

Designing a Groupware Implementation of a Manual Participatory Design Process

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Abstract

TelePICTIVE is an experimental groupware prototype based on the paper-and-pencil PICTIVE participatory design technique. This paper describes a number of design issues that arose during the implementation of a computerized version of the manual process. The major classes of issues included: (1) Transformation: How well do the manual process and low-tech object model serve as metaphors for the groupware implementation? Which new computer-supported capabilities are desirable? (2) Embodiment and Skill: What changes may result from the more formal and technological groupware implementation of a deliberately low-tech and informal manual process? We discuss these issues, strategies for resolving them, and the lessons learned in using the manual PICTIVE process to design the groupware TelePICTIVE prototype.

Keywords

Participatory design, PICTIVE, mock-up, groupware, multimedia, video, paper, collaboration, CSCW

This paper deals with design questions encountered during the participatory design and implementation of an experimental

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groupware prototype, based on an established manual process. We will describe the prototype and its architecture in some detail, but as yet have insufficient data to assess its usability or usefulness. However, our design experiences and prototype implementation raised a number of questions that we suspect others may also face. We will therefore focus on those questions.

The groupware prototype, TelePICTIVE (Smith, Miller, and Muller, 1992), is intended to be an implementation of the manual PICTIVE¹ participatory design process (Muller, 1991b). PICTIVE is currently used in a same-time-same-place fashion. By contrast, TelePICTIVE is intended for use by participants who are dispersed in location and/or time. As a manual process, PICTIVE is intended to support the design of user interfaces and systems by heterogeneous groups of peer co-designers, such as users, developers, human factors workers, marketers, and other stakeholders in the design (Muller, 1991a). Previous experience (Brothers, Sembugamoorthy, and Muller, 1990) suggests that the transformation of the medium — from paper to computer — will lead to transformations of the social processes and of the structuring of the work, and that those in turn will lead to further transformations of the computer implementation, and so on.

Background

PICTIVE Participatory Design

In general, participatory design attempts to empower and enfranchise users in the design process, either by making them direct participants in the design team, or by making design team members direct participants in the users' workplaces (e.g., Bjercknes, Ehn, and Kyng, 1987; Bodker, Ehn, Knudsen, Kyng, and Madsen, 1988; Greenbaum and Kyng, 1991, 1992; Muller, Wildman, and White, 1992; Namioka and Schuler, 1990, 1992). The PICTIVE technique attempts to provide an "equal opportunity" design environment in which a variety of

1. PICTIVE stands for Plastic Interface for Collaborative Technology Initiatives through Video Exploration.

stakeholders can contribute their ideas with equal ease and access. This is accomplished through the use of a deliberately low-tech set of design objects, consisting mostly of common office tools such as colored markers, colored paper, Post-It™ notes or other removable labels, scissors, and so on. In addition, some custom objects may be constructed for specific user needs or specific target environments, such as pre-printed icon sets or window borders (see Muller, 1992a, 1992b for details). The guiding notion is that, with the exception of certain disability conditions, all participants have approximately equal skill at "operating" the PICTIVE design objects. This is in contrast to current software rapid prototyping environments, in which users and some other stakeholders are often at a skill-disadvantage with respect to software professionals.

The PICTIVE technique has been used on a number of products and projects with considerable success (Bush, 1990, 1992; Muller, 1992a, 1992b; Muller, Kaye, and Sauer, 1991; Muller, Smith, Goldberg, and Shoher, 1991; Nielsen et al, 1992). Some of our work with PICTIVE has involved consultations with users and other stakeholders in multiple geographical regions (e.g., Muller, Kaye, and Sauer, 1991; see also Muller, 1992b). This has led to several questions:

- What happens if the design developed at one location is different from the design developed at another location?
- How can divergent designs be reconciled?
- If each design session improves upon the work done by previous design sessions, then what is the stopping rule — i.e., when will the design stabilize?²
- Is there any way to reduce the time and cost of trips for PICTIVE sessions at multiple locations?

These concerns led to the proposal that we re-implement PICTIVE as a groupware tool that could span space and time.

