professional designers. However, there is still much need for professional designers to be the facilitators of the design activity, and act out part of their role in the heteroglossia through this. In other words, it is their professional responsibility to be concerned with design practice and the development of this.

In [1, 2, and 5] we point out how designers need to prepare for cooperative design situation, since they are the process experts:

1. It is important that designers prepare well for the cooperative prototyping activities, in particular that they prepare to be in control of conducting the process. At the same time, they need to be able to act in an open-ended fashion, and be ready to move to where the users take them. A co-designer role may be helpful.
2. For the users it is important to experience the future computer application in use, but such experiencing is not solely a matter of trying out in "real" use. Other kinds of situations, such as simulated use situations, talking through existing work, etc. may as well contribute in each their ways to the reshaping of practice of use.
3. Scenarios [13, 14, 21], 'frame tasks' [2], and the like can be useful in situating the prototyping sessions, and must be based on profound insight into the work of the users.
4. The different kinds of prototyping situations may be used actively, as may the more or less close access to the actual use situation [12].
5. Forming a prototyping microcosmos as starting point for changing the practice of the whole group or organization is useful [4, 11].
6. Designers can do on-the-fly modifications of prototypes, but need to be aware of the complexity of the change, and the risk of locking the focus of the participating users [1].
7. Users' expectations need adjustment, so that they know e.g. the limitations of the prototype [1, 2].
8. Direct manipulation tools, object orientation, and separation of test data from the application is suggested components for a good prototyping

environment [1, 12]. These topics are developed further in the DEVISE Center (e.g. Grønbæk & Knudsen, 1992).

9. Cooperative prototyping cannot stand alone, and the technique needs to be adjusted according to the particular design settings.

4.8 A toolbox

The ideas summarized in [13] have come out of the EuroCODE project, where we worked to support the design of CSCW applications which were technically based on the EuroCODE open development platform. To facilitate the design process, scenario-making - supported by a conceptual toolbox - is suggested as a potential springboard.

The foundation for this suggestion is an understanding of the interplay between technological and social change, involving different communities of practice inspired from activity theory.

[13] suggests a prototypical device, a thinking tool for designers engaged in developing computer supported cooperative work. The toolbox consists of *checklists* addressing social as well as technical issues, *examples*, and an *outline* of how to work with scenario making throughout the design process (the presentation of the toolbox is developed further in [14]). The actors in a "design-as-change-and-expansion-process" need boundary objects as springboards, which capture the ideas and present them in an open-ended way, *and* checklists for systematic reflection.

All the tools in the toolbox are meant to both speak to and contradict each other to stimulate discussion and dialogue. That is e.g. the main reason for choosing two separate checklists (and the possibility of adding more), one for *work* and one for *technical matters*, and why redundancy is intended. [14] emphasizes how the toolbox unites theoretical knowledge (checklists and prototypical examples) practical design skills (experiences with materials, tools and application domains) and situational knowledge (through scenarios). The use of checklists to reflect theoretical knowledge, and scenarios to instantiate and contextualize future use, has been further developed in (Bødker & Graves Petersen, submitted for publication) and [21].

[13] suggests the use of scenarios in design because they support the build-up and use of a shared understanding among the design group, they relate to the past as well as the future, they support the creation of new ideas, and they give theoretical tools to help structure the understanding of complicated empirical use situations.

Making scenarios is a creative process: they are hypotheses or qualified guesses about the future computer application, as embodiments of it. Thus our toolbox cannot be used in a stepwise derivation of scenarios. Checklists may be used for producing documentation, and for systematic evaluation

of the design ideas, and they may be used to clarify and extend the scenarios by pointing to directions to be covered.

Conflicting points of view can only be dealt with in terms of specific empirical situations. Here they may result in solutions that transcend the dilemma, or where deliberate choices are made in favor of one side of the dilemma.

[14] reports on the early and very limited experiences of using the toolbox. Further experiences are reported in Bødker (1995). Some conclusions can be drawn, e.g. that the checklists, in particular the work-oriented one, are useful, and that it is possible, as well as a good idea, to make additional checklists for various purposes. Furthermore, scenarios are useful for situating prototypes, and scenarios thus could be used to hold on to the so-called 'frame tasks' presented in [2].

The design approach may get support from the proposal of [5] of using video analysis as part of a design method. The paper proposes that a systematic analysis of pieces of video contributes to the prototyping/ systems development process at various levels. It offers access to an improved understanding of how the prototype works, it offers access to understanding the work of the future users, and to their patterns of interaction in the process. And finally it gives the designers access to their own patterns of interaction, and thus offers reflexivity (Giddens, 1990), which is in the understanding of Brown & Duguid (1991) a basis for innovation.

The design framework is not a technical solution in the traditional sense, but a conceptual toolbox for supporting the design of CSCW applications (in EuroCODE). Experiences as discussed here imply that a method, in the traditional sense of a universal recipe, is not a feasible path. By borrowing the cooperative approach from Utopia (Bødker et al., 1987) and combining it with theoretical knowledge in an operational form, the framework seeks to acknowledge the value of theory-driven design without ignoring the situatedness of use.

As a researcher of system development, I have a long-standing interest in understanding the general and universal sides of system development activities and artifacts. At the same time, throughout my writings and teaching, I have emphasized that the way to do this is by concern for particular problems of specific settings. If one does not automatically assume that experiences from one setting are generally applicable, one has the obvious problem of making recommendations for design, or research methods, beyond the specific settings. Providing an open and extendable toolbox that is not *per se* claiming generality, but offering context enough to let potential users start trying out the toolbox seems to be a viable, though not uncomplicated alternative.

5

The clay of computing expanded

With the conceptual framework of this summary we get at better understanding of how development in design and use can be supported by the computer artifact. The framework further points out how the mediational role of the computer application is multi-layered and pertaining to all activities in the web of design and use of a particular technology. The work shows, through a number of specific empirical cases, how use and design transform or develop the computer artifact, at the same time as the artifact constrains or disciplines use as well as design. It develops a theoretical framing of our understanding of these processes, and consequently a methodological basis for the development of computer applications, for transforming computer artifacts as materials into computer artifacts as instruments of use. The framework as well as the large number of design techniques are themselves design artifacts.

In [18] I use the system, tool and media perspective to develop an application-oriented perspective of how we may conceptualize computer technology and design from it (see also Maass & Oberquelle, 1992). The system perspective being the birds-eye, control perspective, viewing the human user and computer component as rather equally functioning in exchanging data. A system mediates between the individual contributors of actions and operations, and their object. At the same time, the system is the instrument of an acting subject, who is not directly contributing to the production of the outcome. The tool perspective emphasizes the human engagement with materials through the computer artifact. A tool mediates the relation between the subject and the material object being worked on. The tool perspective emphasizes production of outcome, and the direct learning that takes place by the material "speaking back" to its user. In a similar way, the media perspective emphasizes the human engagement with other human beings through the computer artifact. A media mediates the relation between the acting subject and the community of practice surrounding the subject and the activity, thus the perspective emphasizes communication, and learning through conceptualization and negotiation.

The analysis of a computer artifact is a two step process: proposing first that we need to look at computer artifact s as mediators of human activity and identify appropriate metaphors for these various kinds of mediation. Secondly, using these metaphors, and more normative extensions of them, as mediators of the design activity. It is further necessary to look also

towards how these perspectives support or prevent the development of the use of computer applications.

Since development presupposes an active human subject it is inherently difficult for aspects of a computer application designed according to the system perspective to develop. This is much in a way that is analogous to how organizations organized according to the machine metaphor fail to develop and adapt to changes in the surroundings. Morgan (1986) describes how the separation between planning and execution lead to problems where the workers tend to work according to rules, and deal only with what they are asked to do, and management have little understanding of what actually takes place in work. Attempts have been made to mend these problems by reintroducing acting subjects from the bottom (e.g. Greif, 1991). However, these remain at a level similar to our attempts at re-educating users of VIRK (Bødker et al., 1993c). These were still quite different from a profound development of use, because VIRK fundamentally supports/enforces the separation of planning and execution and was not meant as planning tool for the users [7].

Since a tool supports the direct learning through the material speaking back to its user, it primarily supports learning at the level of formation and mastering of operations, a level that is indeed important when it comes to the transparency of the artifact (see also Bardram & Bertelsen, 1995). In order, however, to support the shared development by a community of users, including also re-conceptualization of the activity in what Bardram (1998) calls co-construction an artifact that supports development in use must be designed also from the media perspective in order to support communication within the community of practice.

This opens a design process that insists that we need to look closer at the clay of computing. At the same time, we need to look further away, not just to the use activity as such but to the web of activities of design and use; to their future and their past.

In a sense there is in my work an asymmetry between design and use in that change, and thus design, is fundamental to the framework (see also Mathiassen, 1997) and stability is in a sense temporary. However, at a practical level design is continuously seeking to establish these temporary stable platforms that we call use, where acting subjects appropriate the technology in their activity and come to master it. And use, in turn, makes further change possible, as well as it directs it in certain ways through the human encounters with the computer applications. Because of this tension I will not argue for a technology that develops itself, as it is often stated in the AI-literature, by attuning itself to the doings of the users, and thus, in a sense by attempting to guess the aims of the human actions. Such technology would profoundly prevent the users from mastering technology in that it would prevent the users from developing a repertoire of actions and operations through which the artifact may be applied.

An appropriate place to end this outlook is with the debate started by Winograd (1996) about bringing design to software. Winograd and co-

workers seem to argue that our field (software, HCI, systems design) is primarily a design science and ought to be taught and developed from this perspective. While I appreciate that design sciences have much to offer to software, I hesitate to accept Winograd's argument (panel CHI 97) that traditional computer science has nothing to offer whatsoever. I find that the obligation that we have as computer scientists in this interdisciplinary field is to investigate much further what constitutes this malleable "clay" that we design out of. The object-oriented approach that Alan Kay originally adapted and developed is one possible design of such a malleable clay that has improved on some aspects, and lost on others over the years (see also Bertelsen & Bødker 1998). In my mind, technical complexity needs to be supplemented with a use-oriented understanding of complexity; optimal ways of representing and simulating objects and materials from the use domain is an issue that is far from explored and gaining importance e.g. with the emergence of 3D, etc.

