

**OPEN-ENDED INTERACTION IN COOPERATIVE PROTOTYPING:
A VIDEO-BASED ANALYSIS[†]**

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Abstract

Cooperative Prototyping can be characterized as the use and development of prototypes as catalysts during discussions between designers and potential users – the overall intention being one of mutual learning. On the one hand, the designers learn more about the work practices of the users in ways that are tied concretely to some current version of the prototype. On the other hand, the users learn more about the potential for change in their work practice, whether computer-based or otherwise. This paper presents the results of a field study of the cooperative prototyping process. The study is based on a fine-grained video-based analysis of a single prototyping session, and focuses on the effects of an *open-ended* style of interaction between users and designers around a prototype. An analysis of focus shifts, initiative and storytelling during the session is brought to bear on the question of whether and how cooperative prototyping can be successful with users who are reluctant to “play in the future.” The paper also discusses issues in applying video analysis to system design.

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1. Introduction

In recent years, system developers have been searching for approaches that better align their designs with the needs, work practices and organizational settings of prospective users. Among such approaches, prototyping has emerged as one of the most promising. Prototyping positions a primitive, but suggestive, artifact at the juncture between the users' and designers' worlds during the initial stages of system development. Advocates claim that the probability of long-term success is improved if users are able to provide early feedback on concrete design ideas (Lantz 1986, Nauman & Jenkins 1982, Wilson & Rosenberg 1988). Closer inspection of the processes of interaction around the prototype as well as the relevant organizational settings shows, however, that the presumed malleability of the prototype's design can be illusory (Grøn­bæk 1989). At times, system developers using prototypes seem to be merely gathering approval or user acceptance for what is already a rather fixed design. But even when designers have the best intentions, they tend to carefully structure interaction around the prototype. This is justified as a means of validating parts of the prototype through controlled experiments (Baecker & Buxton 1987, Monk 1987), "user testing" (Gould 1988) or "user observation" (Gomoll 1990). However, the result is that control of the interaction is placed firmly on the side of the designers. That is, the designers specify tasks for the users to perform, observe user reactions, and analyse behavioral data (often statistically) after the experiment.

The cooperative prototyping approach

Cooperative prototyping, devised by two of this paper's authors, proposes an alternative approach to interaction around and with the prototype (Bødker & Grøn­bæk 1991a, 1991b, 1991c, Grøn­bæk 1991). The approach is an exploratory prototyping approach (Floyd 1984), but in line with the Scandinavian tradition of user participation the process is seen as a cooperative activity between users and designers rather than as a new way to extract user requirements.

The goal of cooperative prototyping is to establish a design process where users and designers participate actively and creatively based on their respective qualifications. Initial prototypes support a mutual learning process where the participants' visions are made concrete with respect to core tasks in the users' work domain. Prototypes are modified, thrown out, or built anew in an iterative process that increases all participants' understanding of both the relevant technological possibilities and the users' work practice. Activity around the prototype generally involves either exploration of design ideas and users' work practice or work-like evaluation of prototypes. In the first case, the focus is on cooperative use of the prototyping tools to create a prototype or extend an existing one in order to provide support for specific work tasks. In the second case, the prototype is used to simulate a fluent work-like situation with a future computer application. If the prototype is sufficiently robust, one can even imagine employing it experimentally in a realistic use situation.

When possible, breakdowns involving the prototype's design lead to on-the-fly (in-session) modifications in cooperation with the users. Deeper breakdowns lead to new versions of the prototype developed by the designers between prototyping sessions. Ideally, cooperative prototyping should be performed by a small group of designers and users with access to flexible computer-based tools for rapid prototype development and modification. For further discussion of the theoretical

basis of cooperative prototyping and practical experience with the approach in work settings, see (Bødker 1987, Grønbæk 1990, Bødker & Grønbæk 1991a, 1991b, 1991c, Grønbæk 1991). For specific differences between cooperative prototyping and other approaches to prototyping, see (Grønbæk 1991).

Interaction around and with the prototype

A crucial aspect of cooperative prototyping sessions is that sole control is moved out of the hands of the designers. An *open-ended* style of interaction is adopted that encourages users to take control of the proceedings. As described in (Bødker & Grønbæk 1989), this can lead to users feeling free to take charge of the prototype and "play in the future" by performing work-like tasks. In contrast to traditional evaluation techniques, users' reactions and comments are not in response to prespecified questions from the designers, but arise freely during the course of performing work-like tasks with the prototype. In (Bødker & Grønbæk 1991a, 1991b, 1991c) the interaction between users and designers is seen as successful if the users gain the initiative and work with the prototype themselves. Because the interaction is less structured, the designers have the opportunity to learn things they couldn't have anticipated.

But does handing over control of the interaction to the user always result in him or her "playing in the future," that is, actively incorporating the prototype into an imagined future work situation? Is "playing in the future" the ultimate criterion for success of cooperative prototyping? Are there other styles of interaction among the three parties (users, designers, and the prototype) that could be just as fruitful, just as likely to improve the chances of future technological artifacts being aligned with users' work practice?