Groupware Infrastructures

TelePICTIVE was implemented using the Rendezvous™ system (Patterson et al. 1990).³ The Rendezvous system is one of a small number of experimental groupware infrastructures that have recently entered their first generation. Using the abstraction-link-view paradigm (Hill, 1992), the system's centralized architecture maintains a single set of data objects that are manipulable by multiple users on a simultaneous basis (Rohall, Patterson, and Hill, 1992); each user's view of the

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2. We thank Darren Kall for proposing this question, based on his work with PICTIVE.

3. We are indebted to Chris Koster for making this suggestion, and for seeing the relevance of the Rendezvous system for a PICTIVE-at-a-distance implementation.

shared data objects may be different from other users' views. The Rendezvous environment provides a powerful and extensible object hierarchy through which we implemented representations of the PICTIVE objects (Smith, Miller, and Muller, 1992) and the experimental prototype that has given rise to this paper's design quandaries (Miller et al, 1992).

Participatory Design of Groupware for Participatory Design

We used PICTIVE to design TelePICTIVE. The initial design session included two implementors and one "PICTIVE process expert." Four subsequent design sessions included the original three people, plus two projected users of TelePICTIVE (human factors workers) who were already users of PICTIVE. Each design session took two to three hours. The authorship of this paper reflects the composition of the design team.

A typical design session began with a demonstration of the current status of the TelePICTIVE prototype. We would then move to a paper-and-pencil PICTIVE session to design new aspects of the application, or to answer specific questions which had been proposed by one or more members of the design team since the last design session. With one exception, all design sessions were videotaped, and the implementors used the videotapes and the PICTIVE paper records of the design sessions to guide their development of the prototype. Most design sessions ended with a walkthrough of the results of the session, as a kind of videotape "minutes of the meeting."

High Level Description of TelePICTIVE

The Current TelePICTIVE Prototype

In the current experimental prototype of TelePICTIVE, each participant in the design session uses her or his own workstation. Usually, all participants share the same design space; Figure 1 shows a typical view. (In the future, we will support multiple design spaces, so that one or more people may work together or individually on separate sub-problems.) The components of the visual presentation of TelePICTIVE, as shown in Figure 1, are as follows:

- Shared design space (Figure 1A): The largest window in the application is the shared design space. In Figure 1, this contains a representation of a window (Figure 1B), with several data fields.
- List of design meeting participants: (Figure 1C): Toward the upper left corner, there is a list of the current participants in the design meeting. Through the abstraction-link-view paradigm, each participant sees a different ordering of the same list, with somewhat different capabilities associated with different items on the list. The participant's own name appears at the top of the list of participants.

