Hands-Only Scenarios and Video Action Walls – novel methods for tangible user interaction design

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Abstract

In our research on tangible user interaction we focus on the design of products that are dedicated to a particular user, task and context. In doing so, we are interested in strengthening the actions side of tangible interaction. Currently, the actions required by electronic products tend to be limited to pushing, sliding and rotating. Yet humans are capable of far more complex and subtle actions: human dexterity is highly refined. This focus on actions requires a reconsideration of the design process.

In this paper we propose two design methods that potentially boost the focus on skilled actions in the design of tangible user interaction: The *Hands-Only Scenario* is a ‘close-up version’ of the more commonly used dramatised use scenario. They help focus effort on what we imagine the hands of the users doing. The *Video Action Wall* is a technique of ‘live post-its’ on a (projected) computer screen. Little snippets of action videos running simultaneously help designers group and describe user actions and the qualities they represent.

Keywords tangible interaction, human actions, video, scenarios, design methods

1. INTRODUCTION

Often tangible user interfaces are defined as a way of coupling information from inside the computer with physical objects that allow manipulation of the data outside the screen. The physical objects represent information. Coming from an industrial design background, this definition seems limiting in that it takes a technology standpoint and perceives ‘computers’ as typical office desktop machines. We are interested in actions rather than representation of information: Actions that allow humans to build skills; in keeping with the use context and the non-computer artefacts in it.

Our path into tangible user interaction research is formed through: (1) Our background as the user centred design competence of the Danish manufacturing company Danfoss, and (2) our inclination towards the Scandinavian approach to user participation in design.

The industry background means that our focus is on manufactured products, plant contexts, and professional technicians rather than PC-based applications for office-type environments and knowledge workers. Over the last decade we have developed user interaction for heating and refrigeration controls, flow meters, motor controllers, hydraulic equipment etc. for contexts like heating plants, supermarkets, waste water treatment plants, breweries, construction machineries. Such products are typically designed to solve specific control-related tasks. In the sense of Norman [1999] they are ’strong specific’ rather than ’weak general’. The people interacting with such products are typically heating installers, refrigeration mechanics, process operators, industry electricians, service technicians, and vehicle operators. They share a crafts tradition with strong respect for the work of hands, and they have a well-developed sensitivity to the physical surroundings they operate in. Touching, listening, smelling, is—besides observing—a central part of their work and a precondition for constantly adjusting their activity.

The participatory design approach makes us constantly inquire into the broader picture of context and work practice and strive to include a user’s point of view in all design activities. Through the 90s our group has developed its practice from the one-shot involvement of users in usability testing, to a continuous user dialog staged in user field studies, user workshops, and collaborative design activities (Buur and Bagger 1999; Bødker and Buur 2002). We build on the Scandinavian tradition of experimental systems development (Greenbaum and Kyng 1991). In general, we work from observing users towards redesigning the artefacts, rather than first redesigning the artefacts to then observe the effects on users.

2. RESEARCH APPROACH

As this is research into the process of design—the work practice of designers—our primary method is action research, (e.g. Van Beinum 1998). In action research the researchers strive to understand and describe social reality through intervention in practice; by solving a problem *with* ‘the studied’, rather than *for* ‘the studied’. In this way the participants become part of the research process and contribute to the results through feedback, discussions, and new actions.

In practical terms, we staged a series of design experiments with both design students, researchers, and industrialists over a 2-year period. It developed from the original proposition that ‘designing actions before product’ would be beneficial, i.e. focusing on user actions separately from the design of the interface mechanisms that afford such actions. Based on results, participant reactions, and experiences from each experiment we reiterated and improved activities and techniques for the next event. In this way our understanding of tangible interaction and design process developed along with the refinement of design methods.

The series of design experiments included:

Student design events (IT Product Design graduate students):
3-week projects Tangible Interaction, SDU (2002, 2003)
2-day event Tangible Interaction, TU Eindhoven (2002)
2-week projects Video Studies of Crafts, SDU (2001, 2003)

Research seminars (researchers and industrialists):
1-day workshop, Danish Center for Pervasive Computing (2002)
1-day workshop, Designing Interactive Systems, London (2002)
1-week summerschool, University of Southern Denmark (2003)

The design cases we have worked with include car alarms, office telephones, video recorders, brewery automisation, and playground equipment.