In this paper, we focus on one cooperative prototyping session involving a user who did not appear to be inclined to "play in the future." Though the session was initially viewed as largely unsuccessful, closer inspection led to the recognition of a potentially different interaction style between users and designers around a prototype. In this case, the prototype was just as clearly a catalyst for discussion, but of a quite different form. Rather than feeling moved to drive the prototype, the user offered incidents and work procedures she saw as relevant to the part of the prototype being viewed. Ever conscious of the specific nature and demands of her own work, she directed the designers' navigation through the prototype. Her (usually negative) reactions to what she saw were invariably followed by concrete stories and explanations of her work that could later be seen to cohere. It seems clear that designers and users engaged in mutual learning of a most valuable sort around the prototype.

An Interaction Analysis-based methodology

Henderson (1989) points to four uses of video in connection with design: design as a process to support with video, design as a human activity to study with video, video as a medium for design communication, and video as a subject matter for design. Our use of video corresponds to the second of these. That is, we conducted an analysis of a single cooperative prototyping session with the goal of better understanding this kind of design process.

Our methodology follows Suchman & Trigg (1991) in combining ethnography and interaction analysis. Although ethnographic field work (discussed in Bødker & Grønbæk 1991b) was crucial to understanding the session's content, this paper focuses primarily on our subsequent interaction analysis of the session.

Interaction analysis is a field growing out of both sociology and anthropology (Jordan et al, in preparation). As described by Suchman & Trigg (1991), it involves the "detailed investigation of the interaction of people with each other and with the material environment." Specifically, "In work settings ..., [the] analyses focus on the joint definition and accomplishment of the work at hand, through the organization of interaction and the use of supporting technologies and artifacts."

This study should not, however, be viewed as a representative instance of interaction analysis.¹ Rather, our goal has been to apply certain practical techniques from that field so as to better understand the process of cooperative prototyping as observed and experienced in practice. Among the techniques we applied were event logging, transcription, conceptual categorization, and instance collections (Suchman & Trigg 1991). An event log of the video record provided a description and chronological index of observed events. The analysis then proceeded by identifying and transcribing sequences from the video of particular interest. Finally, we identified conceptual categories and gathered collections of instances. With such understandings in hand, we were able to turn to non-transcribed portions of the video record and search for further evidence of phenomena of interest.

In the remainder of this paper, we briefly describe the project setting and then present our findings. In addition, we offer recommendations for designers interested in using the cooperative prototyping approach and/or the analytic perspective adopted in this study.

2. Field study and analysis

The study documented here stems from a project carried out by two of the authors (referred to hereafter as S and K) in collaboration with caseworkers in a Danish municipal office. The caseworkers included architects, engineers and draftspeople working in a technical department handling tasks such as long-term urban planning and environmental control and advice. Specific requests from municipality residents are also treated on a day-to-day basis. The architects, engineers and draftspeople call their tasks *cases*. Following this terminology, we refer to the architects, engineers and draftspeople as caseworkers and their work as casework.

The department currently possesses three different kinds of computer equipment. PC's are used for small budget and environmental control calculations and graphical workstations for advanced text and picture processing. In addition, the caseworkers use terminal connections to access databases on a mainframe shared by several municipalities. (The latter system is managed by Kommunedata, a country-wide software development and information processing company owned by Denmark's association of local governments. The caseworkers use the term Kommunedata to refer to both the mainframe and its databases.) In general, the computer equipment is poorly integrated and the

¹ For example, the transcribed segments presented in Section 3 should not be viewed as complete according to the standards of conversation analysis (Jefferson 1984). Neither non-verbal interaction among participants nor interaction between people and the prototype itself is properly represented in the transcript. (For more on transcription of non-verbal materials, see for example, (Goodwin 1981).) Nevertheless, we found that our "loose" transcriptions proved to be a valuable means of revealing the subtleties present in this particular session.

caseworkers feel that their work could be improved with better computer support.

Our study focuses on one of the caseworkers (referred to as E), a draftsman in the Urban Planning Department working primarily in support of architect caseworkers. She maintains a map archive, prepares letters and other materials on a graphical workstation, and handles all transactions with Kommunedata. Moreover, there are certain tasks for which she alone is responsible, for example, the naming and numbering of new streets. Finding inspiration for street names in encyclopedias and local history archives, E informs those affected by the naming and registers the new names on maps. She uses similar registration and notification procedures when changing existing street names and numberings.

An instance of cooperative prototyping

The design process conducted at the municipal office consisted of the activities shown at the top of Figure 1 (described in detail in Bødker & Grønbæk 1991b). During this process, an initial planning office prototype was set up and tried out in one half-day session. The prototype was modified collaboratively during the session and further revised by the designers thereafter. The prototype was then used in separate one-hour sessions with each of five caseworkers. The five sessions were all video-taped, and it is the last of these that we consider here, namely the one with caseworker E. (For an analysis of the sessions with caseworkers A, B, C and D, see Bødker & Grønbæk 1991b.)

Each session was oriented toward a frame task, so called because they comprised frameworks for the evaluation sessions. The frame tasks were chosen in collaboration with the caseworkers and correspond to tasks carried out in their day to day work practice. Street naming was chosen as the frame task for E's session.

Course of the analysis

The work documented in this paper can be characterized as an analysis of interaction among people participating in cooperative design and of how computer tools mediate such interaction. As shown in Figure 1, the analysis can be represented at various levels of detail involving increasingly fine-grained analyses of progressively smaller segments of the process documentation: notes, audio and video recordings. (Although the following description suggests a step-wise progression through these levels, we often focussed on several at once.)

