A White Paper

DESIGN FOR WHAT? SIX DIMENSIONS OF ACTIVITY

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Introduction

When I think casually about people working with technology, it is not uncommon for me to instinctively choose a rather narrow view of that activity. I find myself imagining the simple case of "using" the technology. I imagine:

- a single person is working;
- they are working successfully using their technology;
- the technology is already set up;
- all needed supplies are on hand;
- the technology is appropriately configured for the work task it is part of;
- the user's work task is within the accepted norms of the work situation and is understood by all concerned.

On the other hand, from years of experience with design of various kinds, I know that this view of technology in use is narrow in many ways. And when I stop to think about it, I am aware that I am not thinking things through as carefully as I might. When I think about it, I know that I might instead imagine:

- a task involving a number of people;
- the users have difficulty with the technology while doing their work;
- the technology is not ready to go, and requires being set up;
- supplies are not on hand and the user has to be found;
- the technology must be re-configured before it can be put to use;
- the work goes beyond what is expected or permitted, and people must negotiate with and about those norms in order to get the job done.

Over the years, as part of scientific studies and design practice, I have found myself organizing the vast array of human activity that designers must address along six dimensions. I do not believe that this structure is complete or even the best; it is just a way that I have found useful to think about what I am designing. I use these six dimensions is a checklist to help ensure that I am not inadvertently forgetting any of the lessons that, sometimes painfully, experience has provided.

This essay describes the six dimensions. They provide a high level structure for the human activities associated with using technology as I have come to see them (this is science: the seeing of where you are). However, knowing what is there, although an excellent foundation for seeking solutions (design: the exploration of where you would like to be), does not in any way dictate what those solutions should be. Therefore, in this essay, I do not suggest solutions; I only indicate that solutions are needed. And, further, implementing any such solutions (engineering: the getting from where you are to where you'd like to be) is another set of concerns that is not addressed here.

I will not go into detail on any of these. (For those interested, a more thorough treatment will appear in a book on Task Analysis, edited by Gerrit van der Veer, in press.)

A structure for activities

Narrowness of view can affect our ability to see all that is relevant to our analysis, even when we are thinking carefully, as for example when we are explicitly and purposefully observing and analyzing the tasks in which users are engaged. As we analyze the tasks that people are doing as they use technology, our pre-theoretical naïve viewpoint can restrict our ability to see clearly all that should be seen for a thorough analysis.

On the other hand, any activity is infinitely full-bodied; the structure and details of carrying it out are not only of arbitrary richness in themselves, but they are also based in physical and social arrangements that extend without bound. Most of this material will not be of focussed concern most of the time. Further, when issues do become of concern, the user will usually deal with them only to the point that is needed in order to get on with the job. However, at any time, any part of this extraordinarily complex reality can become of concern, and when it does, the user will have to address it. Thus, the activity in which the user is engaged is unbounded in extent. A complete description is impossible, indeed unthinkable.

Still, there is value in attempting to lay some structure over this infinite mass of subject matter. With such a framework in hand, studies of activity and the resources brought to them by participants, can be focused, design can be undertaken, and systems implemented. Lacking such an orienting framework, our science, design and engineering will remain hopelessly awash in important and relevant "details".

Each perspective is an extension of the analytical viewpoint, permitting the analyst to see activity more fully. Each perspective identifies a particular sort of work that people must do as part of making use of the machine. As a consequence, for the analyst, additional user activity means a broader subject matter for analysis; and for the designer, more user activity means more to be thought about in the development of the technology, including how the technology could be designed to support that activity.

A word of acknowledgment: These perspectives arise out of my years of work in HCI-related research, mostly at Xerox Corporation. Although the crafting of the experience into perspectives is of my own making, the grounding experiences all occurred in the course of collaborations with Xerox colleagues. In particular, I want to thank Lucy Suchman, Annette Adler, Kathy Carter, and Jeanette Blomberg, and to acknowledge their profound contributions to my understanding of the world. Without them, these viewpoints would no doubt have remained literally unimaginable to a techie like me. Responsibility for what I make of it is, of course, my own.