3. TANGIBLE USER INTERFACES AND RICH ACTIONS

Currently, much of the (HCI-rooted) tangible interaction community focuses on the coupling between the physical and virtual representation of data (Ulmer and Ishii 2000). Tangible user interfaces are taken as a method of making virtual information in the computer subject to physical manipulation outside the screen. The core design challenge is how data is represented in physical objects, and how the data may be controlled through configuring the objects in 2D or 3D space. The shape of the physical objects (Holmquist, Redström and Ljungstrand 1999) tends to get far more attention than how the users will interact with the physical components. The most common realisation is a table with computer projected image, on which physical objects, tokens, can be moved around to control how the computer handles data, for instance metaDESK (Ullmer and Ishii 1997) and PitA Board (Eden, Hornecker, and Scharff 2002).

We regard this type of solutions as important, but then only as a subclass of a much broader field of tangible interaction opportunities. There are two reasons why we find the prevailing understanding of tangible user interaction too limited:

(1) It builds on the assumption that computers are foremost information processing machines. However, when we regard the vast and growing field of products with embedded processors, such as household appliances, hospital equipment, and industrial components, they all suffer from the intangibility of computer data, although their main purpose is not information processing, rather they monitor or control things in the physical world – think of a washing machine, for instance. With the advancement of electronics technology many of these 'computers' have experienced an explosion in functions that all require choices and adjustments through tiny displays and buttons, if the user wants to benefit from them. We are overwhelmed with user interfaces of smart appliance that beg to be improved. And most appliances already have the computing power that PCs had a few years ago.

(2) It builds on the assumption that interaction – and indeed work – is primarily a cognitive activity. However, as soon as we leave the office domain, people's activities are very much physical. In industrial settings, like heating plants, breweries, factory floors, for instance, there is a striking discrepancy between the non-computer apparatus and the electronic controllers and computers. Whilst the traditional apparatus and tools leverage the action skills of the operators, the interaction with the computer equipment is based almost exclusively on button pushing and display reading. When observing how skilled operators handle such electronic equipment, it is evident

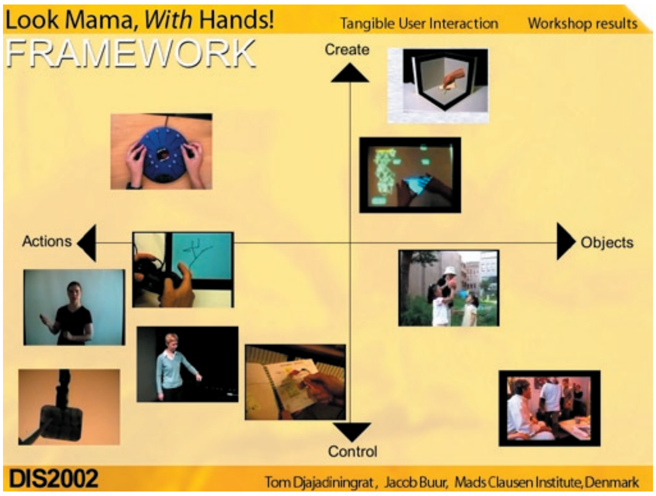

Figure 1: Map of tangible interaction designs, produced by participants at the DIS 2002 research workshop

that the style of interaction bears no relationship whatsoever to the emphasis on hands and tools that is characteristic for their work tradition.

The map shown in Figure 1 was produced in discussions among the participants at the DIS 2002 workshop (Djajadiningrat et.al. 2002). It helped pinpoint our concerns: That the type of tangible user interfaces we talk about here, deal with control rather than create (information), and actions rather than objects (representations).

Most interaction design today focuses on simplifying the required actions thus reducing the skills requirements. With keyboards and buttons the main challenge for the user is to locate the key to be pushed, and to do this sufficiently fast. Locating keys is solely a cognitive effort, whereas the pushing itself is a monotonous string of motorically trivial actions. The same can be said for the type of tangible user interfaces in which users move tokens as carriers of information on a flat surface: Actions are larger but hardly require skill, let alone that they allow building skill. This underrating of bodily actions has its origin in the prevailing understanding that mind and body can be regarded as separate entities; that knowledge is different from skill (Ingold 2001).