Analytic (or rather reflective) work was first carried out informally *in conjunction* with project activities. Drawing on extensive notes and audio-tapes from sessions with users, S and K appraised progress made in the project and planned upcoming work. The first proper analysis took place *after* the project's conclusion and resulted in a paper documenting the cooperative prototyping experience (Bødker & Grønbæk 1991b). The study was based on approximately five hours of videotape from the closing prototyping workshop, and focussed primarily on the sessions with caseworkers A through D.

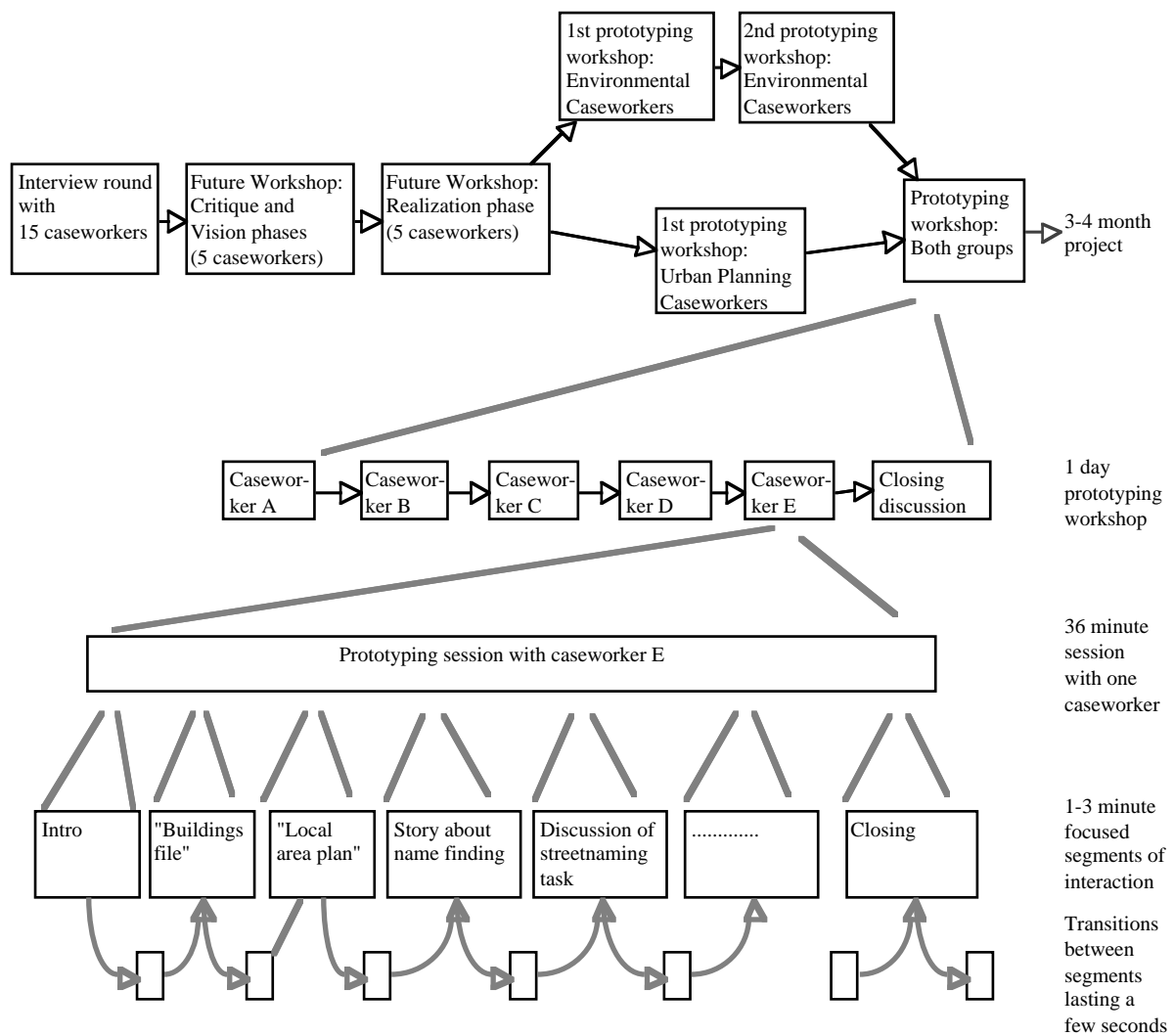


Figure 1: Levels of analytic detail

During this work, S and K consciously omitted E's session from the analysis, due in part to certain frustrating memories (Table 1). Uppermost among these was a sense of E as disinterested, negative and generally difficult to engage in constructive discourse. As contributing factors, they also identified E's foreign accent and the fact that the session was the last in a long day. Finally, they wondered whether the street naming frame task had been ill-chosen. For their purposes, the sessions with the other caseworkers provided sufficient material and appeared easier to analyze than E's session. Upon completion of that study, however, we decided to take a closer look at E's session using S and K's frustrating memories as our jumping off point.

This decision meant "zooming in" the analysis to the 36 minutes comprising the last session. Repeated viewings of the video from E's session resulted in an event log marking focussed segments of interaction, e.g. "E explores Local Area Plans" or "S starts an in-session modification of the prototype." We then transcribed approximately 25 minutes of the session's talk onto paper and used it to analyze and compare parts of the session directly.² Concentrating on shifts of

² Transcripts (and event logs) support a kind of "random access" to places of interest on the video whereas the video by itself primarily supports linear search.

focus and initiative, we discovered several revealing patterns of interaction. We also studied the role of the prototype in interaction and the emergence of concrete stories from E's work practice. Finally, we used our findings to conduct a less detailed analysis of the non-transcribed parts of E's session as well as the sessions with the other caseworkers.