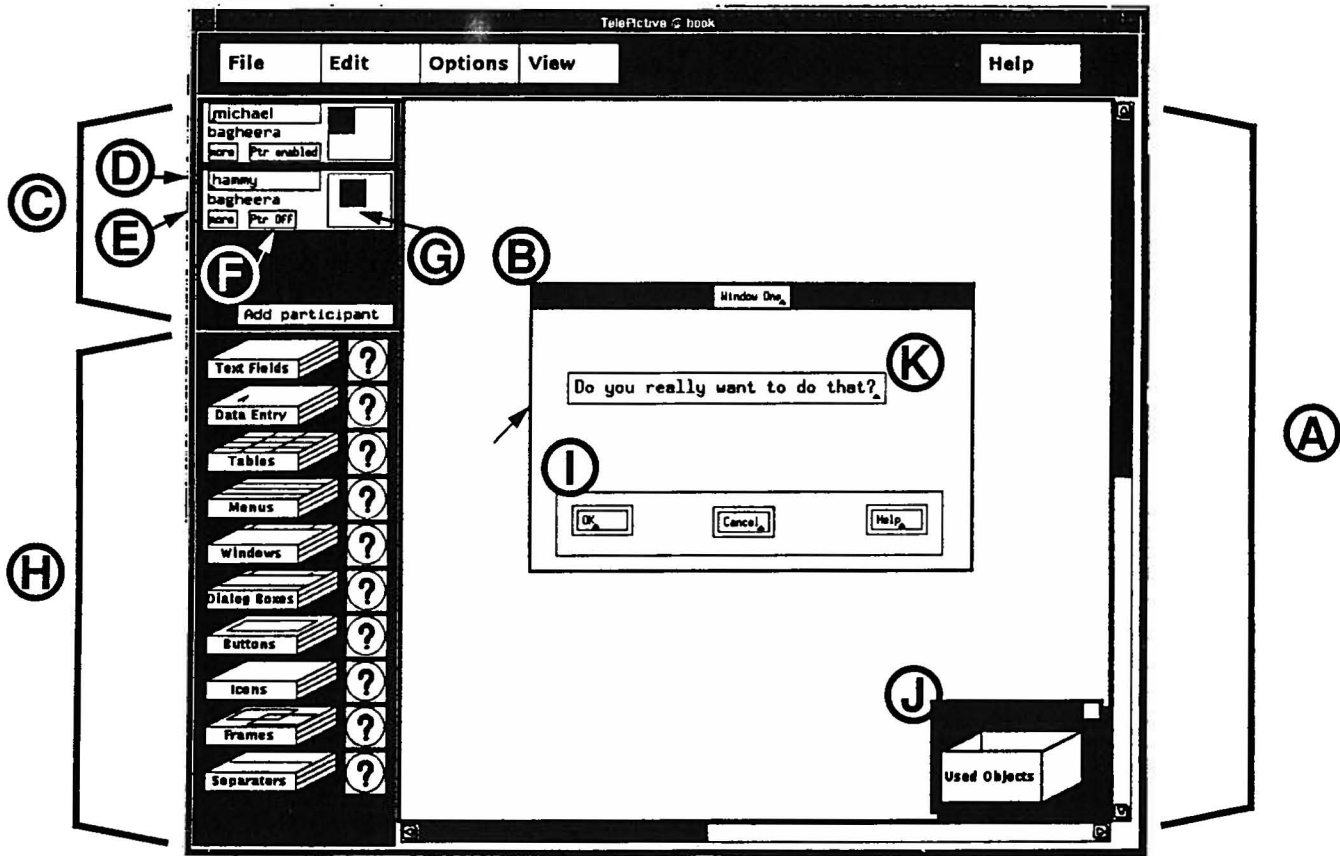


Figure 1. One participant's view of a TelePictive session. A. The shared design space. B. A Window. C. The list of participants. D. The name of one participant. E. More information about the participant (the participant's workstation). F. Control of the participant's telepointer. G. The box-within-a-box notation that shows where on the design space this participant is focused. H. Palette of TelePictive objects. I. A panel within the window. J. The Used Objects box. K. Text within the window.

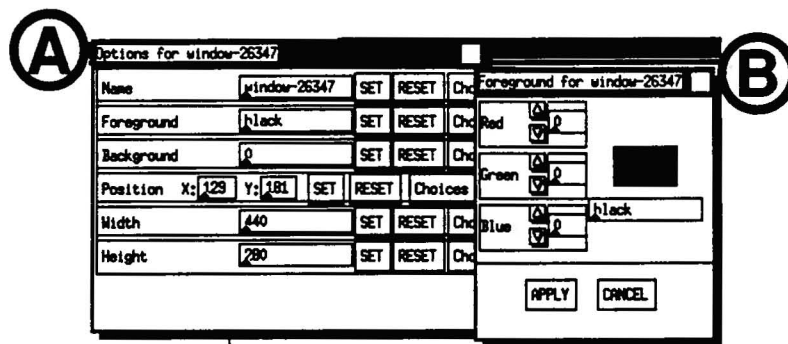


Figure 2. Specifying the attributes of objects.
 A. Options pull-down menu for a window object.
 B. Color chooser box.

Each participant's individual listing includes the identity of the person (Figure 1D), a brief set of information about her or him (Figure 1E), an indicator that controls the appearance of his or her telepointer (Figure 1F), and a simple box-within-a-box representation to show which subsection of the design surface is currently being viewed by that participant (Figure 1G). The color of the box-within-a-box is used to denote the identity of that participant to other participants (e.g., through the color of her or his telepointer, and through the color used to indicate that he or she has selected an object — see "Front Stage Action in TelePICTIVE," below).