Whereas 10 years ago, user participation was a term that belonged with some rather exotic "tribes", primarily in Scandinavia, the notion has, in recent years, gained widespread acceptance. This has mainly been as a way of gaining knowledge about work, and various models for user participation have made their way into mainstream conferences such as CHI and textbooks such as Newman & Lamming (1995), Preece et al. (1994). Today it has become possible to talk about user participation as a rather uncontroversial assumption, when limited, though, to discussions over quality of products, at times even making users the instruments of design rather than acting subjects. This development we have witnessed with great concern: on the one hand one can argue that this kind of user participation is only a start and better than none. On the other hand much of this so-called user participation is far from the genuine involvement with the interests of groups of users that we find necessary. And as illustrated by the title of Kyng's (1994) PDC keynote address it is of great concern if user participation has moved from subversion to hype.

6

Research methodological concerns

My work and research approach is action-oriented, in a way that establishes computer applications as centerpieces of possible change. As mentioned in Chapter 1, this action-oriented approach follows a long tradition dating back to the early Scandinavian collective resource projects from the mid-70s (Kyng, 1995c, Ehn, 1988) developed as discussed e.g. in [11].

It is further grounded in activity theoretical approaches to understanding work and HCI, in particular the focus on mediation and development. Through and around these approaches other sources of inspiration have been relevant, and the main aims of this section are to motivate:

• how and why these approaches fit together in my work,

• how and why my work fits into a larger picture of research done by colleagues around the world, and

• how the bringing together of the approaches is a useful way of innovating theory and research method.

Nardi (1996) suggests that activity theory is a powerful descriptive tool rather than a predictive theory. It offers a set of perspectives on human activity and a set of concepts describing this. According to Engeström (1987) activity theory does not offer ready-made techniques and procedures for research, rather its conceptual tools must be concretized according to the specific nature of the object under scrutiny. In my work I have tried to do that for design and use of computer applications.

"Activity theory proposes that activity cannot be understood without understanding the role of artifacts in everyday existence, especially the way artifacts are integrated into social practice" (Nardi (1996), chapter 1, p. 14). In my work I am interested in the particular relations between computer applications and human activity.

Summarizing my research approach and the possible combinations of research methods coming out of it, time is important. Time, because we are dealing with design, and thus with past work and artifacts as well as present and future. It is fundamental to the learning-oriented view that I have presented that research and design take place over a period of time, not as a snapshot; focusing on use which is equally spread over time. It is at the core of this way of thinking that what is future use at one point of time in design and in research becomes part of the past later; and in a

partly different shape. This is because of the difference between the anticipated new and what that is, once one gets there. This means that when we plan research and design activities, we must be concerned both with the past and future from the current point in research and/or design, and with how this concern may be useful once the future becomes part of the past. This is indeed no small challenge on top of the general problems of planning research while being sensitive to the actual interesting situations that occur along the way. In Figures 3-5, I have presented the actual flow of research in some of my projects with respect to how research activities focus on "use time", and with respect to how they change use, and thus create something new to be researched.

Along with time, we are dealing with a potentially infinite web of activities that is, or could be, affected by our design, our research and the introduction of a new artifact. My research approach has basically been taking slices of the space constituted of use time along the one dimension, and the relevant web of activities on the other, be it in the time dimension, in the web of activities dimension or across these, depending of the purpose of the research activity.

In order to develop an activity theoretical approach for the particular object under scrutiny, computer applications in design and use, it has been necessary to further extend the scientific approach. I have found inspiration from various approaches, not least ethnomethodology, grounded theory, and Latourian studies of science; research traditions, which have made their way into computer science through the emergence of CSCW. In particular, the way ethnomethodology insists on accounting for the particular nature of specific work situations has been important for my empirical work. This insistence is well in line also with the discussions of gender and research by Greenbaum and myself (Bødker & Greenbaum, 1988, 1993, Greenbaum & Bødker, 1989) as well as by Markussen and myself (Markussen & Bødker, 1993, Bødker et al., 1992). As pointed out in (Bødker, 1992), however, I have found it important to get beyond the purely narrative account of ethnography, and activity theory has been a big help in that. As pointed out by (Juul-Jensen, 1989) it is important to be faithful to the spirit of activity theory more than perhaps to the words. My sources of theoretical inspiration have included Lave & Wenger (1991), Wittgenstein (1953), and Wartofsky (1979); sources well recognized and discussed within the activity theoretical community as well as (Engeström, 1987, 1996, Engeström et al., 1996, Engeström & Middleton, 1996b) and other activity theoretical sources.

This particular approach to understanding the practices of design and use of computer applications joins a wide, and growing attempt uniting micro-sociological studies of human practice (ethnomethodology, symbolic interactionism) with activity theory and related theoretical approaches. The reasons for, and implications of this attempt is discussed well in Engeström & Middleton (1996a), in particular in the introduction (Engeström & Middleton, 1996b) and in the theoretical chapter by Star (1996). According to these authors, *practice* is at the core of this attempt.

However: “Analyzing culturally mediated work practices does not accommodate directly issues of agency and history within the same analytical stance. Rather, it is a beginning of a search for more integrative and boundary-crossing units of analysis, conceptual tools, research methods, and alliances” (Engeström & Middleton, 1996 p.3). The united efforts of the authors of that volume (which includes [4]) share the following quest (Engeström & Middleton, 1996b):

1. Work practices are mediated by artifacts. However, as the semiotic and the instrumental are forming layers of mediation in new and complex ways, the dichotomies between the instrumental and the communicative are not as useful as the ongoing *dialectics between the structural and processual*, the stable and dynamic, representational and discursive forms in work practice (this kind of dialectics very similar to Mathiassen (1981)).
2. *Expertise is an ongoing collaborative and discursive construction* of tasks, solutions, visions, breakdowns and innovations.
3. Continuity and change can be studied within a single work practice, but it is necessary as well to *trace connections to other work practices* and construct networks of practices.
4. It is necessary to examine the reflexive relationship between research methods that analyze a particular practice and their impacts on this practice.

The issue of reflexivity is particularly interesting when the practice we study is a design practice: When I do design it is also research, and when I do research it is also design. Yet, not all design has to be research or scientific, which sometimes makes it difficult to discuss the practical potential of our research-design. This particular kind of research is in other words double reflexive. Being serious about participation as a research approach has consequences: Not only do we demand participation from the people we work with; the researchers obviously need to be equally committed to the problems of these people and organizations. This means that it is difficult to stand back and reflect; one does not entirely get to choose the problems to work with, and thus one finds little help to reduce the complexity of these problems.

Star (1996) nicely illustrates how empirical studies of work practice originating from symbolic interactionism, and the activity theoretical approach to understanding historical and material specificity “afford” each other, politically, aesthetically and scientifically through their insistence on antiidealism, antiindividualism and a dialectical model of development. Similar arguments are made by Lave (1993) and by Chaiklin (1993) in their co-edited volume, Chaiklin & Lave (1993).

Star (ibid.) ties this in with the problems of system development in the following way (p. 310): “ Two things are occurring quite rapidly in the modern world. The first is the failure of rationalism to account for or to prescribe people’s behavior (which is not new), and what *is* new, a large interdisciplinary movement in the academy and in the sciences that is

documenting this state of affairs. The second is the rapid rise of information technologies, which are insinuating themselves into the conduct of work, being integrated with each other in new kinds of international networks, and also being embedded with each other to produce a newly complex state."

She ends by saying (p. 313) "I believe that jointly activity theory, interactionism, and information-systems research have some important insights to offer scholarship and development. We know that, in spite of the failure of rationalism, the world does not fall apart. We've begun to understand that the absence of a monolithic voice does not mean chaos or babble, but pluralism, and that requiring translation."

Burell and Morgan (1987) in their review of contemporary sociology / organizational theory point out that very few approaches come from the perspective of change (in opposition to regulation) at the same time as they apply interpretative approaches to understanding their domain. As discussed at length in Bertelsen (1998), these dimensions have been picked up by Klein and Hirschheim as regards systems development / design. Whereas Hirschheim & Klein (1990), as pointed out by Bertelsen, see their own contribution as the only one mending the problem of change-oriented interpretative approaches, the above discussions suggest that they are mistaken about this, and that in a sense, there are much more at stake. Bertelsen uses his background in philosophy of science to point out how the kind of dialectical materialism, that activity theory is based on, raises itself above the subjectivism / objectivism dichotomy, pointing in the same direction as Star, namely that there is room for constructive confrontation of ideas and methods. Morgan (1987), seems to be on the mission of trying to "populate" this space as regards organizational theories through his approach to imaginizing. I see this present contribution, as well as other more recent works in the Scandinavian systems development tradition as aiming towards the same goal for systems development / systems development research and HCI / HCI research.

In my view this means that the most useful place for *theoretical concerns is as sparring partners in reflection*. In line with this, Bertelsen (1994) argues that the most useful role of theories is as mediators of design: "When designers build specific computer systems they use what they have and what they know, no matter how incompatible from a theoretical point of view. Current social and cognitive science tend to misunderstand the strengths of science and just collect everything that seems to be right together. Scientific theories are not one-to-one reflections of the world, but artifacts mediating understanding of, and action in the world, through reduction. By stuffing everything together, nothing interesting about the world will appear, powerful theories have to be based on cruel reductions" (p. 16). Instead of creating theoretical approaches or methodologies that aim to study everything at once, it is beneficial to develop and use a number of different approaches that focus on particular aspects of use and design.

One such aspect is that of history. Activity theory proposes that artifacts are historically developed, and thus, crystallizing a certain praxis. At the same time, the history is not just an absolute and given thing, and history does not only concern the past. In [13, 14] we seek inspiration in Ricour (1988). Mogensen, (1994) develops his Heidegger-inspired understanding in a similar fashion, to emphasize the relation between the past, the present and the future. The key point from the perspective of action research is that we are dealing with both experience and expectation as soon as we start researching a practice, and as soon as we e.g. introduce a prototype. The historical analysis of artifacts and their development has roots in activity theory (see e.g. Bærentsen (1989)) and in my own research tradition where the Utopia project made attempts at such. Engeström further uses this kind of historical analysis as part of his methodological cycle (Engeström, 1987). Fundamentally, we cannot design from understanding the artifacts alone. Neither can we understand the artifacts only from understanding design as it is carried out "here and now". In this sense, an activity theoretical approach needs to go further, and e.g. Carroll's (Carroll et al., 1991) "task-artifact" cycle (as discussed in [9]), thus, is insufficient for understanding design and for designing support for it.