The six dimensions for extending our framework for understanding people's activity in using technology are organized to address three aspects of use:

- *operating:* the activities in which users engage to make the technology do what they want: roughly, "driving" the technology;
- *enabling*: the activities of arranging things so that the operating activities are possible: roughly, "preparing" for operating the technology; and
- *empowering*: the activities of establishing the social circumstances within which the activity has meaning and value, roughly, "justifying" the enabling and operating activities.

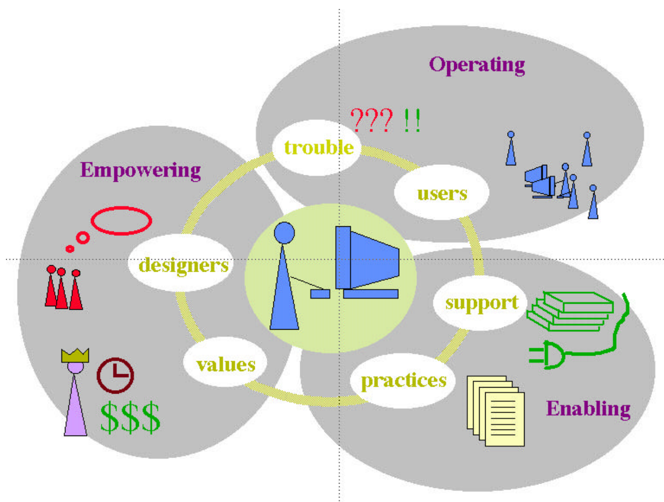

Figure 1: Six dimensions along which to describe the activity in which people engage while making use of technology.

Operating activities

This aspect of the activity of using a machine attends to the mechanics of users making the machine do what they want. It includes the actions and thought involved in "driving" the machine.

Dimension 1: Trouble

Case: Operating the 8200 copier.

In the spring of 1981, Lucy Suchman and I observed pairs of people operating the Xerox 8200 copier, the first machine with an automatic document handler for handling entire documents of loose sheets [12]. One pair of users changed their minds about how many copies they wished to make while they were part way through making them. But the copier was not prepared to accept the change; the "clear" button was pushed, and the machine responded by not changing anything. However, the users interpreted this inactivity (what the designers presumably expected them to see as a refusal) as a possible failure of the machine to "hear" them; they tried again. The machine interpreted the second attempt as a request for a complete restart of the job. The control panel reflected the change, but the operators did not notice the shift. The copy count on which they were focused was reset and subsequent entry of the new count was successful: they believed they had made their desired change. Thus, the machine was starting on a new job, while the operators were continuing on the modified original job. Much difficulty resulted from this misalignment. Interestingly, sometime later, these folk came to exactly the same juncture in another attempt to do their job, and again attempted the same "illegal" change in copy count. The interactions were the same, but this time the users saw what had happened. Of course, now they wanted to "undo" that second push of the "clear" button. But again, the machine was not prepared to do this.

Activity: People get into trouble

Users rarely carry out activity flawlessly. Rather, they act out of partial understanding (both learners and experienced users) and work it out as they go along. Further, the world in which they are operating is constantly changing, and as a result presenting new situations. Designers embed particular views of the world into the technology. People will take actions that depart from those views; they will get into "trouble" of varying degrees of complexity, and will have to deal with that trouble in one way of another. In this case, the operators had trouble both with understanding the interaction with the machine, and with the impasse presented by having made a mistake and not being able to undo it.

Design requirement: Help people in getting out of trouble.

As designers we should design technology to help users get out of the trouble that they inevitably get into. As designers we should consider the ways that things can go wrong, as well as the ways that they can go right. That is, once a design is completed with scenarios of how users will complete tasks, a second phase must be entered: consider all the actions that users might take that are not the ones we have addressed in our scenarios of "right" use. The reason that users might take each action are completely open-ended, so designing around any particular reason is not wise. Instead, having thought about possible incorrect actions, we must ask how the user will experience them, detect that they are incorrect and correct them. Machine interactions to support these activities must be added, and then examined for how they too can go wrong, and be corrected.

Dimension 2: Users

Case: Video-connected offices.