The box-within-a-box notation provides two means of navigation in addition to those provided by the scroll bars. First, a participant may move her or his window across the design surface by dragging his or her box-within-a-box. Second, a participant may click on another participant's box-within-a-box in order to "snap" his or her window to view the same part of the design surface as is currently being viewed by the other participant.

- Design objects (Figure 1H): Along the left margin of the application window, there is a palette of design objects. These are intended to be representations of stacks of removable labels, analogous to physical Post-It notes. Each stack of notes is specialized as a different type of design object, including windows, data fields, text labels, icons, menus, buttons, and so on. Participants use drag-and-drop operations to enact the metaphor of picking up one note from the top of the stack, and placing it on the design surface.

Within this metaphor, each note is sticky, and adheres to any object on which it is placed. Thus, a window can be populated with data fields and icons, and all of these will move as a unit when the window that they are stuck to is moved. However, each individual object within the window may be picked up and moved independently of all the others. The stickiness relationships may be nested. For example, a panel (Figure 1I) might be created within a window (Figure 1B), and several buttons might be created within the panel. If the window is moved, all of its contents stick to it and move with it. If the panel is moved, the window sticks to the background, and therefore doesn't move — but the buttons stick to the panel, and move with it. Each button may be picked up and moved independently of the other buttons or the panel to which they are stuck.

Certain other special relationships obtain. A menu may be placed within a data field, thus creating an option menu (in the sense defined by version 1.1 of the Motif™ Style Guide (Open Software Foundation, 1991). Windows or menus may be added to existing menus as cascading

events (e.g., a menu selection may lead to a subordinate menu, or to a dialog box).

- Used objects box (Figure 1J): Discarded design objects may be dragged to the used objects box.
- Specifying attributes of objects (Figure 2): Each object class is associated with certain attributes. These may be specified or changed through an Options pull-down menu (Figure 2A), which may lead in turn to more specific cascading dialogues, such as the color chooser box in Figure 2B.

Front Stage Action in TelePICTIVE

During a design session, multiple participants can design at the same time. They can place objects simultaneously. As soon as one participant releases an object, it is available for modification by other participants.

Each participant may select one or more objects for modification. During this period, the selected object(s) is highlighted in a color corresponding to that participant's entry in the list of design meeting participants (Figure 1C). The participant may move the object by dragging it. She or he may change the shape of the object by dragging on one of the handles that appear as part of the highlighting of the object. He or she may also use the Options pull-down menu to modify other attributes, such as color, font, and so on (Figure 2).

While an object is selected by one participant, other participants are locked out of being able to act on the object, and of all objects that contain the object or that are contained by the object. However, the lock-out protocol does not extend to objects that are sisters of the selected object. For example, in keeping with observed PICTIVE protocols from other projects (e.g., Muller, Kaye, and Sauer, 1991), one user could rewrite the text of the first button in Figure 1I while a second user simultaneously rewrote the text of the second button, and a third rewrote the text of the instructions appearing above the buttons (Figure 1K).

However, other simultaneous access scenarios are more troublesome. For example, we currently preclude two users from stretching the same object at the same time, or one user from moving a window while another modifies one of the contents of the window. From the point of view of PICTIVE process, this appears to be unnecessarily constraining, and we will have to re-evaluate this and other approaches to avoiding or managing access conflicts involving user interface objects.

Behind the Scenes with TelePICTIVE

The entire design can, of course, be saved at any time. The save includes all information about the design (including all attributes of objects). It also includes the contents of the used

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objects box, so that objects discarded in one design session can be retrieved and used in a later session.

In order to keep a useful record of the design session, every action that results in a change to one or more design objects is logged. The contents of this change log constitute a record of all changes that have occurred since the last checkpoint save of the design. Multiple checkpoints and logs can be kept, resulting in a complete record of the design process, even over multiple sessions. This is intended to address a number of issues:

- Temporally disjoint attendance. Such a record allows designers to “attend” the design meeting at a later time, and still be able to follow the entire design process. The record will typically be supplemented by video tapes, but the on-line record shows more detail than can be captured on the limited resolution of video.
- Reviewing and “changing history.” Through the change log, time becomes a navigable dimension of the design. Participants can do the conceptual equivalent of scrolling backward and forward in time, reviewing past decisions, recapturing design rationales, and even “changing history” by altering a prior design decision, and then propagating the change “forward” in time to the “present.”⁴

A similar logging mechanism permits a kind of animation of the design. Ordinarily, TelePICTIVE is run in design mode. In record mode, all events are captured, and can be replayed in replay mode. This provides a computer-based version of the videotaped design walkthroughs or “minutes of the meeting” that occur at the conclusion of most PICTIVE sessions (Muller, 1992b; see also “Participatory Design of Groupware for Participatory Design,” above).