With the move towards physical interaction we are interested in exploring the very opposite: basing interaction on actions that require the user to build bodily skills. We see 'rich actions' as a so-far neglected yet essential approach to tangible interaction. If interaction with computers becomes more physical, it is essential to make the most of man's motoric skills.

An extended understanding of user actions as skill can help us set ambitious goals for tangible user interaction design: We want to create products that address the body, that allow users to learn skilled operation through bodily action and to let them perfect this skill over time until it becomes second nature.

This may be in direct opposition to the prevailing easy-to-learn paradigm, but we feel that this is indeed a necessary step to take to radically improve tangible interaction design. Since many industrial, computerized products show how difficult it is to make the easy-to-learn mantra come true, we are interested in directing the seemingly unavoidable learning effort toward bodily rather than cognitive skills.

4. DESIGNING TANGIBLE INTERACTION

We set out from the working hypothesis of 'designing actions before product'. With this we want to force ourselves to be explicit about actions before linking them to physical design solutions. This approach has taken inspiration from projects such as Xerox PARC's 'Embodied User Interfaces' and FX PAL's 'PaperButtons'. Fishkin et.al.(1999) observe how people handle a book and operate a Rolodex card index. They use this information to embed interface mechanisms that allow users to 'Turn' pages in an E-book and 'scroll' cards in a PDA, using familiar actions. Rønby Pedersen et.al. (2000) observe how experienced speakers use paper cards to control their multimedia presentation. Based on that they augment the cards with wireless buttons that accept actions similar to paper handling.

To talk about *designing* interaction or user actions is in itself presumptuous; Designers can hardly influence how humans act directly. At best we can design user interfaces that afford certain ways of handling them. But the conception of *designing* actions does help focus on the broader level of user activity rather than technology.

Equally, to talk about design *methods* may appear premature in a field as young and fast moving as tangible interaction design. However, the field of tangible interaction does need new approaches and experiments, and this is how we view our methods proposals; as inspiration for particular approaches to design, rather than production rules that promise to deliver specific results in any context.

Interaction is temporal; it unfolds in time. Our prior experience with the use of video as a 'design material' (Buur et.al. 2002) has proved very valuable in this work with the design of tangible interaction. The basic idea is that we may regard the video media not simply as an objective record of for instance users' work practices – as 'hard data' from the field – but we can exploit video as a media for expressing understanding and sculpturing ideas, collaboratively in the design team, and with users. In these design experiments we have used the video camera both to capture actions, but also to provoke actions (users' and designers' alike), and to maintain focus on actions, for instance in scenarios.

Also, we have previously struggled with the idea of mapping actions to functions in tangible interaction design. The method 'Interaction Relabelling' (Djajadiningrat et.al. 2000) introduces everyday objects with rich mechanical actions to inspire designers to think of physical interaction. – If the heating controller were this toy gun, what function would the trigger action represent?

Figure 2: Students use gestures to analyse human actions in video footage from ethnographic studies of children's play

From our design experiments, in particular two methods stand out as very promising in creating a strong focus on user actions: Hands-Only Scenarios and Video Action Walls. We will present them along with project examples in the following two sections.

5. HANDS-ONLY SCENARIOS

Use scenarios – short stories of projected use of future designs – have been recognized as a powerful means of relating ideas to use context and work practice. In industrial design circles the dramatising of use scenarios has become increasingly popular for exploring and evaluating ideas on interaction qualities (Burns et.al. 1994; Brandt and Grunnet 2000), more so than the format of written stories that is widespread in HCI-circles.

So far, most scenarios focused on the social interaction, the interaction with the use context and the sequence of events. Tangible user interaction requires particular attention to hand actions. For this reason we have developed *hands-only scenarios* as a supplement to full-body acting of use scenarios. The hands-only scenarios focus on what the hands will do to interact with the artefact to be designed.

5.1 String of User Actions

For some years the influence of anthropology has taught us that the narrow focus on how humans operate computers is not sufficient to grasp the complexity of interaction design. Ethnographic field study techniques - in particular participant observation and video recording - help designers understand the broader context of work practice and socio-culture as background for human actions. Designers have learned to shift from telephoto shots of interaction in usability labs to wide-angle views of users in their natural environment.

For tangible user interaction design the wide-angle view is still valuable, but as designers we need an additional, detailed focus on hands and actions to get a feel for skilled hand actions and motion preferences of users. To stay within the focal length metaphor, designers need not only the wide-angle views of real work practice but also macro footage of how humans use their hands with familiar tools and objects.