Throughout my writings I haven't been content with attempts to define cooperative work. In [12] we discuss some of the more naive definitions e.g. the ideal of the small research group. In Bødker & Mogensen (1993) we discuss how later, and more well-founded, concepts are equally weak as starting points for design in that they are trying to delimit what is cooperative work and what is not, instead of discussing how and why to make work more cooperative through computers. This has triggered my interest in the emergent cooperation around a computer application [15], a topic that is methodologically difficult because it requires long-term studies, and not just studies of a situation here and now. I have, however, been fortunate enough to be able to conduct a couple of such studies [15, 17]. In order to study a practice emerging over long time, I have found it necessary to develop a series of site visits, combining observation and informal interviews, and in one case helping out with various technical problems in the organization. On the one hand, it may not be so easy to understand development from such snapshots, and we were at risk of missing some important steps. On the other hand, it is resource-wise almost impossible to follow such a process more closely than I did, and I would also be running the risk of not seeing the development if I was located in the organization continuously.

From an initial rather unfocussed interest in using video recordings as part of research and systems development, the papers [2, 4 and 5] develops the use of video analysis, and in particular in [5] this aspect is important. The work takes interaction / video analysis from its general concern for situated action and interaction between people to an approach is operational with the particular focus on people collaborating around a prototype, and the interaction triggered in such situations. What is fundamental from the original interaction analysis is the respect for what happens in the actual situation, and to get deeper and deeper into an understanding of

this instead of applying preconceived patterns and concepts to understand the situation.

In Figure 14 I place examples of my research approaches in the two-dimensional space of use time and web of activities. The idea is to illustrate what kind of slices of this space that a particular research activity focuses on. Some are rather narrow in both dimensions but allow for a deep look into the activity, some stretch out in one or both dimensions, and emphasize the need for delimiting the scope of any particular investigation. This figure neither gives justice to all my work since I have also worked at a meta-level aiming to understand research / design [2, 4, 5, 11]. Nor does it deal with the additional concern of the developing research time, illustrated in Figures 3-5, that is indeed an important part of the research methodology as well.

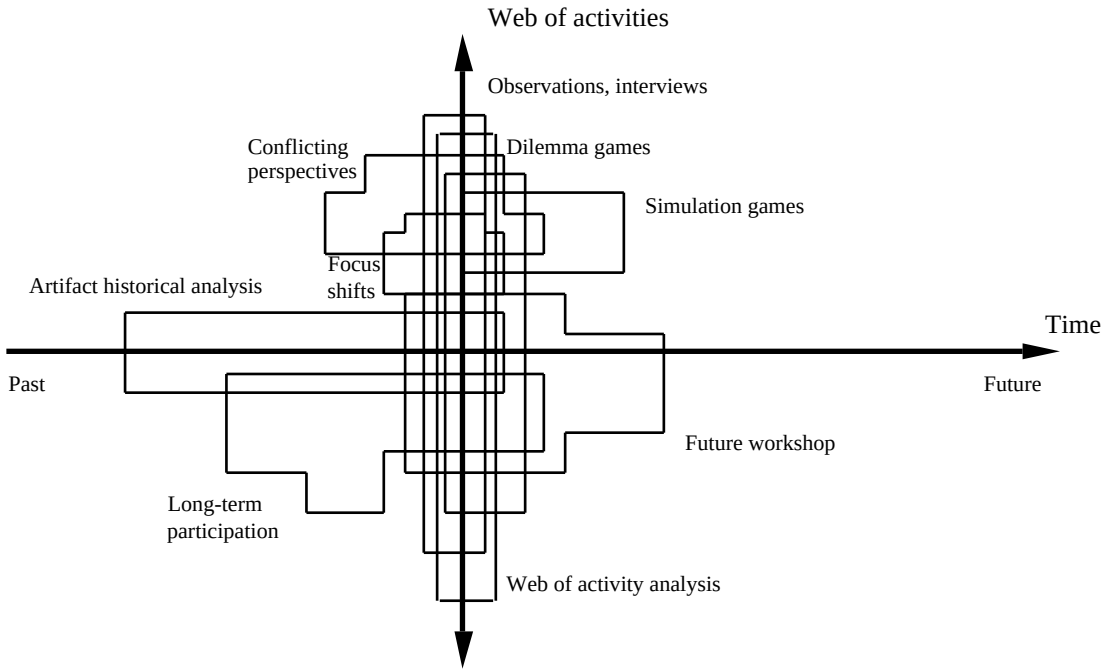

Figure 14. Research methodology

One remaining issue is how to delimit one's research, provided that one is concerned with e.g. a particular computer artifact in design and use. As I am convinced that it is not a concern for computer science research to enter into studies that are concerned with this infinite two-dimensional space in general, we will in the particular cases have to delimit the scope of our research. Fortunately, as research is a purposeful activity as well as any, it is possible to delimit the research to what informs our research and design in useful ways. Activity theory, with its mediating perspective on theory, provides this option in contrast to randomness and eclecticism. In my own work I have been much concerned with breakdowns as a source of insight. Engeström (1996) suggests, on a more general scale, that we concern ourselves with ruptures or disturbances as the place to start when

understanding and working to change a particular activity system. I find this way of thinking a substantial help in delimiting the domain of scrutiny in a particular situation, in particular when we are concerned with design that is fundamentally a result of disturbances at the same time as it leads to such. This means that just as the kind of disturbances that I have called breakdowns are important starting points for analysis and design when looking at the computer application-in-use in the narrow, other disturbances are good starting points for wider analyses of the web of activities of design and use. The analysis of design representations in [16] is one example where the overall contradiction between the design representation as a means of cooperation and as a means of formally describing the future computer application is the starting point.

7

Related work

The Scandinavian tradition of system development research has always been concerned with the connections between computer artifacts, and processual and organizational issues of design. It has always been seeking inspiration from other research disciplines such as sociology, psychology and organizational theory, at the same time as it has been concerned with technical issues regarding the clay of computing. Over the years, the research has diversified. Some researchers have primarily been concerned with action-research together with designers (e.g. Mathiassen, 1998), with less concern for usability of outcomes of design. And others, such as Kyng (1995c) and myself, have been collaborating mainly with users, giving less attention to practical, organizational issues of design. With the most recent work, e.g. in the BIDI project and the Mærsk project (Christensen et al., 1998), these concerns are likely to meet again.

My work has been inspired by a number of sources within participatory design and systems development/software engineering, HCI, and CSCW. I have in numerous places of this summary discussed how my work relates to specific instances of work by other authors, and these discussions will not be repeated here. Nor will I repeat my introductory situation of my own work in the history and development of the collective resource approach and the group of people that I have worked with over the years. I will instead give these people credit for their particular contributions as well as paint a bigger picture of less obvious relations and sources of inspiration. I will focus on a number of issues that I find characteristic to my own contribution, beyond research methodology. These points are structured in accordance with Engeström and Middleton's (1996) summary (Chapter 6), attuned to my particular contribution:

- the insistence of understanding use and design as situated in human activity with its particular material and social conditions, and mediated by artifacts,
- focus on the ongoing dialectics between the structural and the processual, regarding use as well as design
- focus on learning as fundamental to use as well as to design and that it is collaborative and situated in both respectively, in particular emphasizing cooperative design,

- the concern for continuity as well as change, within activities and in webs of such,
- focus on reflective practices of design and research.

7.1 Use and design as situated and mediated by artifacts

Through our investigations of system development dating back to the early 80's it was evident that the actual practice of system developers and users is indeed very different from the procedures outlined in system development methods that the developers claimed to follow, and from organizational handbooks and charts claiming to describe use / work in particular organizations (Ehn & Kyng, 1984, Bødker, 1984). With the work of Suchman (1987) it became evident that it is indeed necessary to study the actual practice of people, be they users or designers, and not try to understand work through plans, manuals and methods alone. The emergence of CSCW as a research area boosted this type of investigations (e.g the seminal paper by Heath & Luff (1992) on the work of controllers in the London Underground). This is not least because it was very evident that many of the early groupware systems, which were based on rather idealized versions of how people cooperate, were indeed much too narrow to provide support for real cooperative work situations.

The volume edited by Nardi (1996), in which [10] appears is a collection of state of the art papers on activity theory and human-computer interaction that was intended to emphasize empirical work focusing on use as situated and mediated by artifacts. As it turns out, very few contributions are made to the analyses at the level that I have attempted in my contribution. As a matter of fact very little work in the book is empirical at all, and much more needs to be done in my opinion. Fortunately, we have been rather successful in developing further such analysis methods and concepts in various Masters and ph.d. projects at Aarhus: On top of the already mentioned work by Bertelsen and Bardram, Bardram & Bertelsen (1995) worked specifically on the notion of graceful tutoring, Bardram & Pedersen (1994) extended the analysis of cooperative design situations, Bouvin, Nielsen & Sejersen (1996) worked on the approach to analysis of focus shifts. And further projects tried out the focus shift analysis in various particular use contexts (e.g. Just 1998). As outlined above, we are continuing our research along those lines.

Suchman and her group at Xerox PARC have made challenging and significant contributions to the area of design and research methodology with their background in ethnomethodological ethnography. Through my personal connection to the group, and my collaboration with Randy Trigg in particular, my work has been heavily influenced by the use of video analysis established by the group (Suchman & Trigg, 1991). Suchman has made similarly significant contribution to the field through her field work of people using technology in complex settings, in particular through her

analysis of the dialectics between routine work situations and situated problem repair situations (Suchman & Wynn, 1984, Suchman, 1987, 1996).

I see a further importance of [2,4 and 5] as well as of Bowers & Pycock (1994) in illustrating the usefulness of a detailed ethnographical study of design situations and the role of design artifacts. From within the ethnomethodological tradition, Button & Sharrock (1994) have made elaborate analyses of design organizations using a particular method, pointing to the many reasons for applying, or claiming that one applies, a method. Those reasons have little to do with the actual design work carried out by the project. These conclusions are quite similar to those drawn by Mathiassen's (1998) in his summary of years of action-oriented research with system developers, and with the basis of my own work in e.g. [13]. The mediational role of system development methods is not that of prescription of everyday design; rather they have a learning role, along with mediating the relation between a project and the outside world in terms of e.g. politics. With heavy influence from ethnomethodology as well as Latour (see e.g. Latour, 1990), Goguen and colleagues in Oxford have made an important move away from the limitations of traditional approaches to software engineering and requirement "capture" towards focus on actual practice as the starting point for getting to such requirements (Goguen, 1994, Goguen & Luqi, 1995). I am aware that similar steps are being made in requirement engineering (see Bannon, 1996). A general discussion of formalisms and formalization versus a concern for situations and of the actual and possible roles of computer artifacts in these [13 and 16] has certainly been important. I am less convinced that the specific situated data types provided by Goguen solve the problem, because they are themselves abstractions, though perhaps more sophisticated.