In 1991, Annette Adler and I connected our offices at Xerox PARC with video [1, 5]. Our two offices became very much like a single two-person office with a "barrier across the middle" which restricted the motion of physical things. This 7/24 video window was new to people in our laboratory, and many surprises developed. Not least of these surprises was the fact that we were not the only users. We began to notice that neighbors from down the hall came to my door and peered in as a way to reach Annette. They even would ask Annette to help them reach Annette's neighbors, or in some cases (usually when neither of us was there) they would call through, hoping that Annette's neighbors would hear. This spilled over into the hallways. When the fitness class started near Annette's office, the music would spill out into the hallway outside my office. This connection created some embarrassing situations for those who did not know, or forgot, that the connection was there. On occasion, people—including me—would rearrange clothing forgetting that their actions could be observed beyond the physical room they were in; occasionally there was someone in the other office observing, or discretely not observing. We learned that we had to inform neighbors about the link. And we had to inform the cleaning staff too. At the largest and most diffuse level, everybody was affected by this technology and its use. People became aware of the link's existence and capability. The very possibility of being able to install holes between offices changed the shape of space in the building from being something fixed to something that was malleable. This slowly worked its way into people's awareness. During a space allocation meeting, it was even suggested that rather than move someone to be nearer to a colleague, the two be provided with a video connection.

Activity: Technology has many users.

The presence of technology affects many more people than those with their hands on the controls. It is so easy to think only of those identified as "the users" when justifying the purchase of the equipment. However, many others may use it, either directly, or indirectly through others. Furthermore—the neighbors, the competition—may be affected by it. Still more—leaders and managers, the community at large—will become aware of it.

Design requirement: Design for the needs of all the users

Many people are engaged in the use of any technology, with a correspondingly wide range of activities that they do with/through it. As analysts and designers we must watch not only those who have their hands on the technology, but all the others who are affected by its presence. The needs of everyone must be considered, and the support of their "operation" of the technology must be addressed and designed for, just as seriously as for those ostensibly more directly engaged.

Enabling activities

We now move beyond the activities of operating technology to examine activities in which users engage to make the operating activities possible. Enabling activities include both the physical and the social. These are often mechanistic in nature. They are the small, often unconsidered, but usually critical arrangements that must be in place to enable users to operate the machine. The first dimension of enabling addresses resources; the second (in the next issue) addresses practices.

Dimension 3. Support

Case: Making a copy.

Once in 1994, when doing a routine piece of office work, I intentionally and self-consciously tried to pay attention to everything I did that was not directly associated with operating the technology, but that was still needed to get the job done. I wanted to print a letter on Xerox letterhead. First, I had to decide whether to change paper in the shared hallway printer, thereby risking someone else's job getting there first to our mutual annoyance, or to print on plain paper and copy onto letterhead. I chose the latter because I liked control. I invoked "Print" and walked down the hall to the printer. Finding no output, I discovered that the machine was out of paper. I added paper, and the print appeared. I turned to the copier, and found not only no letterhead, but no table on which the letterhead usually sat. After some unsuccessful searching, I appealed to the administrator who "owned" the copier; she informed me that the repair people required more space around the machine, so the table had been moved around the corner. Returning, I found the table, but still no letterhead. More search turned up the letterhead stored in shelving beside the table. I replaced the letterhead on the table, and put a sign above the machine pointing around the corner. Turning once again to the copier, I found my friend Steve doing a big job on it. We negotiated an interrupt because my job was so small and because Steve knew how to do it without losing his place in his own job. Steve showed me how to use the bypass tray for the originals, and an auxiliary paper tray for letterhead. After getting the orientation wrong the first time, I successfully got my letter on letterhead. The elapsed time for all of this: around 5 minutes, with most of the time being spent writing notices and talking to the administrator and Steve. I was amazed at how much supporting work there was, work that was normally unremarkable and hence invisible.

Activity: The support of doing requires activities associated with knowing, changing, and managing.