Literalism and Magic

The first set of design issues that we encountered falls into the area that Smith described as “the tension between literalism and magic” (Smith, 1987). In the Alternate Reality Kit (ARK), Smith addressed the question of how to use a literal real-world metaphor in a computer application, without leading the user into assumptions that later cause problems (for related cautions, see Halasz and Moran, 1982; Plum, 1977). He distinguished between the literal behaviors that correspond to the real-world metaphor, and the magical behaviors that violate the metaphor. Based on his experiences with ARK, Smith proposed that the boundary between literalism and magic be made quite distinct and evident in the interface.

4. We anticipate adding intelligent agents in an intelligent interface framework (Smith and Cebulka, 1990) to assist in this forward propagation of design changes.

This advice proves difficult to follow in TelePICTIVE. On the one hand, we use a set of real-world metaphors based on common office objects. However, it seems foolish to limit ourselves and our participants to the limitations of the physical analogues of our computer representations (e.g., see the argument that interpersonal communications services should go “Beyond Being There” [Hollan and Stormetta, 1992]). For example, several sets of objects are based on the metaphor of Post-It notes. In the real world, these have a fixed size and color. By contrast, in the TelePICTIVE world, design objects may be stretched—and certain aspects of their window border will stretch proportionately. Moreover, in the TelePICTIVE world, the color assigned to an object is arbitrary and changeable.⁵ Other examples of going “beyond being there” include the logging and animation capabilities described above, under “Behind the Scenes.”

These capabilities are, in Smith’s typology, “magical” with respect to the real-world metaphor of office objects. The strength of PICTIVE was its basis in common objects that could be operated by nearly any participant (Muller, 1992b). Will that strength be preserved when the office objects metaphors become permeated with computational capabilities that violate those metaphors? Will the inclusion of the non-literal capabilities re-introduce divisive issues among the participants in terms of who has the skills to operate the user interface and its underlying domain? Will our technological improvements impair the social process that we want to support? How can gains in technological feasibility and enhanced functionality be measured against losses in impaired social processes? This measurement question becomes even more complex when we consider the heterogeneity of skills, attitudes, and job requirements among the intended users of TelePICTIVE: A gain for one user constituency may turn out to be a loss for another, and the assessment criteria for the different user constituencies may be divergent or even conflicting. These problems are further underscored by the fact that all of the current TelePICTIVE design team are computer literate: Clearly, our design experiences must be expanded to include representatives of other stakeholder groups, as well.

Public and Private

A second set of issues arose around the question of public vs. private operations that become possible when PICTIVE is transformed into TelePICTIVE.

In PICTIVE, there is a single design surface that is used by all participants. As in many small group activities (e.g., Bennett and Karat, 1992), we attempt to keep the whole group working

5. In another sense, this distinction between literalism and magic begs the question: which domain is the domain of reference? PICTIVE, after all, was intended as a paper-and-pencil analogue of a computer domain. It could be argued that the paper-and-pencil domain is therefore magical, and the computer domain is literal.

together, rather than splitting into separate subgroups. For example, one early PICTIVE session involved eight users who were improving a printed report from a trouble reporting system: their session was almost derailed when they split into two separate subgroups that created two conflicting designs (Muller, 1992b). Since then, we have carefully limited the scope and duration of separate PICTIVE activities during a PICTIVE session, either by individuals or by sub-groups of the design team. Maintaining a single group focus is facilitated by the visibility of all portions of the design surface by all participants all the time.