Ethnomethodological ethnography has been the starting point of a strong body of work dealing with CSCW design, e.g. Hughes et al. (1991). My major concern with this tradition is that the design side has been very inspired from traditional software engineering instead of more iterative and participatory perspectives on design. However, the work of Shapiro (1994) and his later cooperation with Mogensen (Mogensen & Shapiro, 1998, Bücher et al., in preparation), has been important in building a bridge between participatory design and ethnomethodological ethnography. This work has established a debate about what may be achieved through ethnographic fieldwork as regards systems development, and what may be achieved through participatory design. This discussion is one that runs through my own work, but not as a primary concern.

I have found studies of the actual mediation of artifacts for use of various sorts, including for use in system development very informative. My studies of the work to make a technological installation work, be this a design platform, a common information space or a network has largely been inspired by the work of John Bowers (1994). He points out how many artifacts along with their general support of work introduce a need to maintain, and develop further, the artifact, making reference to actor

network theory as well as ethnomethodology. Leigh Star has, with different co-authors and on a similar basis (Bowker et al., 1996, Star & Ruhleder, 1994, Star 1989, 1991) made an important contribution to our understanding of the roles, processes of introduction and maintenance of large classification schemes and systems. These studies are examples of how such artifacts need to be maintained and developed over time. They have further been very important in understanding what happens when artifacts get used in local contexts at the same time as they travel and maintain an identity across such local contexts. Star (1989) focuses on heterogeneity and introduces the concept of boundary object. Her thoughts fit well in with some of the newer work within activity theory, e.g. Engeström's interest in heterogeneity as driving force of change. Both Engeström and Star have been instrumental in bridging between activity theory and actor network theory (See e.g. Engeström & Escalante (1996)'s study of the design and (failing) implementation of the "Postal Buddy" an information kiosk application for the US postal services).

In conclusion there is a rich body of literature studying use and design as situated and mediated by artifacts. The influence of this work on my own has been quite evident not least as examples to think from. The general cross-fertilization between these studies and researchers who provide, more narrowly, the clay of computing and the tools and techniques for its design, e.g. software engineering and design of user interfaces / HCI is beginning to emerge, and still needs to be worked on.

I find that one of the most promising perspectives coming out of software engineering is the Tools and Materials Metaphor developed by Züllighoven and collaborators (e.g. Riehle & Züllighoven, 1995). This approach shares with my own the sensitivity towards human competence and development of use, and works to develop a design methodology accordingly. Where my understanding builds on material and artifact / tool as two faces of the computer application, Riehle & Züllighoven (1995) seem to locate the two as different parts of the software. It is promising, however, that software engineering literature start to talk about computer applications as materials and artifacts and not only as systems.

7.2 Ongoing dialectics between the structural and the processual

The dialectical thinking regarding the structural and the processual has been embedded in my own background since Mathiassen (1981) introduced a schematics to understand the relations between computer systems and computer system development in those terms, and the fundamental ideas behind Figure 13 is inherited from this perspective. The computer application as a structure constrains use at the same time as it inevitably getting changed by use. The computer application as a structure is transformed in design, at the same time as it resists its own reshaping. Mathiassen along with e.g. Bjerknes (1989) has moved on to use this way of thinking primarily in dealing with computer system development as a

process in relation to its various surrounding conditions, methods, etc. more than to its outcome and the embedding of the outcome in use. Engeström's (1987) activity system analysis with its 4 types of contradictions provide a general supplementary understanding of work, the artifacts and general conditions of work in relation to change. These contradictions are developed further regarding design by Bisgaard et al. (1989). Where I see my own contribution is on focusing both of these two approaches on what can be seen as their overlapping concern: the computer application in use in relation to design.

The ongoing dialectics between the structural and processual aspects of design and use is further emphasized in the way I look at experiences and expectations, or at the past[3] in terms of artifacts etc. as *constraints* for development, and the *possibilities* of the future. The current practice, including experiences, material conditions, etc., creates important constraints on what development may be initiated. At the same time they constitute potentials for development. Design, thus, must be concerned with the (ever changing) conditions for development, i.e. constraints and potentials for change that exist within current practice in relation to particular possibilities of the situation. It must further be concerned with envisioning and concretizing possibilities in relation to conditions within the involved practices. This way of thinking led us to suggest a 2-level strategy for design in the AT project (Bødker et al., 1993c). This particular dialectics between continuity and change is developed further in Section 7.4.

7.3 Learning, in particular cooperative design

Many researchers in HCI today wish to include many of the aspects covered by my work such as a focus on learning as going beyond adaptation to technology, and human action as situated and not fully anticipable (e.g. Norman, 1991). At the same time, though, they maintain an ideal of being able to do design based only on analysis, not on interaction with real people conducting work. I find it necessary to take a more radical step out to where the users are, at the same time as I share Carroll's (1991) concern, namely to find a theory to explain what we are doing. What I have tried to show is that such theories exist and can be made instrumental for detailed studies of human-computer interaction and extend towards design, at the same time as they make necessary focusing on larger issues such as historical, social and material contexts [20].

Getting out where the users are is an issue fundamental to participatory design. Participatory design is a fairly wide area with roots in Scandinavian systems development research. Many Scandinavian researchers have

[3] This analysis was developed in relation to the AT project in cooperation with Preben Mogensen.

participated, and I hesitate to discuss the contributions of all of them. However, Ehn's (1988) theoretical contribution, building on the experiences of the Utopia project, deserves to be mentioned. Ehn establishes a number of the fundamental principles of participatory design through a rather post-modern reading of Marx, Heidegger, and Wittgenstein. In a more recent summary, Kyng (1995c) takes a more practical and pragmatic approach to establishing experiences and principles of participatory design. I share very much background with these authors. Our approach to research in participatory design has always been driven by the needs of the specific design settings and always action-oriented. This means that my contributions, at a practical level, cover a variety of aspects and approaches (overviews can further be found in Bødker et al., 1993b, Bødker et al., in press). At the same time, I have had the main urge and responsibility of casting what we have done within the frames of activity theory. The activity theoretical frame and empirical method have made it possible to progress at a number of levels: in the theoretical understanding of what participation is, in analyses of actual design situations, and in understanding the role of computer applications in design and use, and not least in the particular focus on learning and development.

The developmental work research approach (Engeström et al., 1988, Kuutti, 1991, Kuutti & Bannon, 1993) through the shared theoretical basis with my work (Bødker, 1991), has provided an important further source of inspiration. Both at a theoretical and a methodological level Engeström and collaborators work in ways that are quite similar to ours. Where (e.g. in Bødker, 1992) I have been rather critical to Engeström's (1987) notion of the new as something predetermined, he has in more recent years moved towards an interest in heterogeneity as the driving force of change (Engeström, 1996), and worked accordingly. Though his aim is development in work in general rather than design and use of computer applications, many of the methods applied are the same, and e.g. change laboratories, an approach developed by the Finnish group, is an inspiration for our current work with usability workshops in BIDI.

Whereas participatory design includes many approaches that do not entail direct and active cooperation between designers, this has been the main emphasis of people around me (Kyng, 1995c, Mogensen, 1994, Grønbæk et al., 1997), thus the terms cooperative design and cooperative prototyping. To recapitulate the reason for this, overall we do not see learning as a side effect of design, but as necessary for change. And since learning is fundamentally cooperative and based on hands-on experience, these components are necessary in design.

To the best of my understanding the term 'cooperative prototyping' was coined by Kaj Grønbæk and myself. Preben Mogensen in his ph.d. thesis (Mogensen, 1994) helped extend (and articulated what we had extended) the concept also to cover situations and aspects of situations that more traditionally would be seen as analysis (e.g. the kinds of situations that [2 and 4] talk about as talk-throughs of work). Bowers & Pycock (1994) introduced the concept of "gradient of resistance" in discussing prototyping situations

quite close to ours. They pointed out that in their case the pattern of cooperation around the prototype was somewhat different from ours. Though in many ways their observations were quite useful, our cases are different from theirs because the prototyping session follows after various other activities aiming to create a cooperative basis between designers and users. This basis is concerned with understanding and dealing the use context of this artifact as well as the artifact being designed. Both of these kinds of understanding were being developed further in the prototyping sessions. In the example of Bowers & Pycock (1994), the designers and users do not seem to share a history in the same way. From activity theory, both Raeithel (1992) and Bardram (1998) have developed useful distinctions between different kinds or degrees of cooperation within groups.

7.4 Continuity and change

It is striking to me how similar the HCI tradition of cognitive science, the software engineering and system development traditions are in their approach to the human users. For rather opposite reasons they have chosen to “mirror” human beings in the computer, to describe human capabilities in terms of concepts that also describe the computer, to decompose human action in terms of how one may decompose a computer program. Both kinds of traditions have severe limitations regarding our understanding and design of computer applications. Despite this, several of the main proponents recognize that description of current action is not enough and that "*Design is where the action is*" to quote a memorable phrase of Allen Newell's, one of the founding fathers of the North-American tradition of HCI. In a similar way, Floyd’s (1987) paper on a process-oriented view of software engineering, profoundly challenges this descriptive view. In my own work I have for a long time worked by rejecting analogies between human activity and the constitution of computer programs, with inspiration from Ehn & Kyng’s (1984) work on the tool metaphor as ideal for an application-oriented view of the computer. At a very overall level, I see my own later work re-approaching the description of computer applications in a new way.

Designing computer applications based on a description of human work as it is carried out before the introduction of technology, be this description a task analysis as promoted in HCI or an ISAC activity graph, or an OOA model, has several problems. It is perceiving work as static, preplanned and tool independent, so that the description of the pre-application work can be mapped into the computer application, *and* remain unchanged, when the computer application is introduced. New computer applications disrupts the continuity of work, and design, thus, benefits from being concerned with the dialectics between continuity and change. Design must seek ways to investigate these disturbances; in work and in artifacts. In the next step, change may as well be supported through the technology.