Supporting activities are usually much more extensive and varied than the operational activities. These support activities do not necessarily have to be carrried out before the operation begins, and in fact often emerge as needing attention as the operation unfolds (e.g., the copier running out of paper leads me to find and load more; wanting to avoid unloading a big job leads me to learning how to use the bypass and auxiliary paper trays). A crude breakdown of these support activities is:

- <u>Knowledge activities</u>: all those things that need to be done to ensure that the people using the technology know how to do so. They include: *learning* (which we tend to design into our technology), *teaching* (we help those who help others - my interaction with Steve), *organizing the information* (we add newly generated understanding that we want to share - my posting notes), and *taking responsibility* for seeing that these knowledge activities happen and happen well (who is the local expert, either assigned or self-appointed - knowing that the admin was the person to talk to about letterhead).
- <u>Technology modification activities:</u> all those things that need to be done to ensure that the technology is capable of doing the job. Although copiers are not usually adjustable, other technology is increasingly tailorable to individual needs and preferences (e.g., car seats, radio presets, preferences in software applications). These activities include: *customizing* the technology to its context (tailoring), *arranging ancillary technology* (moving the table around, repositioned the letterhead for others to find), *maintaining* the machine, and *cleaning up* the surrounding work area.
- <u>Resource management activities</u>: all those things that need to be done to ensure that the resources associated with operating the technology are managed. They include: the management of the *resources required for the technology* to work (ensure the power is on, that paper —including special kinds like letterhead—is available, that toners of the right colors are available) and management of the *resource that the working technology provides* (the ability to make copies—my negotiation with Steve).

Design requirement: Support knowing, technology modification and resource management.

People often expend considerable effort on such support activities, in fact more effort than in operating the technology when things have gotten properly set up. As designers, we must understand these support activities and address them in our designs as much as we address the activities of operation.

Dimension 4. Practices

Case: Video in support of a worldwide project.

From 1990 to 1994 I led a project for Xerox that involved the participation of over 50 people from around the world, and many more observing. Annette Adler was instrumental in working on the social practices in this community, and in making things work well for all concerned.

For the first two years, we met for a week in various locations about every two months, shared progress, solved problems, focused on next steps, and returned to our various locations to work further. In January 1993, Xerox acquired commercial video-conferencing equipment. Annette arranged for this equipment to be available to our team worldwide. For the next two years of the project, because of the effectiveness of the video connections, the time between worldwide meetings became longer and longer, while our contact with each other increased dramatically. Instead of meeting physically every few months, we met every few days through video; the planning horizon was for next week rather than next quarter. Using video to support distance collaboration was new to us, and we had to learn—indeed invent— many practices. We were amazed at how many of these practices there were.

Activity: Use of technology includes practices: genres, routines, and mores.

For groups of people to make use of technology, there must be patterns that they grow to understand and share with others, concerning the way that the technology fits into their activities. Because these activities may include any human endeavor, the patterns must be correspondingly broad. However, a crude analysis of the types of patterns is:

- Genres: It is tempting to define usage by the technology being used (e.g., sending e-mail, putting up a website, holding a teleconference). However, for any technology, there are many "genres" of using it, each with its own purposes and practices. For each of these genres—technology used in a certain way for a certain purpose, activities vary widely; indeed part of the work of acquiring a new technology is discovering the genres that it makes possible. For full-duplex video of moderate interactivity, we discovered at least four distinct genres: one-to-one meetings, small group discussions, larger group presentations, and project meeting attendance.
- Routines: For each of the genres, routine ways of working also had to be discovered. In our case, we learned how to join in and leave video activities, how to make introductions, how to control and manage microphones, cameras, and monitors, how to use drawing surfaces (white boards, paper, computers), how to interleave the talk ("manage the floor") and execute interruptions. We learned or developed rules of the road that provided the feel of connection and interaction that was appropriate for the genre at hand.
- Mores: On an even wider front, we had to identify what users' expectations for activities were, and work to establish mores—norms for acceptable behavior. And as we saw last issue in discussing Users (Dimension 2), this means considering *all* the users, including ourselves, that are impacted by the use of the technology. For example, when holding large project meetings, we used video equipment that was in special large conference rooms. These were often "owned" by more senior managers. We had to learn how our using their conference rooms could upset their patterns of work, and in negotiating for the rooms ensure both that the owners understood what the impact could be and that we were agreed on what would be mutually acceptable.