By contrast, in TelePICTIVE, each participant's window shows only a subsection of the design surface. Thus, it is possible for one or more participants' current work to take place on a portion of the design surface that happens to be outside of the current view(s) of other participants. It is true that the list of participants (Figure 1C) gives some information about who is working where, and that one participant may click on another participant's box-within-a-box in order to view that other's current focus. However, this information is not as salient or as accessible as in the physical PICTIVE model, in which each person's peripheral vision keeps at least a low-grade notion of what others are doing. It might prove desirable to offer a fish-eye view (Furnas, 1986), providing details on the user's current focus, and showing only the highest-level of other users' activities. Alternatively, we might provide a transparent video overlay of activities on the entire design surface, in a manner analogous to the graphical and video overlays that have been explored in the TeamWorkStation project (Ishii, 1990). However, we have no current plans in either direction.

A second potential problem in the domain of public and private activities occurred through our too-literal incorporation of the PICTIVE physical model into TelePICTIVE. Most of the objects in the PICTIVE model have invariant colors. Color selection has therefore never been an important issue in PICTIVE sessions. When we added the color chooser capability (Figure 2B), we implemented it as one of a set of operations that were under individual control. Following this unthinking assumption, we designed the controls for this attribute as a pull-down option on the menubar, and we did the same for other attributes of TelePICTIVE objects. These controls are outside of the shared design surface. Because of this localization of the menubar, the actions taken to control or change the color are viewable on a private basis only, by a single participant. The results of those actions become public and visible to other participants, but only after the individual has completed them. In consequence, our design prohibits a shared discussion and determination of color choices and other attributes of the objects.⁶ Future uses of the prototype may force us to reconsider this allocation of public and private views. This, in turn,

6. We thank Robert Kraut for pointing out this set of group-inaccessible specifications.

may require a revision of our architecture, and perhaps of the architecture of the Rendezvous system infrastructure.

Embodiment and Skill

The third set of concerns centers on questions of skills, and the embodiment of those skills in familiar artifacts. The PICTIVE process is intended, in part, to minimize the impact of differences in computer-operation skills among participants, so that their domain-specific knowledge can come to the fore. For example, skills at mouse manipulation should not be important. We want to facilitate the integration of the domain-related knowledge of the participants — e.g., one participant's expertise in computer implementation might be combined with another participant's expertise in the users' work flow, and with yet another participant's expertise in the product's market. The office objects model appeared to be ideal for this purpose, for two reasons:

- participants' skills in manipulation of these objects are relatively equal
- participants' skills are exercised in a relatively unconscious fashion for these objects (i.e., Schon's knowledge-in-action [Schon, 1983])

When we move to the TelePICTIVE domain, we fear that both of the advantages of the PICTIVE physical model may be affected. Graphical user interfaces often involve (a) elements of distinct, learnable manual skills (e.g., mouse operation, etc.); (b) familiarity with specific affordances in the user interface; and (c) attitudes related to exploration, experimentation, and willingness to expose to the group one's own ignorance — or assumed ignorance — of technology. These three factors may lead to differences in the effectiveness of different participants in expressing their ideas through TelePICTIVE. Knowledge-in-action may breakdown into reflection-on-action in which the mechanics of the user interface interfere with the participants' attention to the design domain, and to one another.

For example, our PICTIVE-for-TelePICTIVE design sessions have frequently been concerned with how to make TelePICTIVE functionality available to the participants. When we speak as advocates for naive users, we are concerned to preserve the relative simplicity of a single-button mouse model, and to make all operations accessible through a combination of one mouse button plus menubar or other selections. However, when we speak as advocates of technology — or of technological experts — we are tempted to provide more streamlined access to the same functionality through the use of additional mouse buttons, keyboard accelerators, and so on. Thus, even though we are implementing one set of affordances that is intended to minimize skill issues, we must balance these users' needs against an alternate, more skill-based set of affordances

for expert users. Eventually, we will have to assess the impact of both (a) skill differences in the participants' backgrounds, and (b) skill differences introduced by our dual-skill interface decisions.