In my work on tailorability, or local design, I approach this phenomenon from the development of practice and instruments of tailors, platform co-ordinators, and local developers. Bannon (1986) talked about how users may help each other and saw a role for active users in relation to development and consolidation of local platforms. Mackay (1990) talks about "translators" and proposed that managers give them official recognition and status. Thereafter, Gantt and Nardi (1992) found that certain CAD organizations already had such positions. Our work in [15], and my continuation in [17] can be seen as continuing the enterprise started by Mackay, Nardi and others. What distinguishes our studies from some of this work, however, is that we are concerned not only with the technical tailoring activities of local developers and the attendant activities of support, maintenance and training. We also want to understand the work practice of local developers as it is defined and constrained by the organizational and institutional contexts in which they are embedded. Thus, for example, we have found the classification by MacLean et al. (1990), with its primary focus on technical skills, to be far too limited. At CSCW '94, where [15] was presented, Okamura et al. (1994) presented a study that heavily emphasized the role of human mediation in establishing a news network in an organization, with perspectives and foci surprisingly similar to ours (though in a rather different kind of organization). Star & Ruhleder (1994) discussed the conditions for setting up local nodes in a research network. This is a further example illustrating how a standard computer application, even when developed for a particular purpose, cannot just be implanted in a local organization without an effort.

I find a serious gap in literature in bridging between these kinds of studies and the actual design of technology, and I see the theoretical framework presented here as a step to making a bridging of this gap possible, together with e.g. the work of Kyng (1995a & b). A particular approach to this is the use of scenarios as design artifacts, which has been discussed in HCI for awhile [13, 14, 20]. Campbell (1992) categorizes scenarios based on the assumption that a scenario refers to "representative instances of interaction between user and system". Kyng (1992) points out that these categories are presented as a goal per se in much of the literature, rather as an instrument to be used in co-operation between users and designers, dealing with early ideas about an application as well as almost finished ones. Various approaches to scenario use in design are developed in Carroll (1995). Carroll & Rosson (1992) point out that the use of empirical analyses of the use of computer applications are, "not merely rich; they are too rich" and they are "necessarily a posterior", i.e. we cannot wait for the computer application to be built before we start being concerned about the use. Scenarios may help on this, and theory may help organize scenarios, as well as generate them.

7.5 Reflective practices of design and research

More than anything Schön's (1983) book about the reflective practitioner has influenced how computer system design has come to see itself as a reflective practice (see e.g. Mathiassen, 1997, Madsen, 1987). Reflection in action in Schön's (1983) terms is about how researchers and practitioners become able to better reflect upon their own practice while carrying it out. Research is a cooperation between researchers and practitioners, but with very individualistic purposes, not as I see it as a multi-practical activity. In the work of Andersen et al. (1990), Schön's idea of the reflective practitioner has led to identifying, and dealing with design situations according to their uncertainty in terms of (un)familiarity of work methods and object of work. These types of situations are very similar to Bardram's (1998) three general levels of collaborative activities, rooted in activity theory. This general framework identifies conditions under which collaboratives, e.g. design groups are able to maintain a reflective practice, both through reflections on the means of work and the object of work, and through the reverse moves of stabilization of the two.

With the interweaving of design and use proposed in my own work, it is necessary to move beyond this perspective. The reflective practices of use, while covered by Bardram's (ibid.) general frame, needs to be brought together with the reflective design practice. Computer application is constituted through the web of design and use operations, actions and operations. Gasser's (1986) workarounds are the low-level design transformations of breakdowns of use operations. To be innovative, design needs to make transformations also on the level of questioning the purpose of what takes place (the activity, reflecting on the object of use/work). Since it is the object of use that is of concern for design this type of transformation will work better if the reflection is a capacity of use as well as of design. Thus, design is in many ways better able to deal with a reflective use practice, and to involve such a use practice in design. This is indeed the essence of truly cooperative design, and a basis for innovation (Brown & Duguid, 1991).

And on top of this comes the reflective research practice that is part of the participatory design tradition (e.g. Kyng, 1996c, Blomberg et al., 1997), where the main outcome of research is of design methodological nature.

7.6 Voices of criticism

In the following, I will look at some of the criticism that I have come across of my approach, if not particularly directed towards me, then directed towards writings that are in certain ways similar to mine. Criticism can come from within a research community, across disciplines, or be en-

tirely external to the community-at-large. And not least, criticism can be constructive or destructive, and I am indeed more interested in the constructive than the destructive.

I take certain things for granted, such as the need for use-oriented alternatives to the classical, formal methods of computer science. This need has been pointed out by people who are themselves well-established in the classical disciplines, e.g. Floyd (1987) and Goguen (1994). I also take for granted that contributions from social and human sciences are not as such sufficient to establish a use-oriented understanding of computer artifacts. This is simply because a technical understanding of the computer materials are necessary make such an understanding constructive.

Consequently, I am concerned primarily with criticism that has come out of concerns similar to mine. These points of concern deal with the relationship between methodology and design suggestions; descriptions of work as the starting point for design; the extent to which the outcome of a design process needs to be a computer application; the constitution of the community of use practice as well-established or emergent; the conservatism of user participation; and the practical conditions of cooperative design.

Design is used in this summary primarily as pertaining to process. I have linked my concerns over process to an understanding of the material that we work with in the discussions over 'the clay of computing', and I believe that this interlinking can be taken a lot further than I have managed to do here, based on my present empirical work. The reader who expected to find *designs* presented here is likely to have been disappointed. This is a consequence of my methodological focus and not because I find the presentation of e.g. improved interfaces unimportant.

One is very often confronted with a wish from various parties to reduce an activity theoretical analysis focusing on activities, actions and operations to an infinite hierarchy of 'activities', 'actions' and 'operations' as seen from an outside observer. This wish may stem from a need to compare to cognitive science, a want to design hierarchical computer systems, or e.g. an ethnomethodological critique focusing on the profoundly situated. Independently, the proponents of such a view forget that activity theoretical analysis presupposes an acting subject: there is no activity without an acting subject (be it a group or a person) who sees a purpose in the activity.

Inasmuch as I share much of my research perspective with the developmental work research tradition, we have different agendas in that they are interested in development of work in general, whereas I have a somewhat more narrow focus in dealing in particular with possible changes through computer technology. I find this necessary in order to explore a particular kind of mediating artifact, the clay of computing, in closer detail. However in practical research I find very little difference between the two approaches because in my own tradition we are very well aware that not all problems can be solved through computer technology. Thus, we in some

cases need to start with much more general questions, and the answer may *not* be a new computer application.

In distancing himself from what he calls 'the cooperative approach', Mathiassen (1997) claims that "The cooperative approach is influenced by well-established work settings" (p. 37). Looking at my own empirical cases I believe that this is far less true than what Mathiassen claims. The supervision of the Great Belt Bridge construction is an example of an organization that is highly transient, regarding its purpose, its specific work practice as well as its technology. And what is more important, my theoretical approach emphasizes these dynamic aspects, and makes it possible to support them in and through design.

In Brown & Duguid (1994) one will find accusations that participatory design is able to focus only on internal demands ("design from the trenches"), something that has never been true neither practically nor theoretically. It is even less true with this framework which is concerned with a wider web of activities of design and of use, and with contradictions in an activity system. I hope to have provided a framework that makes it possible and necessary to make design demands meet (and contradict) beyond the trenches. I find myself much more vulnerable to Newman's (1994) projection that Brown & Duguid have not dealt with the practical conditions of setting up the kind of design situations that they describe. Such practical conditions were certainly considered in the specific empirical cases, not least the AT project. However, the integrated view of design and use of computer technology needs to be brought back to practical design, and the practical conditions for instantiating such computer technology in design-and-use needs to be reconsidered so as to facilitate the handling if not resolution of actual contradictions.

Liam Bannon in his panel presentation at ISCRAT 1998, claimed that it was time for activity theory to deliver, i.e. to show its applicability to HCI and CSCW issues. Admitted we are continuously struggling with general conclusions and recommendations as regards usability of computer technology in its widest sense. However, I find activity theory to be much more of a frame of mind than specific recommendations. This said, I find that we have over the last almost 10 years developed a number of instrumental and operational ways of approaching human-computer interaction in particular. There is however, a severe lack of a place for new practitioners to start, and this is something that we must work towards.

8

Future work

The writing of this summary has been a way of wrapping up a large body of work that has been carried out over a long period of time. This wrapping up is fortunately not the end. Actually the summary asks a lot of new research questions – more than can be pursued by one person or group. At the same time, new technology in terms of advanced interaction devices, portable technology, immersive technology and much more enter the research and design field. In particular, a lot more can and ought to be said about the clay of computing as seen from the point of view of use. User participation need to be reconsidered in the light of the introduction of tailorable standard technology, as well as in the light of the increasing pressure on organizations to innovate.

My own future work is planned to continue in two directions, which are outlined in the research proposal for the Center for Human-Machine Interaction, that started March 1, 1998, and for the continuation of the CIT project, Usability work in Danish Industry (BIDI). One is contrasting the computer as material and artifact with other kinds of artifacts where usability is at stake; another is investigation of the particular relations between tools and materials in large heterogeneous information spaces. In both cases, the ongoing development is a key concern, along with a concern to be design-oriented, i.e. to move from post-hoc analysis of work situations to proactive design.

These concerns are indicated in the research proposal of the Center for Human-Machine Interaction:

“Activity theory gives an important contribution to the theoretical basis by its emphasis on the mediating role of artifacts such as common information spaces in human work. The theory is a promising means in analyzing the multi-leveled and multi-aspected nature of a common information space in a web of human activity. It further yields important concepts for understanding the historical, social and material context in which the common space is created and used, and the interlinking between the common information space and other artifacts in the organization. By proposing that artifacts such as common information spaces are crysallizations of human practice it helps understand how common information spaces get created and develop. Activity theory has traditionally been used in understanding of organizational remembering and forgetting and con-

cepts from this particular domain are expected to be of use in understanding common information spaces.

Since common information spaces are seen as emergent phenomena that are not constituted once and for all, but continuously created and recreated through the addition of information, as well as the ongoing reinterpretation of the available information, we propose that participatory design is an important theoretical and methodological component."

Within a Danish context, two theoretical and empirical traditions have emerged, which share with my own approach the concern for work, the situations in which human-computer interaction takes place, and the emergent nature of HCI: The cognitive systems engineering approach developed at Risø (Rasmussen, 1986, Rasmussen et al. 1994) which addresses the problem of modeling human behavior during work, and computer semiotics (Andersen 1990, 1993). Computer semiotics sees computer systems as media whose main purpose is to communicate knowledge and experience to the individual and coordinate the tasks of the group. Its empirical data consist of the verbal and non-verbal signs that can be observed in the place of work (speech, drawings, diagrams, etc.). These data are used as a vehicle for understanding the work processes and the organization and as a basis for designing interfaces that fulfill the users' needs.