<p>Memories from the session: E's negativity, lack of interest Inappropriate choice of frame task (street naming) Contributing factors: E's foreign accent Last session of a long day</p>

Table 1: Perceived problems with E's session

3. Interaction around the prototype

Our study of interaction during E's cooperative prototyping session began with an analysis of talk and action during the first 20 minutes of the video record. The goal was to better understand:

- E's overall level of involvement / engagement in the session;
- the question of control or initiative and how it shifted among S, K and E;
- the role played by the prototype and interaction oriented towards it as opposed to interaction "away from" the machine.

In order to get a handle on such a diverse set of questions, we identified certain recurring patterns of interaction as well as transitions within and among them. Our analysis of a selection of instances of such patterns focussed primarily on the sequential organization of an interaction, its work-relevant context, and the orientation of participants with respect to the prototype.

The left side of Table 2 lists the most frequent foci of interaction grouped according to overall orientation, either toward the machine or toward E's work. Shifts among these foci were often the result of inquiries directed from E to S/K or vice versa as shown on the right side of Table 2. Suppose, for example, that the participants were focussed on the machine, say, navigating through the running prototype. Then an inquiry directed from S to E, "Could this be useful in your work?" was intended to shift orientation from the machine to E's work practice.

In general, the two inquiries from E to S/K attempted to shift the focus toward a specific part of the running prototype and toward a discussion of the prototype's potential, respectively. Of the inquiries directed from S/K to E, the first attempted to enlist E's help in relating the tool to her work practice and the second to move toward a more general work practice discussion. The offer of prototype control ("mouse handoff") attempted to engage E in trying out the tool herself.

Foci of interaction	Attempts at focus shifts
The technology: Current state of prototype (discussing, demoing, navigating) Future state of prototype (discussing, modifying) E's work practice: Procedures Materials Stories/anecdotes	Inquiries from E to S/K: "What's that (on the screen)?" "Could the prototype support X?" Inquiries from S/K to E: "Could this (on the screen) be useful?" "Do you do X in your work?" S/K offer control of prototype to E

Table 2: Shifting the focus of interaction

As we'll see, the focus of interaction sometimes changed more abruptly. In the latter part of the session, E introduced cases from her work (sometimes with the help of physical materials she brought to the session) without waiting for an inquiry from S or K. In any case, looking closer at the foci of interaction and shifts among them gives us access to the degree of E's involvement and initiative during the session.

A1. S/K directs a query toward E. A2. E gives an initially negative response, "No, but..." A3a. E opens a work practice-focussed discussion, OR A3b. E queries S/K about the prototype leading to discussions, demos and occasionally on-the-fly modifications by S/K.	B1. S/K attempts to hand control of the machine to E. B2. E "drives" the prototype for some time (with verbal help from S and K). B3. E pulls back from the machine and mouse following a breakdown caused by the prototype or "gap" in the prototype's sample data.
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Table 3: Two recurring patterns of interaction (A and B)

3.1 Patterns of interaction

Inspecting the first half of the session with E, we observed two recurring patterns of interaction. The first (labeled 'A') begins with one of the two types of queries directed from S or K to E, as shown in the left half of Table 3. The second (labeled 'B') begins with an attempted mouse handoff from S or K to E, as shown in the right half of Table 3.

Figure 2 shows a segment of the transcript illustrating two consecutive instances of pattern A³. After showing part of the prototype, S asks E whether

³ Figures 3-8 contain English translations of portions of the transcript. (Readers interested in obtaining copies of the original Danish transcript should write to the authors.) Parenthesized numbers appearing in the transcript correspond to duration of pauses in

anything visible on the current screen might be useful. E's negative response is followed by a suggestion that they return to the table of contents. S then navigates back to the table of contents, talking and explaining as she goes. A second instance of the pattern follows immediately, this time resulting in an explanation of part of E's work practice.

This example is typical of interaction throughout the session. On the one hand, E's negative responses to requests for feedback on the tool explain S and K's sense of frustration during the session. At the same time, these responses were invariably followed by requests from E for further explanation of the tool or by explanations and anecdotes from her own work. Thus, attempts to hand control and initiative to E did in fact succeed, although not always in the ways S and K expected. Recognizing this more indirect way of taking initiative led us to reconsider our preconceptions regarding possible forms of successful interaction between designers and users.

S query →	S: [S showing and explaining part of the prototype.] Is there any of this you need to go in and (1.0) and look at?
E negative response →	(1.0) E: Not really.
E query →	S: No. E: It's more that, let's, let's go back to contents.
	S: Yeah. Let's do that, if we now say "Table of Contents." There. So this here, this is plan
	E: Yeah.
	S: tables, that's the environment tables (right)?
	(1.5)
S query →	S: What is it then that you need to go in and look at, is it the area overview or site number overview?
E negative response, E work-practice discussion →	E: It's probably more, it's a little different. When I work with local plans
	S: m hm
	E: then I look at the addendum to see how it gets to look.
	S: Yeah.
	E: And so I find out about the streets to name. One street or two streets or

Figure 2: Consecutive instances of pattern A (see Table 3)

The example in Figure 3 illustrates pattern B from Table 3. S starts by suggesting that E take control of the prototype and look for useful information.