A second aspect of embodiment has to do directly with the social atmosphere of the design sessions. Over a number of design activities, we have learned to make our materials as informal as possible. This reduces the perceived distance between the "given" or a priori materials and the modifications or inventions carried out by the participants. As a result, participants feel more willing to make changes. The informality also encourages people to try ill-formed ideas on a rough-sketch basis, and to brainstorm together to improve them. TelePICTIVE produces a marked shift in the formality of the embodiment, and in the means used to make changes in it: now all materials have well-formed fonts, straight lines, and right-angle corners. This can have advantages in the clarity of the exposition, the accuracy of the representation, and the credibility of resulting design documents. We will have to assess the impact of this formality on the social atmosphere of the design sessions.

A third aspect of embodiment has to do with the incorporation of real-world artifacts into the design session. In several sessions on other projects, we have observed that one participant would present a printed report or other artifact from the current work flow or system, and that this would enter the design surface and become the basis for design modifications. Later versions of TelePICTIVE will support multimedia integration. However, the our first functional version of TelePICTIVE — i.e., the one that will be used to assess its usefulness and usability — does not include multimedia capabilities, and cannot readily incorporate "external" artifacts.

A final concern in the area of embodiment has to do with gestural communication. While telepointers provide a kind of gestural capability, they are gesturally less expressive than the human hand. For example, one PICTIVE design experience involved the use of a hand to cover up portions of the design that were proposed to go into a window; the hand was then removed to indicate the moment when the window appeared (Muller, Kaye, and Sauer, 1991). Similarly, thumbs and fingers appear in the PICTIVE video records at a number of points, covering text, gradually revealing icons, and so on. However, telepointers denote exact locations and movements, and may be recorded as part of the design session record, leading to hypothesized improvements in the accuracy and interpretation of the design. It is not clear how important each of these different attributes is: Our experiences with TelePICTIVE may eventually help to answer that question.

Recursive Design

One of the interesting aspects of the work on TelePICTIVE was the conceptual recursion of using the PICTIVE design

technique in order to design TelePICTIVE, which is an application that supports the design process. As participants in the PICTIVE-for-TelePICTIVE sessions, we found this experience both valuable and confusing. On the one hand, any uncertainties we had about how PICTIVE sessions might be conducted were resolved immediately through use. We could experiment in the PICTIVE domain with capabilities that we were considering adding to TelePICTIVE. Those of us who were primarily interested in implementation, rather than in the design process, found this quite helpful.

On the other hand, using a design tool in the design of another design tool was potentially disorienting. We often had to clarify which of these domains we were discussing and the clarifications were not always successful (a Post-It note on the screen? this Post-It note in my hand? the antecedent Post-It note to the metaphorical Post-It note in the design?). Some of the lessons learned in earlier work with PICTIVE practice were reconfirmed in our exercises, too: concrete, graphical communication is particularly helpful when explicating complex concepts in a heterogeneous design group (Muller, 1992a, 1992b; see also Crane, 1990).

Conclusion: Strategies for Answering the Design Questions

In this section, we briefly outline strategies for resolving some of these design questions.

The traditional approaches to such questions have been two-fold: review/repeat requirements analyses, and perform usability testing (perhaps with prototypes). The first of these is difficult to do: our design team already contains as much requirements information as we know how to find. The second course of action will prove necessary for some of our questions, especially those regarding the social atmosphere surrounding the participatory design procedure. We anticipate as well that certain of our design questions may lead to directly testable hypotheses for usability testing, for example in topics such as combinations of literalism and magic, methods for providing awareness of others' actions, and assessments of the impact of the dual-skill interface.

However, we are hoping to employ some interim measures. We know of no rapid prototyping groupware environments that meet our needs. However, there are several techniques from participatory design that may help us to assess several of our questions with users. For example, for we plan to develop video prototypes (i.e., stop-action simulations) of multiple-screen scenarios to show design alternatives (Clanton, Iannella, and Young, 1992; Curtis and Vertelney, 1991; Vertelney, 1989; Young, 1992). In other cases, we will modify PICTIVE materials to show coordinated activities or changes on multiple paper "displays." This may involve the construction of specialized paired writing instruments such as were used in an

informal groupware dramatization by Greenberg (1990) and Mantei (1990). We will experiment with some of the privacy issues by intervening in conventional PICTIVE exercises to obscure some participants' view of other participants' work. Sometime in the future, we may be able to learn more about these questions through one more design recursion: using TelePICTIVE to redesign TelePICTIVE.

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