In the Center for Human-Machine Interaction we have been fortunate enough to be able to bring those theoretical traditions together and we believe that they can inform each other. Thus, we will confront the three theoretical frameworks empirically and theoretically in order to see how far we can get.

I have not since Bødker (1991) attempted any general "dissectomy" of user interface components and I find that time is ripe to do so. I plan to make this an important component in the Center for Human-Machine Interaction, and in the BIDI project. Keywords for such analysis is to get closer to computer applications that are open, flexible, transparent and expandable; and to what this means for the clay that we work with in design, and the mechanisms that we have to somehow direct the development of the users beyond sheer trial and error.

9

A final word

This dissertation presents an application-oriented view of the clay of computing. This view is bridging between an activity theoretical understanding of use, and a computer science-based understanding of computer technology. This view is at one level independent of whether we believe in structured programming or programming-by-example, in rigid or malleable interfaces. At another level it does bring us closer to development of use, to how learning in design and use is better supported by the computer application, and thus to how transparency is multi-layered and pertaining to all activities in the web of design and use of a particular technology. The clay of computing has an interesting similarity to real clay: Fresh clay is very malleable and offers little resistance to its own reshaping. However, as it gets stiffer, the disciplining takes over at the cost of malleability. It is much the same way with computer artifacts: In what we could call early design, a lot of possibilities are left open. Getting used to a particular artifact, whether in design or in use limits our ability to see beyond the present computer artifact. And the technical choices made in design further what technical changes may be made 'easily.' I do not think that we can always make computer artifacts be open to any kinds of changes, but, as discussed in this summary, I do find that we need to work towards computer applications that remain malleable in use.

The work shows, through a number of specific empirical cases, how use and design transforms or develops the computer application, at the same time as this constrains or disciplines use as well as design. It develops a theoretical framing of our understanding of these processes, and consequently a methodological basis for the development of computer applications, for *transforming computer artifacts as materials into computer applications as instrumentss of use*. I would like to mention the mapping approach that I developed in [7, 8, 10] as a particularly successful example of how the activity theoretical basis, through confrontation with particular instances of use and development of computer applications, has lead to very specific methodological steps in analysis and design of computer applications. The use of scenarios [13, 16, 21] in the design process is another such example.

In a sense it is artificial to separate theoretical perspective, design practice and research methodology, given the reflective nature of this research. However, I hope that by keeping this reflexive nature in mind it is possible

for the reader to understand both the individual contributions of my writings, and how the interrelate:

As I outlined earlier, use as well as design transform or develop the computer application, at the same time as this constrains or disciplines use as well as design. The same may be said of research. *With the close interlinking of use, design and research, computer applications further become the clay and instrument of research, much the same way as it is of design and use*. According to Latour (1990) the development of scientific instruments is very important for the development of new insight as such. It is exactly in the field of tension of research-design-use that I have placed computer applications, and that makes me propose that computer science is about understanding and creating the clay of computing.

10

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Vocabulary

Since the papers that I present are written over a long time span, and with a variety of theoretical references, it is necessary to relate the core concepts to one another and to the vocabulary chosen for this summary. The definitions in the following have an axiomatic character in that they will not be discussed further in the summary.

Activity: The fundamental concept in activity theory as presented by Leontjev (1978, 1981) and others is defining the dialectical relationship between the development of the individual and the society in which the person exists. The theory takes *human activity* as its basic component. Human activity is collective and motivated. Each activity is conducted through *actions* of individuals, while the activity is what gives meaning to our actions. The same actions can of course appear in different activities.

Artifacts: An activity is mediated by one or more instruments or tools. Tools, norms and language can all be seen as mediating artifacts: they are made by humans, and they mediate the relations among human beings or between people and the material or product in different stages. Artifacts are there for us when we are introduced to a certain activity, but they are also products of our activity, and as such they are constantly changed. This *mediation* is essential to our understanding of artifacts. They have a double character: they are objects in the world around us, which we can reflect on, and they are instruments which mediate our interaction with the world, in which case they are not themselves objects of our activity in use. Artifacts are continuously being reshaped as a result of everyday use and the changing conditions of work. They carry with them certain ways of *sharing and dividing work* and they are given meaning only through their incorporation into a practice. It is not until they have been incorporated in practice that they can be the basis for thought and reflection. Computer applications are a particular sort of artifacts, in my writings often called computer artifacts. Artifacts are mediators of a multitude of activities; and to understand them we need to understand their multitude of contexts and motives.

Organization: though the concept of an organization is not as such part of the vocabulary of activity theory, it is mentioned so often in my writings that I find it necessary to define it here. Morgan (1986) presents a number of theoretical perspectives on organizations and suggests that to understand organizational life we need to move beyond either one of these : “For organizations are complex and paradoxical phenomena that can be understood in many different ways” (p. 13). In my work, I apply (at

least) the following understandings: Organization as a structural delimitation of a work-organizational, technological, etc. unit that pursues a certain purpose, in connection with other such units. Organizations are inherently full of *conflicts,* not just conflicts between employers and employees in the traditional sense, the concept is usefully extended as suggested by Engeström (1987) to understand how and why activity systems change. The organization is constituted through the activities, actions and operations carried out by human beings, and is undergoing continuous change.

Human beings are the active actors of webs of activity. Together they conduct the particular actions through which the outcome of activities are produced. In their interaction with other human beings and with artifacts and materials, they are continuously learning and developing the practice of work.

Practice: When getting trained as a carpenter or a nurse, one gets to share a practice. At the same time each individual who possesses a practice, keeps it up, and changes it as well. It is practice that allows us to talk about more than just individual skills, knowledge and judgement, and not just about a "generic" human being. Practice is shaped historically, which is of particular relevance for design and use of computer applications. Lave and Wenger (1991) use the term community of practice to denote a group of people who shares a practice and parttakes in, what is in activity theoretical terms called an activity. In some of my papers, the term language game (borrowed from Wittgenstein (1953)) is used in a similar fashion.

Theory. Activity theory proposes to view theories as artifacts or mediators (see Bertelsen 1994, Juul Jensen, 1989) for action and reflection.

Design denotes activities and actions that have computer applications as the object (material and outcome). Design is collective and multi-practical, being carried out partly by people the practice of whom is primarily design, or e.g. computer science, and partly by people who come from communities of practice of use. In my writings, I sometimes use the term system development as synonymous for design. The term design is sometimes used to distinguish parts of systems development that are directed towards creating the new computer application and use from e.g. those directed towards understanding the present use / work activity (e.g. Mathiassen, 1981, Mogensen, 1994). In my work I rarely need such a distinction because change is seen as a profound part of all kinds of activities.

Use denotes activities and actions that have computer applications as instruments / mediators. Since use is always part of a particular work activity, there normally is no particular use activity and the term use is used rather as a generic term to denote common properties of computer applications in work. Thus, users, with a rather unfortunate general term, are the people who use computer applications as part of their daily practice. I would much prefer to call these people by what they do: case

workers, carpenters, nurses, etc. but I do need a more general term for the capacity of using the particular computer application.

Computer applications as mediators of design and use - a developmental perspective

Edb-artifakters mediering af design og brug - et udviklingsperspektiv

Susanne Bødker

Dansk opsummering

Forord

Dette er den sammenfattende redegørelse for de afhandlinger, som jeg har indleveret med henblik på erhvervelse af den naturvidenskabelige doktorgrad (dr. scient.). Da afhandlingerne er skrevet på engelsk, er sammenfatningen affattet på dansk. En udvidet, engelsk version af sammenfatningen findes først i denne rapport. Læseren henvises til den engelske version for litteraturreferencer, figurer og uddybende beskrivelser af de enkelte indleverede værker.

Sammenfatningen består udover dette forord af en indledning, som beskriver problemstillingen, en beskrivelse af forskningsfeltet, en sammenfatning af afhandlingernes overordnede teoretiske resultater, en sammenfatning af det teoretiske arbejdes praktiske udmøntning, en forskningsmetodisk sammenfatning, en diskussion af de opnåede resultater i forhold til andre forfatteres arbejde, og en afslutning.

Indledning

Denne redegørelse sammenfatter en forståelse af edb-artifakter som materiale, der formes i design på den ene side, og som redskab i brug på den anden. Denne brug finder sted som en del af menneskers daglige arbejde, eller andre typer af hverdags-virksomhed. Forståelsen baserer sig på en procesorienteret forståelse af brug, såvel som design, og udmøntes i mit arbejde først og fremmest metodisk.

Udgangspunktet for mit arbejde er min licentiat-afhandling fra 1987 (Bødker, 1987a, 1991), hvor jeg etablerede en virksomhedsteoretisk basis for menneske-maskine interaktion. Denne basis er gennem det indleverede arbejde blevet udvidet ved at fokusere på nye teoretiske udfordringer og nye typer af teknologi, og ved at vende tilbage til tidligere udfordringer f.eks. vedrørende brugerdeltagelse i design. Arbejdet har haft empiriske såvel som teoretiske sider og har ledt til såvel teoretiske som praktisk-metodiske resultater. Disse resultater er forankrede i de konkrete problemstillinger, som kommer ud af at gå i dybden med specifikke cases.

I min forskningstradition er det at gå i dybden et spørgsmål om at fokusere på konkrete problemstillinger, som kommer ud af samarbejdet med mennesker i organisationer. Jeg har arbejdet på i alt fire empiriske projekter af forskellig omfang og karakter i forbindelse med afhandlingen. Disse projekter har det til fælles, at forskningen har været udført som et samspil mellem forståelse og design, der har ledt til en praktisk forandring i brugernes arbejde. Projekterne har yderligere det til fælles, at de har benyttet og udviklet teori og metode baseret på virksomhedsteorien, især i dens handlings-orienterede iklædning (Engeström, 1990, Engeström et al., 1996).