E first experiences some confusion over where the active ("mousable") region is relative to a word on the screen. After S helps her get around this problem, they move to a card containing a local plan for an airport. Then, by accidentally clicking too often, E brings them to an empty card. S explains that there could well have been a map there and asks what E would have done. S's inquiry begins another instance of pattern A. As before, E responds negatively but then goes on to explain certain relevant work practices. In short, E took the mouse when offered, "drove" the prototype for a while, and moved away from the machine when an empty card was encountered. We found this same pattern

seconds. A single parenthesized period indicates a small gap of no more than a few tenths of a second. The parenthesized ellipses correspond to inaudible or unclear portions of the talk.

repeated elsewhere during the session. E accepted "mouse handoffs," but relinquished control of the prototype at the first opportunity, usually involving a breakdown in the tool or gap in the sample data.

Attempt to hand control to E →	S: Yeah. Try to see whether you can find any of the information you need in some of these tables. (1.0) [S gives mouse to E]
E "drives" the prototype →	E: (...) Try to look under local plan, but it, I don't know whether it should be (...) S: You should just click on the word itself. E: Oh, on the word itself (...) S: Try again. Oh, now it says just (...) [pushes key] we'll just ignore that. Try again. S: There it goes. E: Yes. S: So far we have just one local plan here. E: Yeah, yeah. S: We can go in and look at that one. It's the famous airport. E: Yeah. [both laugh] (...) Good that's what we're looking at. [They've arrived at an empty card.]
E pulls back →	S: There it comes, oops, there's nothing there. Oh it's probably because you clicked so many times. E: Yeah. S: Ohh. But there could well have been a map, E: Yeah. S: and then what would you have done? E: Well::, I really don't need that so much, I should have, now I actually have in the drawer a bunch of overviews with different names
S query →	
E negative response →	
E work-practice discussion →	

Figure 3: Consecutive instances of patterns B and A (see Table 3)

3.2 Machine-focussed interaction

Judging only from the above, one might suppose that E took the initiative when offered, but was otherwise a passive observer during machine-focussed activity. On the contrary, we found that E sustained a high level of engagement during machine-focussed times even when S and K were making extended modifications to the prototype. Consider another excerpt from the transcript shown in Figure 4. Two activities are being interleaved here: S's modification of the prototype and a discussion of the means for representing information about renters and owners in the prototype's user interface. E participates in the discussion, and though she never mentions fields and buttons in those words, her awareness of the difference is indicated when she expresses concern over the mixing of two kinds of information on one card.⁴ At the same time, E is also monitoring S's work at the machine. For example, she proposes a name for the button S is working on without being asked.

⁴ The terms "field," "button" and "card" refer to user interface primitives in HyperCard. For more on the prototype's interface, see Bødker & Grønbaek (1991b).

E participating in discussion →	<p>S: That is, one could actually imagine having one more button down here which, which said something about, about eh, who lives about, about resident data.</p> <p>E: (...)</p> <p>K: But, you you would rather have the fields (.) you know, have a field where the residents appear. Eh, eh</p> <p>E: Ahh. But one probably can't do that so well. Isn't it maybe sort of mixing things up?</p> <p>K: Yeah::</p> <p>S: It was that- in that way it might be nicer if one actually had it like a button to another card</p> <p>E: Yeah.</p>
E participating in prototype modification →	<p>S: But what one could do, you see, is to make a new button down here (1.0) which is called, uh [S looking at screen and mumbling] (2.5) [S typing]</p> <p>E: (...) renters and owners or owners and renters or something like that.</p>

Figure 4: E's involvement during prototype modification: Part 1

Later during S's work, we see an even more striking example (Figure 5). S has almost finished building the "residents" button and proposes a field to represent the owners of the site. E suggests that there might be a place in a different card where the owners can be found. After K explains that such information is not available in the current prototype, E justifies her suggestion by relating certain procedures from her work. E and S then "collaboratively" conclude S's online modifications.

E's field placement suggestion →	<p>S: (...) and so there should be another field on the same card, which (.) which is called owners.</p> <p>E: (...) There must be a place where one can see who owns the site. But maybe one can see that, in a completely different place.</p>
E's justification →	<p>K: No, not in this system. It::</p> <p>E: (...) because we also use it for local plans and we should inform all them in that area, when we look up the site number and see, we see who owns it, all the site numbers, inside the boundaries</p> <p>S: hm</p> <p>K: yeah</p>
Collaborative conclusion →	<p>E: And then we should find out where they live and who they are and then one sends them messages on local plans.</p> <p>K: Yes.</p> <p>E: So one can hear from them along the way (...)</p> <p>S: There.</p> <p>E: Yeah. (...) I guess that's that with owners, and renters.</p>

Figure 5: E's involvement during prototype modification: Part 2

This example shows the interleaving of multiple activities engaged in by all participants. S is primarily working at the prototype, but at the same time monitors and occasionally participates in other discussion. K acts as primary discussant with E, but responds to requests for information from S (often registered in a lowered voice). And perhaps surprisingly, we find that E is engaged in maintaining a multiple focus quite as much as S and K. She occasionally responds to S and K's machine-focussed talk as well as contributing to other talk during prototype modification. In fact, in the last line of Figure 5, E seems to be judging the efficacy of continued work on the modification, helping to conclude so they can move on to other matters.