> On occasion, learning these lessons was painful for all concerned. Another example: when we began using the new technology, we did not clearly understand the costs of communication involved, since having video channels open for significant periods of time day after day was new. In the end, we discovered that meeting by video did not necessarily cost less than flying. However, we also learned that the shortening of the design horizon and corresponding ability to respond to changes clearly justified the expense . In the end, we had to learn, understand, articulate the value of, and set expectations for, our usage of communications.

Design requirement: Identify, understand and support practices: genres, routines, and mores.

Designers must address technology use in the larger context of practices: genres, routines, and mores. The technology must be developed to support the demands of these different practices. More important, the activities that people engage in to discharge the demands of these practices must be understood and supported. For example, if practices have been established for splitting costs of communication between visitors and host organizations, people will have to engage in some activities to track the communication usage and produce the information needed to support those splits; and means will have to be provided to enable all parties to reassure themselves that the information so produced is accurate. Establishing and meeting expectations at all levels is work; the activities that effect that work must be understood and supported as part of design.

Empowerment activities

The first two aspects of activities (operation and enablement) address what must be done. The third aspect addresses the question of why it should be done. I find myself breaking this into two issues: what values drive the activities, and how those values—and indeed the whole design—are determined. As with the other dimensions, there are activities associated with these issues that people using technology must engage in, and consequently work to be done in design to understand and support those activities.

Dimension 5. Values

Case: Building buttons.

In 1988 and 1989, I and others at the Xerox Research Center in Cambridge, UK (EuroPARC, as it was known then), developed a computer-based technology that we called "Buttons." Originally created as part of the Rooms research [3,8] at PARC, Buttons became a construction set for lab members to capture and share useful routines: One person would build a button (by writing an expression in Lisp, EuroPARC's local "scripting" language) to do something useful, then mail the button to others, who could get that thing done simply by clicking the button. People using buttons could copy them, open them up and look at how they did what they did, and modify them. Through use, we discovered regularities in their practices of modifying buttons and developed support for those activities as part of the Buttons technology [11]. (This work was further developed in an X environment [10].) As the work proceeded, we noticed that although buttons were being used throughout the lab, the administrative staff were not engaging in creating their own buttons. Making the assumption that this was due to lack of familiarity with the Buttons mechanisms, Kathy Carter spent time working with the administrative staff. She discovered that although buttons could really support the administrative staff's work, and although they agreed that this would help, and although they now understood the mechanisms, they *still* were not creating their own buttons. One day, a senior manager in the lab encouraged a senior administrator to make a button to automate a repeated task. Immediately, everything changed: The administrators began to use Buttons to enhance their work, particularly on routine repeated tasks. An elaborate practice resulted.

Activity: People create and spread the values of the environment through the technology.

The arrival of a new technology (in this case, Buttons) did not necessarily imply in any way that time should be spend on using it. A separate set of activities was needed to establish both who is responsible for what aspects of using the technology, and on what it was acceptable for who to spend time. In this case, until the values of the manager were seen to include working on Buttons, the activity of the administrators did not stretch to include manipulating (creating, modifying) Buttons. The suggestion that making a Button might save the administrator work did two things: it re-directed the work; and—much more importantly—it legitimated time spent manipulating Buttons to get them to do what was needed. That is, what had to be created was not only a technology capable of meeting the needs of those that would use it, but also an environment in which the use of that technology was regarded as being of value [4].

Design requirement: Understand and design for the values of the users' circumstances.

Use is given meaning by a value structure which frames it with power, purposes, and feelings. As designers, we need to be particularly aware of which participants have what power in the activities our technologies are supporting, what are their various purposes and value systems, what are their feelings about the system and existing practices, how proposed changes will shift that power and support or conflict with the purposes and values of various participants. Significant changes in such arrangements will only be possible through considerable work in setting expectations, involving users in design, generating feelings of ownership, involvement and responsibility, and supporting the deployment of not only the system but the practices that make it useful and usable.

Dimension 6. Designers

Case: Address change.