Det sammenfattende perspektiv fokuserer på at forstå edb-artifakter i design og brug, med fokus på samspillet mellem design og brug. Ordet *forstå* bruges i dets handlings-orienterede betydning, som også omfatter at være i stand til at forandre. *Sammenfattende er perspektivet derfor primært metodisk, og omfatter arbejdsformer og redskaber, som tjener til at arbejde med edb-artifakter placeret i samspillet mellem design og brug.*

Design opfattes som co-konstruktion af fremtidig brug; co-konstruktion mellem brugere og designere også i situationer, hvor der ikke umiddelbart er tale om samarbejde: Designerne kan på den ene side ikke forudfatte og foreskrive brugen, på den anden side kan brugerne ikke bare forme brugen af et givet artifakt uafhængigt af, hvordan den er designet. Med dette perspektiv bliver design et mødested for en mangfoldighed af praksisfælles-

skaber; en virksomhed hvor erfaringer, ressourcer, redskaber m.m. mødes og tiltider kolliderer. Overordnet set omhandler afhandlingen derfor *design-artifakter i bred forstand: teorier, teknikker og redskaber, som gør det muligt at arbejde med integrationen af design og brug.*

Forskningsfeltet

Mit arbejde har rødder i den skandinaviske tradition indenfor systemarbejde. Denne tradition er dels præget af en aktionsforsknings-tilgang, som baserer sig på samarbejde mellem forskere og de brugere og/eller designere, som forskningen vedrører. Dels har traditionen altid interesseret sig for samspillet mellem brug og design af edb-artifakter. Tradition har over årene spredt sig, så en del af forskningen primært retter sig mod samarbejde med designere, hvor de organisatoriske sider af design-processen har haft større vægt end produkternes brugbarhed, mens andre dele retter sig mod samarbejde med brugere hvor de problemstillinger, som har at gøre med organisatoriske sider af praktisk systemudvikling har haft mindre vægt. Teoretisk har traditionen også søgt inspiration fra mange hold og discipliner: organisationsteori, psykologi, sociologi og filosofi for at nævne nogle.

Samtidig er der opstået en række internationale, datalogiske forskningsfelter, som har udviklet sig i samspil med hinanden og med vores tradition. Af primær relevans her er 'Participatory design'/systemudvikling med brugere, 'Human-computer interaction'/ menneske-maskine interaktion og 'Computer-supported cooperative work'/edb-støttet samarbejde. Disse er i dag hver især veletablerede i form af konferencer og tidsskrifter, og alle præget af interdisciplinær forskning.

Mit arbejde har udviklet sig i samspil med den empiriske, metodiske og teoretiske udvikling af disse tre felter samtidig med, at de indleverede værker også afspejler en udvikling af perspektiver og metoder, som dels er affødt af behovene i projekterne, og dels af min egen erkendelsesmæssige udvikling.

Det er karakteristisk for forskningsfelterne såvel som den skandinaviske systemarbejdstradition, at de alle er på jagt efter en teoretisk basis, som er i stand til at forene en teknisk side med en brugsside, og med en forståelse af design i relation hertil.

Det er også karakteristisk, at brugerdeltagelse - eller i alt fald en detaljeret indsigt i brugernes daglige praksis - i stadig højere grad ses som en nødvendig forudsætning for godt design. Spørgsmålet er i høj grad hvorfor. Argumentet for brugerinddragelse har ofte alene at gøre med at højne kvaliteten af produktet i snæver forstand, og ikke med egentlig ressourceopbygning blandt brugerne. I henhold til den argumentation, der udvikles i afhandlingen er en sådan brugerinddragelse utilstrækkelig fordi den ikke sikrer at brugerne selv vil kunne udvikle brugen videre.

En vigtig teoretisk og praktisk problemstilling relaterer sig til, hvordan man forstår og arbejder med brug og brugere, ikke blot som samlinger af individer og ikke blot som abstrakte størrelser. Denne problemstilling er først og fremmest udsprunget af HCI-forskningen, men har en bredere relevans også i forbindelse med brugerdeltagelse, fordi den rejser spørgsmål om repræsentativitet og generalitet.

Behovet for indsigt i og fastholdelse af brugernes faktiske daglige praksis præger også sådanne forskningsfelter som 'software engineering' og 'requirement engineering', og der er i alle disse designorienterede discipliner et gryende behov for en anden, brugsorienteret materialeforståelse.

Det er karakteristisk, at man interesserer sig for et procesorienteret perspektiv på design såvel som et produktorienteret, mens det er mindre oplagt, hvordan de to forenes eller konfronteres med hverandre.

Teoretiske resultater: Edb-anvendelser i design og brug

Afhandlingen tager fat i alle disse spørgsmål baseret på et virksomhedsteorisk perspektiv, der understreger

- redskabers mediering af menneskelig virksomhed;
- sammenknytningen af brug og design, og indplaceringen af disse i relation til andre virksomheder;
- læring som central for forståelse og forandring af brug.

Menneskelig virksomhed er teoriens analytiske enhed. Menneskelig virke indgår på den ene side i en fælles virksomhed, hvor en gruppe af mennesker sammen udfører et arbejde med et vist formål eller rettet mod en vis genstand. På den anden side udføres virksomheden gennem en række handlinger og operationer, som udføres af individer med en bestemt hensigt i relation til virksomhedens formål eller genstand. Afhandlingen beskæftiger sig med to typer af virksomheder og deres specifikke karakteristika: Virksomheder, hvori der på forskellig vis udføres design af edb-artifakter, og virksomheder, hvori edb-artifakter bruges som redskaber. Da design og brug af edb-artifakter sjældent er disse virksomheders overordnede formål, er det at tale om designvirksomhed og især brugsvirksomhed en abstraktion, som er nyttig for mit formål her, men som sjældent kan stå alene. Det er værd at bemærke, at design og brug ikke nødvendigvis kan udskilles som separate virksomheder, tværtimod er det en pointe i mit arbejde, at de er tæt koblede, og at vi opnår en bedre forståelse af edb-artifakter, hvis vi holder denne kobling for øje.

En gruppe af mennesker, som sammen udfører en bestemt virksomhed, udgør et praksis-fællesskab og deler en praksis, som de samtidig er med til at opretholde og forandre. Praksis afspejles på den ene side i de redskaber, det sprog, den arbejdsorganisering og de normer, som ligger til grund for virksomheden. På den anden side kommer den til udtryk i det enkelte menneskes repertoire af operationer, som anvendes i virksomheden. I af-

handlingen beskæftiger jeg mig med en række konkrete praksis-fællesskaber, som alle er karakteriserede ved, at de bruger og designer edb-artifakter.

Artifakter er på den ene side genstande, som vi kan reflektere over, på den anden side medierer de som redskaber den konkrete virksomhed, og i den rolle træder de i baggrunden. Det er nødvendigt at interessere sig specifikt for brugen i bestemte virksomheder for at forstå artifakter. Afhandlingen beskæftiger sig derfor med en række konkrete artifakter i brug og i design. De artifakter, som primært har interesseret mig, er edb-baserede, og en væsentlig del af mit arbejde har bestået i at udvikle analyser af, hvordan edb-artifakter medierer bestemte virksomheder, handlinger og operationer. Jeg beskæftiger mig altså både med artifaktets medieringen af individers handlinger og operationer (spørgsmål som traditionelt klassificeres som hørende til menneske-maskine interaktion / HCI), og med medieringen af det fælles – medieringen af samarbejde, arbejdsdeling, regler, normer osv. i en bestemt arbejds-virksomhed (spørgsmål som traditionelt klassificeres som hørende til edb-støttes samarbejde / CSCW). Edb-artifakter indgår i et samspil med andre artifakter i de konkrete virksomheder, og afhandlingen analyserer eksempler på sådanne konkrete samspil, ikke mindst hvad angår artifakter, der medierer systemudvikling / design.

Artifakter er udkrystalliseringer af praksis, som den har udviklet sig historisk, og historiske analyser af edb-artifakter i praksis bliver derfor et vigtigt element i analysen.

Design skaber ny brug, og ændrer dermed brugernes arbejdspraksis. Uanset om der er tale om et egentligt samarbejde mellem brugere og designere er det nødvendigt for designerne at forstå brug, og brugernes "stemme" er, ligesom bl.a. ledelsens, en del af de mange stemmer eller praksisfællesskaber, som spiller sammen i design. Ligeledes spiller forventningen til de fremtidige artifakter og erfaringerne med de gamle, her og nu, såvel som i historisk lys, sammen. Afhandlingerne diskuterer forskellige design-artifakter, som medierer samspillet mellem designere og brugere, mellem det nye og det kendte og mellem forskellige praksis-fællesskaber.

Edb-anvendelser har to "ansigter", nemlig materiale- / produkt-ansigtet, som viser sig i design, og redskabsansigtet, som viser sig brug. Den tætte kobling mellem de to ansigter ses af, at materialeansigtet viser sig i brug f.eks. i sammenbrudssituationer ('breakdowns'), som leder til ny og ændret brug, mens redskabsansigtet også kan vises frem i design, f.eks. når prototyping giver brugerne mulighed for at afprøve den fremtidige brug.

Afhandlingen indplacerer edb-artifakter i den flerhed eller det "spind" af virksomheder, hvor artifaktet designes og bruges (Figurerne 7-12). I forbindelse med konkrete design- / brugs-virksomheder påvises nytten af at undersøge modsætninger og transformationer mellem edb-artifaktets placering i de relevante konkrete virksomheder. Edb-artifaktet er ofte hovedmedieringen i skiftet mellem forskellige involverede virksomheder, og afhandlingen analyserer konkrete eksempler herpå.

Afhandlingen beskæftiger sig med læring som en central side af brug såvel som design: i den ene ende af spektret beskæftiger flere værker sig med,

hvordan sammenbrud i brug leder til udvikling af brugen gennem udviklingen af det repertoire af handlinger og operationer, som brugerne betjener sig af. Andre værker beskæftiger sig med, hvordan prototyper-i-brug hjælper med at undersøge, om etableringen og udviklingen af et handlingsrepertoire kan finde sted.

I den anden ende af spektret udvikles flere analyser af integrerede design- og brugs-virksomheder, som på mere fundamental vis tager en brugsvirksomhed, som er under udvikling, som udgangspunkt for design. Afhandlingen diskuterer forskellige aspekter af sådanne processer i forskellige domæner og i forbindelse med udviklingen af forskellige typer af artifakter.

Afhandlingen beskriver og diskuterer, *hvordan brug såvel som design udvikler edb-artifaktet,* på samme tid som dette altid begrænser brug såvel som design. *Dette fokus på det dialektiske samspil mellem udvikling og begrænsning på den ene side og design/brug på den anden, gør det muligt at udvikle en forståelse af edb-anvendelser under konstant udvikling.* Men brug er ikke bare brug, og det spændingsfelt, der opstår gennem brugen i forskellige brugs-virksomheder, er ligeså vigtigt for den konkrete udvikling af edb-anvendelsen.