Notice also the terminology used by E when referring to the tool. Rather than technical terms like card, field or button, she says "place where one can see ..." (third line of Figure 6). In this way, E keeps her "verbal distance" from technical aspects of the tool while maintaining an active involvement in discussions of the tool's functionality and relevance for her work.

As we see in Figure 6, E then takes an even more active role in directing the proceedings. K's question about the way E accesses information on residents leads to agreement and elaboration by E. But E (after clearing her throat) suggests that perhaps the Kommunedata system is already providing this information. In other words, she is asking about the relation between this prototype and the centralized database they are already using. S then navigates to a place in the tool where support for a remote connection to Kommunedata could be imagined. It is at this point that E changes the subject (to standard letters). She gets an immediate acknowledgement from K and a delayed one from S following completion of her work at the prototype.

E's reminder about Kommunedata →	<p>K: But, but that stuff with resident information, that would be (.) that would really be something one should look up in the people register by address, or what? E: That's exactly what we do. K: That's what you do. E: Yeah. We look up by address (.) or by building number, or site number. Those are the three things we use for looking up yeah. K: Yeah. E: Uhm. (2.0) (clears throat) But if one says Kommunedata (...) so it includes in fact all the information. S: Yeah, that's true of course. E: Yeah. S: [to K] Oops, where was it we came from K: What do you want to do? S: I was just going to (...) S: Oh. There one finds it. (...) S: There one can imagine Kommunedata. E: Yeah (...) E: So I have some standard letters which we write to the people. And these standard letters we can also like (...) or [S typing during E's talk] K: Yeah. (...) S: There we go. Yeah.</p>
Topic shift →	

Figure 6: Example of E taking the initiative

Here we see E not simply responding to discussions started by S and K, but rather, asking a pointed (though polite) question concerning the relation of the prototype to the technologies she currently uses. Her subsequent topic change leads to a shift of orientation away from the machine. In this way, we see progressively stronger indications of E's initiative and personal agenda as the session proceeds.

3.3 Work practice-focussed interaction

In our last example from the transcribed portion of the session, we see further confirmation of E's initiative-taking together with an example of an anecdote

from her work (Figure 7). Such stories introduced into the discussion turned out to comprise a vital part of the information volunteered by E during the session and contributed significantly to S and K's learning.

E's topic shift (in Figure 6) led to a discussion of standard letters and possible means of supporting them in the prototype. This in turn led to a demonstration by S of the "Reports" package to which the prototype had been interfaced. Figure 7 starts at the conclusion of this demonstration. E moves back from the computer and shows S and K an example of a physical letter. At the same time, she describes the procedures involved in changing an address. This general discussion leads to a concrete story involving the change of a street name from "Axel Hansensgade" to "Axel Hansens Gade." E concludes by pointing out that the story is typical of what can happen in her work. The stage is then set for K's question as to whether E might need an archive over such standard letters.

E shows physical letter →	<p>S: ... (...) so for example, one can also use this to make, to make standard letters (...). Here you'd see here we'd get something printed out and what we get printed out is some information on the individual site number. The one, the one thing deals with, which reference the individual site number has, the other it's how many parking places there are, right? (1.0) E: Because I have, I have so many uhm standard- normal standard letters, that look like this [showing physical letter to S&K]. K: Yeah. E: (...) when one reports that the address will change, we're done, the owner should get a message and so one informs all of them (1.0) S: Yeah yeah K: Yeah. S: And that goes automatically? E: Some times, one writes (...) a little explanation why and how, that's because of a street name change. E: [shows letter again] It's named after our old mayor. S: What was it called, Axel Hansensgade, number six. E: And so I write to that street, the whole thing, and according to the standard, all this here. So I should write to them all that it should not be written together and with a capital "G". S: (laugh) E: (...) E: The rules should be followed. But that's the sort of thing one deals with every now and then, politics and such. K: (no) But uh, think about, those standard letters, whether you would like an archive over them? I mean (...)</p>
"Moral" of the story →	

Figure 7: The "Axel Hansens Gade" story

Here we can see the initiative taken by E in turning the focus of the discussion on standard letters from the Reports program to an actual case from her work. But this example also makes clear the way in which this story was positioned within a context of potential technological support. That is, a general discussion of the problem led to S's demonstration of one means of support which in turn led to an actual case from E's work.

Another work-practice focussed story surfaced when we turned our analysis to the non-transcribed part of the session. The story illustrates how the open-endedness of cooperative prototyping allowed E to reflect on her own work practice in the session. E had just described how letters sent regarding street

naming and house numbering cases were stored in paper folders. This description led to an exploration of the possibility of storing such letters in a database, although E was not herself certain whether and why she wanted the letters stored. At one point it appeared that E only needed to store standard letter templates and S started to modify the prototype toward that end. But then E began her story: "A while ago, I assigned numbers to the entrances in a new community building and sent out letters notifying the owners. When the building was completed, however, the owners made their own quite arbitrary numbering of the entrances. In that case I was glad I had my original letter to remind me of the official numbering I had notified them of beforehand." This turned the focus back towards storing the original letters in a database. However, E soon continued with, "Nonetheless, it irritates me to have all these letters stored. I'd rather mark my numberings on a map and get rid of all the old letters." Indeed, the discussion eventually led to the idea of storing name and number information on maps, which would allow the original letters to be discarded. That is, it was enough to save the letter templates that were to be included in the prototype.