In 1978, Eleanor Wynne studied Xerox clerks taking telephone orders for copier supplies (paper, toner) from customers (discussed in [6]). She observed a clerk asking a customer for a shipping address, and in turn being asked about shipping dates: "You see, the copier is on an ocean-going barge; you tell me *when* Xerox will ship the supplies, and I'll tell you *where* to ship them." The clerk coped with this novel requirement by taking a telephone number and a name and filled in the shipping address on the order form with the instruction to call and ask for an address when the supplies were being shipped. In this confrontation with reality, Xerox—through this clerk—collided with the fact that not all addresses are fixed: this address was a function of time. And in that moment, the meaning of "an address" drifted. Unfortunately, the ordering form could not drift with it. The clerk's solution went beyond the assumptions of the form, creating an extension to how Xerox did business (for time-varying addresses). Because the form was on paper which had margins, there was a way to redesign on the spot how Xerox's addressing was done.

Activity: Ultimately, end-users design the system.

The socio-technical practice of using technology continues to be developed throughout the life of the technology by many designers, most importantly the "end-users." Although professional designers may design the technical system, and managers may design the socio-technical systems (the genres), design of the socio-technical practice occurs while people use the technology and carry out their work. Design continues in use [9]. The end-user is the final designer.

With modern computational systems, the potential for people using software-based technology to change that software in the midst of use ("pliancy") is progressively harder to provide within the system, particularly as the systems become larger [7]. This is primarily a matter of designers not considering how the user will to deal with changes that the designer has not anticipated. Our current mythology of system development suggests that by thinking hard about use designers (including users) can get it right "up front" during design. As a result, little effort is spent on addressing how people and systems with cope with novel situations.

Design requirement: Design for unanticipated change, and support users in responding to it when it happens ("continuing design").

As designers of technology, we must understand the activities that make up continuing design, and must provide for people to capture and carry those changes in that technology. For example, it used to be that Xerox copiers had a place in the instructions for identifying the "key operator"—the person locally responsible for the machine. With the advent of electronic instructions, this capacity was lost. Luckily a new convention has arisen for annotating machines: sticky notes. Institutionalizing the location for sticky notes on machines would be an open-ended response to the need for continuing design. For electronic forms, institutionalizing and designing an electronic equivalent of a margin (the place where annotations are placed) could make the rigid computational system more pliant.

When people undertake to continue the design of the socio-technical practice as part of their use of the machine, they can be regarded as entering the realm of professional designers. However, they don't have the skills of professional designers, but rather the skills of amateurs. In particular design per se may be of little interest, as may achieving elegant or generalizable solutions. To support amateur design, we must study amateur designers at work; we must seek to understand how people can be supported in being amateur, not professional, designers.

Putting it all together

In this column I have suggested six dimensions of the activity of people using technology. Correspondingly, designers should ensure that their design work is broad enough to encompass all these activities. However, these dimensions are relatively independent, and therefore each applies not only to the simple case of a person using a machine successfully, but also to all of the other activities as well. For example, design for learning must cover learning the genres of making changes in the management of supplies. And there are mores for learning, and designing for change in users, and so forth. The combinations are endless.

Further, activities often serve more than one purpose, and therefore any real-world, full-bodied human activity will be understood as being made up of different components, each a combination of these dimensions of activity. For example, setting out letterhead so that people can find it is not only about managing resources. It is also about arranging for learning. It may even be about the person making the change positioning themselves as being someone with the interests of the whole user community at heart [2].

Conclusion

In this paper, I have addressed six dimensions for extending our thinking about people's activity in using technology (see Figure 1):

Operating
- Dimension 1: Trouble
- Dimension 2: Users

Enabling (started)
- Dimension 3. Support
- Dimension 4. Practices

Empowering
- Dimension 5. Values
- Dimension 6. Designers

This framework suggests that the activity of using a machine is complex, covering, not only many additional maintenance and management functions, but also the activities of the designers of the system; and combinations of them.

Correspondingly, technology should consider supporting, and design addressing, this broad array of user activities. In my practice of design, this framework has helped me check that I am designing for *all* the users activities.

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