Afhandlingens teoretiske standpunkt bliver uddybet gennem en lang række studier af de virksomheder, som former edb-anvendelserne hvadenten de har edb-anvendelsen som materiale eller som redskab.

Edb-artifaktet som redskab for menneskers arbejde er i fokus bl.a. i forbindelse med udviklingen af fokusskift- og artifakt-historiske analyser.

Edb-artifakter i fælles og ofte distribuerede omgivelser belyses gennem arbejdet med fælles informationsrum (CIS), gennem udgrænsningen af CSCW og gennem udviklingen af arbejdsformer til design af CSCW-anvendelser.

Lokal videreudvikling (’tailoring’), som finder sted, når et edb-artifakt tages i brug i en organisation, gøres til genstand for flere analyser. Arbejdet illustrerer, hvordan denne lokale videreudvikling foregår i fællesskab og involverer udvikling af strukturer, mekanismer og roller i organisationen. Afhandlingen belyser yderligere, hvordan lokal videreudvikling kan danne ramme for aktiv brugerdeltagelse.

Gennem mit arbejde med at drage aktiv nytte af brug i design, indplaceres ’cooperative prototyping’ som central i design, så brug-i-design ikke bare rettes mod at afprøve fremtidig brug, men også mod at skabe ideer til den fremtidige edb-anvendelse, mod at forankre forskellige fortolkninger og perspektiver i noget konkret, og mod designernes refleksioner over egne arbejdsformer.

Edb-anvendelse har en central rolle i mediering af design; som design-artifakt såvel som materiale. Afhandlingen diskuterer også andre design-artifakter og udvikler en forståelse af disses samspil med de edb-baserede materialer og produkter.

Edb-baserede materialer og redskaber indgår i en mangfoldighed af delvist overlappende design- og brugs-virksomheder, og det konkrete edb-artifakt undergår konstante ændringer i, og på overgangen mellem disse. Afhandlingen giver redskaber til at forstå og isolere disse positioner i konkrete analyser og for at kontrastere positionerne teoretisk og praktisk. Design må nødvendigvis prøve at forudfatte brug for at være meningsfuld, på samme tid som brugen fundamentalt ikke kan forudfattes. Afhandlingen diskuterer derfor, hvordan *de designede edb-artifakter kan og må gøres mere velegnede til lokal videreudvikling*.

Design i brug, brug i design - praktiske udmøntning

Afhandlingen beskæftiger sig med en lang række praktiske design-virksomheder og -arbejdsformer, som på forskellig vis integrerer design og brug. Udgangspunktet er følgende fokuspunkter for design, som uddybes i afhandlingen, samtidig med at der udvikles praktiske arbejdsformer, som understøtter de pågældende punkter:

Design er et mødested for mange praksis-fællesskaber. Understøttelse af samarbejde mellem forskellige grupper af designere og brugere er derfor vigtigt.

Design skal give brugerne mulighed for at opleve den fremtidige brug.

Design skal rettes mod forståelse af nuværende, tidligere og fremtidig brug, og være teoretisk såvel som praktisk inspireret.

Design skal baseres på en forståelse af, hvordan brug udvikler sig, og hvordan brugsvirksomheder spiller sammen med andre virksomheder.

Design skal baseres på en brugsorienteret forståelse af især de edb-baserede materialer.

Design skal være innovativ.

Design skal udføres, så designerne får lejlighed til at reflektere over deres egne redskaber, teorier og praksis.

Konkret opsummeres disse praktiske erfaringer i en design-værktøjskasse, som gør det muligt at

- benytte teori målrettet til praktisk designbrug i form af checklister kombineret med designforbilleder af brugsorienteret såvel som teknisk art;
- basere sig på 'cooperative prototyping' teknikker i aktiviteter, der formålsmæssigt rækker fra analyse af eksisterende brugssituationer til afprøvning af konkrete designforslag;
- forankre design, proces- og produktmæssigt, i konkrete beskrivelser af nuværende brugssituationer og scenarier for fremtiden baseret herpå;
- kombinere disse teknikker med andre arbejdsformer, som understøtter brugerdeltagelse i form af samarbejde mellem brugere og designere.

Forskningsmetode

Den aktionsforskningstilgang, som er fundamental i mit arbejde, har en lang tradition i den skandinaviske systemarbejdsforskning. Forskningstraditionen understreger vigtigheden af at arbejde sammen med de personer, hvis gøren og laden man interesserer sig for, og at give dem noget til gengæld for den indsigt, de hjælper én med at få. Det de får til gengæld er en ressourcemæssig oprustning, som gør dem bedre i stand til at deltage i og stille krav til teknologien. Dertil kommer i mange tilfælde konkrete løsningsforslag til brugbare artifakter.

Traditionen har delvist fælles rødder med de virksomhedsteoretiske tilgange, som jeg er mest inspireret af, ikke mindst den finske 'Developmental Work Research' tradition. Det har derfor været både nyttigt og muligt at bringe disse to traditioner sammen i mit arbejde, hvor jeg jo ikke har fokuseret på arbejde generelt, men på edb-anvendelse. Dertil kommer, at virksomhedsteorien mest af alt er en ramme, som lader sig udfylde for mere specifikke problemstillinger sådan som design og brug af edb-artifakter.

Forskningsmetodisk har jeg yderligere søgt inspiration bl.a. fra den ethnometodologiske og den Latourske tradition, som de har udviklet sig, primært i CSCW.

Afhandlingens generelle syn på artifakter, som medierende menneskelig virksomhed, omfatter også teorier. Derfor må nytten i teorier i sidste ende bedømmes i forhold til, hvordan vi som forskere kan benytte dem til at forstå og forandre de situationer, vi står over for. I mit arbejde har jeg benyttet mig af en række begreber og metoder, som ser på fortiden, såvel som nutiden og fremtiden på præcis samme vis, som jeg foreslår at designere skal gøre det, men med den forskel, at hvor design kan være selektiv og til en hvis grad vælge redskaber, som fremmer det umiddelbare mål, må forskeren gå bredere og mere systematisk til værks, og fortsætte med at undres over det uventede, som er det, der skaber spænding og dermed fornyelse til forskningen.

Diskussion i relation til forskningsfeltet

Jeg ser min og andres udvikling af virksomhedsteorien som én teoretisk basis, som er i stand til at forene en teknisk side med en brugsside, og med en forståelse af design i relation hertil. Perspektivet gør det yderligere muligt at arbejde med et teoretisk perspektiv samtidig med, at man beskæftiger sig med problemstillinger, som opstår ud af den konkrete empiri. Teorien giver gennem selve virksomhedsbegrebet et bud på, hvordan vi kan håndtere individuelle handlinger på den ene side, og fælles praksis på den anden, samt afgrænse og kontrastere edb-artifakters brug i flerheden af virksomheder.

Gennem mit arbejde skifter brugerdeltagelse fra at være en interessant udvidelse af design, som kan give bedre produkter, til at være ligeså central som ”designer-deltagelse” – det at designere har en teknisk indsigt i teknologiens muligheder og begrænsninger. I modsætning til den tildels misforståede kritik, som ofte rejses af at inddrage brugere aktivt i design, leder et sådant samarbejde netop til innovation og ikke til konservatisme.

Afhandlingen giver fragmenter af en brugsorienteret materialeforståelse, men der er endnu mange uløste spørgsmål. Jeg ser f.eks. Joseph Goguens og Heinz Züllighovens arbejder som andre interessante måder at tilbyde en brugsorienteret materialeforståelse.

Den læser, som forventede sig at se en masse designforslag eller produkter præsenteret i mine arbejder, er nok blevet skuffet. Mit arbejde har primært været metodologisk, mens forslag og anvisninger til godt design har måttet vente. Jeg er imidlertid overbevist om at afhandlingen ruster mig selv og andre interesserede forskere til at gå i gang med at undersøge forskellige designforslag og til selv at komme med sådanne.

Fremtiden

Afhandlingen sætter et punktum ved at sammenfatte mange års arbejde, men den kridter samtidig banen op ved at stille nye spørgsmål. Ressourceopbygning for brugere i en organisation må diskuteres i nye termer bl.a. i forbindelse med, at fleksibel edb-teknologi lægger op til lokal men ikke individuel tilpasning, og i forbindelse med at der stilles større og større krav til, at organisationer kan omstille sig. Nye typer af artifakter trænger sig på: små bærbare edb-artifakter i den ene ende af spektret, og krops-omsluttende virtuelle omgivelser, hvor mennesker samarbejder, i den anden. Edb-artifakterne går fra at være monolitiske systemer og individuelle værktøjer til at understøtte en mangfoldighed af delvist overlappende menneskelig aktivitet.

Jeg fortsætter med at arbejde med en lang række af emner, som udbygger det arbejde, som sammenfattes her. I vores nystartede Center for Menneske-Maskine Interaktion vil jeg bl.a. fortsætte arbejdet med fælles informationsrum. Udfra konkrete eksempler er det hensigten at udbygge vore teoretiske og praktiske forestillinger om disse artifakter, som understøtter en mangfoldighed af delvist overlappende brugsvirksomheder, med delvist overlappende redskaber og materialer og i stadig udvikling i samspil med disse virksomheder.

Jeg vil yderligere arbejde med at kontrastere virksomhedsteorien med to andre vigtige teoridannelser indenfor for menneske-maskine interaktion, det økologiske perspektiv og det computer-semiotiske.

Afslutning

Afhandlingens sammenfattende begrebsramme gør det muligt *at forstå og inddrage udvikling som en central del af design såvel som brug af edb-artifakter*. Edb-artifakternes multi-medierende rolle i det relevante virksomhedsspind er en vigtig drivkraft for at forstå og arbejde med edb-artifakter i design og brug. Afhandlingens teori og metodologi er derfor baseret på forståelsen af *samspillet mellem brug og design, og mellem udvikling og begrænsning*. Derudover præsenterer afhandlingen *en brugsorienteret forståelse af edb-artifakter*, som de materialer vi, som designere, har mellem hænderne. Denne forståelse baserer sig på karakteristikken af brugsegenskaber for systemer, værktøjer og medier, og interesserer sig især for, *hvordan edb-artifakter kan tilbyde en fleksibilitet i forhold til lokal videreudvikling*.