Because of the open-ended nature of the session and the presence of the prototype, E was encouraged to reflect on her own work and even propose changes to it. At the same time, E's anecdote turned out to be crucial for the designers' understanding of her uncertainty as to the utility of saved letters and yet, why it was important to her to store the letters' contents in some form. Such mutual learning by users and designers is the primary goal of cooperative prototyping. Enabled by open-ended discussions around a prototype like the one described here, such learning should lead to systems that align better with users' work practices.

4. Reflections on cooperative prototyping

In previous writings on cooperative prototyping, Bødker and Grønbaek (1991, 1991b, 1991c) stressed the importance of exploring design ideas through in-session prototype modification and evaluation in work-like situations. In some ways, the session discussed in this paper challenges this conception of prototyping, in particular with respect to the need to simulate work-like use. The user in this case seemed reluctant to enter into a game of simulated future use. Not so much, it seems, because she was afraid of the technology (she was a frequent user of the computer terminal already present in the work environment), but because she chose not to behave in the ways such games require. One might have concluded that organizing the session around a prototype was a mistake in this case. In our opinion, however, just the opposite is true. We believe the findings outlined in the previous section show both that constructive interaction took place and that it was catalyzed in large part by the prototype. With this in mind, the question is not whether to use a prototype in such sessions, but rather what kind of interaction processes to expect and encourage around the prototype. In what follows, we identify and discuss specific implications of our analysis for the cooperative prototyping process.

Cooperative prototyping requires open-ended rather than prespecified interaction

We have characterized cooperative prototyping as mutual learning where designers learn about the work practices of the user and vice versa. What we have seen in the cooperative prototyping situations analysed here is an *open-*

endedness quite different from what is seen in traditional evaluation techniques. For example, controlled experiments (Baecker & Buxton 1987, Monk 1987) or "user observation" (Gomoll 1990) don't provide such open-endedness. The tasks to be performed in controlled experiment sessions are usually strictly defined so that the system can be thoroughly tested. Moreover, results are often collected from questionnaires and analyzed statistically. In experimental sessions, control remains strictly in the hands of the experimenters. But even in less controlled evaluation situations we have observed designers taking silence as an opening to go on demonstrating features of the prototype or as implicit acceptance of the current prototype (Grønbaek 1989). In contrast, the frame tasks used in cooperative prototyping sessions are selected from among the user's own work tasks by users and designers in cooperation.

As we have seen, E did not have to battle for control of the session with S and K. Rather the session can be characterized in part as a succession of "handoffs" of initiative from S and K to E and vice versa as well as instances of E taking the initiative on her own. Indeed, there are indications that E came to the session with her own agenda and found unobtrusive ways to insert questions, procedures, and stories into the ongoing talk.

Users have different ways of engaging in prototyping activities

The sense of frustration recalled by S and K is understandable when considering the negative responses consistently made by E to their suggestions and requests. But at the same time, the constructive follow-ups to these responses led to just the sort of interaction and mutual learning hoped for from the cooperative prototyping approach. For example, in a typical case S asked a question meant to get E started on the prototype. E was quiet. S reframed the question into something related to E's work task. After an initial negative response, E took the initiative and started talking and asking questions. In other words, control of the situation was passed to E despite the initial failure to hand over the mouse.

E's session can profitably be compared with an earlier session with the user denoted A in Bødker & Grønbaek (1991b). A threw himself into the future use situation by acting out his imagined work tasks. His awareness that he was playing is indicated, for example, by his repeated statement, "All right, so let's just pretend." A engaged the prototype, encountering breakdowns and asking for help, and in this way maintained control of the situation. E, on the other hand, did not view the prototyping session as a game. She was well prepared and willing to take control of the situation, but her control was not exercised through the technology. Rather the control was of a social, conversational nature, involving stories from her work as well as requests to the designers to run some part of the prototype. Such differences cannot be explained on the basis of this study alone. However, we expect that factors like educational background, gender, and position in the organisation influence the way users approach the cooperative prototyping process. In any case, the difficulty in anticipating user styles again argues for situated, open-ended interaction during sessions rather than the use of prespecified protocols.

Confrontation with a prototype can trigger story-telling

Although E may have been reluctant to "drive" the prototype herself for extended periods, her talk, including stories, work procedures and queries about the prototype were tied to what currently appeared on the screen. In particular, the

prototyping session served as a jumping-off point for concrete stories illustrating various aspects of E's work. The stories sometimes concerned situations that were remarkable in some respect, but as pointed out by E herself in Figure 6, they also illustrated typical situations.

In general, we recommend paying close attention to stories about users' work practice arising during the design process. Such stories typically reveal exceptional cases and valuable details about the work that might otherwise be overlooked if users are encouraged only to provide abstract and overview-like descriptions of their work practice. Although E's stories might have arisen in other sorts of user-designer interaction (e.g. interviewing), we believe it was advantageous that they were triggered in reaction to a potential change in computer support and work organization, here embodied in the prototype. The fact that the stories were "anchored" to particular points in the prototype improved the chances that developers could make concrete use of them in the redesign process.

Prototypes provoke users to reflect on their own work-practice

A clear example of the prototype triggering reflection on current work practice appears at the end of Section 3. Confronted with a facility from the current prototype, E engaged in an extended discussion of her practice of archiving letters. In the end, she suggested changing her daily work procedures even in advance of new computer support. The session thus served as a learning process for E with respect to her own work as well as the technology. Mogensen (1990) proposes the term 'provotyping' to describe the use of prototypes to provoke such reflection and critique of current work practice.

5. Two roles for video-based analysis

As can be seen in Table 4, the sort of fine-grained analysis undertaken here is labor-intensive. We hope that this paper has demonstrated that in one case at least, the payoffs were substantial. In what follows, we consider the general question of the utility of video analysis in two contexts: (1) during the design process and (2) following completion of the design.

The role of video analysis during the design process

We believe that undertaking video analysis on the order of Table 4, row 3, can serve two goals during the design process. First, designers can use an understanding of the prototype's utility to improve the design of the application under development. For example, video records could provide access to problems in the current version of the prototype observed in the context of use. Reviewing such breakdowns between sessions could give a more solid basis for ongoing redesign. (See Tang & Minneman (1990) for a discussion of video-based analysis of use as input to ongoing prototype modification.)

Focus	Activities	Materials	Effort
Project	Reviewing materials and memories	Notes, audio-tapes, prototypes	~6 * 1-2 hrs
1 day prototyping workshop (A, B, C, D, E)	Logging, several viewings	Notes, 5 hrs video	~4 * 10 hrs
Session with caseworker E	Event logging, identifying focussed segments	36 mins. video	~15 hrs
Segments of interaction	Transcription	25 mins video	~40 hrs
Transitions between segments	Identifying and collecting patterns of interaction and instances of stories	20 mins transcribed video	~25 hrs
Prototyping workshop	Analysis of non-transcribed material	10 mins from E's video, video from other sessions	~4 hrs + future work

Table 4: Analytic foci, activities, materials and effort (total time spent)

Second, designers come to understand parts of the ongoing process better in order to adjust both the process and their future work practice. Although in our case, video analysis was first conducted after the project's conclusion, we can imagine that certain of our results could have provided valuable input to ongoing design. For example, after several viewings of the video, we identified a pattern of interaction where E repeatedly used a negative response as a lead-in to proposals for prototype design (Section 3.1). Searching for instances of such patterns revealed suggestions made by E that S and K had initially overlooked, perhaps because they mainly recalled E's negative statements.

By better understanding E's style of interaction, we were able to discover indirect but significant contributions she was making to the design process. Our hope is that such understandings could lead designers to adjust the ongoing cooperative prototyping process to match particular users' contributions.

The role of video analysis after the design process

Andersen et al. (1990) argue for the importance of system developers reflecting on their own work practice in order to learn from their experiences. We claim that video-based analysis can catalyze such reflection. For example, our deeper analysis led to the recognition that E was much more involved than we had originally thought, at times even taking explicit control of the situation. Though not driving the prototype, she was clearly following what happened and influencing design decisions. By studying the stories E told during the session, we gained a better appreciation of their coherence and their implications for mutual learning. By comparing the sessions with caseworkers A and E we understood and came to appreciate two very different styles of interaction around and with a prototype. In short, the result was a deepening of the cooperative prototyping model itself.

One important question remains to be addressed. Assuming the decision has been made to engage in video analysis and a large body of video recordings has been gathered, where does one look first? Indeed, the same question arises as one confronts the data at each next level of detail. (For example, which pieces of

video should one take the time to transcribe?) Our heuristic was to look first at those parts of the process considered most problematic, those that seemed to be outliers according to our current framework. For example, E was an outlier according to our earlier framework of cooperative prototyping. And within her session, the attempts by S and K to hand off control were remembered as most problematic. In the end, we were able to fold back the results of such analysis to parts of the data we had initially viewed as less problematic.

6. Concluding remarks

According to the goals of cooperative prototyping, the session with E must be judged a clear success. Both the designers and the user participated actively, exchanging initiative and control over the process. The open-ended interaction process was also successful, leading to mutual learning by all participants. S and K learned about E's work practices in a way that bore directly on the question of the prototype's utility. E, in turn, learned about the possibilities for further computer support in her daily work. In addition, the prototyping session caused her to rethink some of her own work practices.

S and K's feelings of frustration were in part a reaction to E's unanticipated style of interaction. The lesson learned from this analysis, however, is expressly *not* that users like E are inappropriate candidates for the cooperative prototyping approach, or that S and K have to rethink their open-ended style of interaction. (In fact, we have no evidence that their feelings of frustration hindered the process.) On the contrary, the results of the session argue for a reformulation and broadening of the expected process of doing cooperative prototyping so that sessions like this one not only fit, but are to be expected and even encouraged.

In fact, this study provides evidence for the thesis that different approaches to prototyping sessions are appropriate at different stages of the system development process (Grønbaek 1991). At the earliest stages of the design process, exploratory sessions like E's are encouraged. The designers are oriented toward learning about the users' current work practice, users toward learning generally about the potential for using computer technology to support their work. Less weight is placed on direct evaluation of the prototype viewed as a design proposal. Sessions like A's where the prototype is expected to support work-like use, become appropriate at a later point. Much later, at the near-product stage of development, the designers could choose to structure sessions, employing user reactions to specific prototype features and associated work procedures in order to tune the final system.

We feel strongly that the tools and methods designers employ with users should serve to open dialogs. The open-ended style of interaction discussed in this paper enabled fruitful dialog with a user initially perceived as difficult to involve in cooperative design. Analyzing this dialog opened our eyes as designers, broadening our conception of the possibilities for meaningful user-designer cooperation.

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