Established methods for analysing video include Interaction Analysis Labs (Jordan and Henderson 1995), in which a multidisciplinary team works closely with selected video sequences to offer observations and hypotheses about the activities recorded. However powerful this method is in making sense of user studies in general, it has proven inadequate for studying human actions, as it is a purely intellectual, non-physical effort. Instead of using words only, we have experimented with gestures as a way to analyse and convey findings, see Figure 2.

At a recent summerschool on Tangible Interaction Design at the University of Southern Denmark, we had a mixed group of PhD researchers and usability professionals from companies experiment with understanding and designing actions.

At first, we took inspiration from a modern dance instructor (McBride 2002) to focus attention on the human body and expressions of movement. Then we split the participants into five teams and asked them to analyse selected video footage of brewery operators at work and children playing in playgrounds, respectively. This material had been prepared in advance by some of the participants as part of research projects on Pervasive Computing in Industrial Plants and on BodyGames Interactive Playgrounds. To communicate the results of their analysis, we asked the teams to perform a sequence of actions

Figure 3. A design team acts out a string of user actions in a small coreography. It is inspired from a video observation of a brewery worker grabbing a handle, pulling, pressing a button

– a little dance, if you like – as a concentrated reproduction of the most characteristic actions observed. We observed that many of the teams chose to exaggerate the actions a little to make their point clear, see Figure 3.

– 'It was like a cool, in-control movement; a bit firm, so we played with it. The scenario we gave the operators was the following: There are two [motor controllers], and one of them is shut down for cleaning, and the operator needs to adjust the frequency of No 2.'

The challenge in this type of scenarios is to capture and express the qualities down to the details of the human actions – embedded in the context of work practice. The teams certainly gained a 'bodily understanding' of the user's activity very different for what could have been achieved by discussing only.

'Scholars suggest that the curiously disembodied view of human beings that until recently has permeated the social sciences is due to a longstanding bias against the body in the tradition of thought we call Western...' (Farnell 1999).

One can see the hands-only scenarios as a means to overcome the preoccupation with mind and cognition prevailing in HCI-circles.

5.2 Actions before Product

We experiment with hands-only scenarios that show actions only, as a vehicle to design a string of hand movements without yet considering the physical shape of the product.

In two design projects on tangible interaction we have asked graduate students to work with our strategy of 'designing actions before product'. I.e. we suggested them to first select a set of actions to work with, then map which actions can be used for which the function. From this, they should create a hands-only scenario, before proceeding to design a mock-up of the actual artefact. The object of design was an office telephone for the first experiment, and a video tape recorder for the second.

Before the first experiment we were anxious that gesturing how to interact without having thought about what the product should look like might lead to a lot of vague hand-waving. But in the course of the experiment we learned a couple of tricks that made the second experiment more successful:

(1) Compared to those teams that selected one team member to act out the hands-only scenario alone, the teams in which all participants presented their scenario simultaneously were much more precise in their actions. With several members acting together, the team has to train to get the synchronisation exactly right. In this way they get to pay attention to little details about movements and fingers and to be very exact in each action, see Figure 4a.

(2) Also, introducing a video camera to record the actions helped create a discipline and further strengthen precision and rhythm. A shot of the table from the top proved an interesting camera angle, because the image then has only hands, all sticking into the frame.

5.3 Product Interaction

On the following day the students worked with simple tinkering material to create a mock-up of a product, which took the selected actions to operate. This brought about a variety of untraditional solutions, and the students agreed that the 'designing actions before product' strategy had help them thinking out-of-the-box, Figure 4b.

In the reflection session following the first experiment, the students discussed if they really managed to maintain the action qualities when moving from hands-only scenario without product to the interaction scenario with the product. Therefore, in the second experiment, we organised a presentation of the two video scenarios side by side on the screen, so the students could visually compare the 'before and after' scenarios. This made it quite obvious that indeed it requires much care to create a design that affords the precise actions intended. The students realised a tendency to exaggerate the actions in the first step, then simplify them in the next. But now, at least we now have the means to put the discussion on the agenda.

It also became apparent in these experiments that it is crucial to find a precise way of describing qualities of actions, which is what the second method supports.

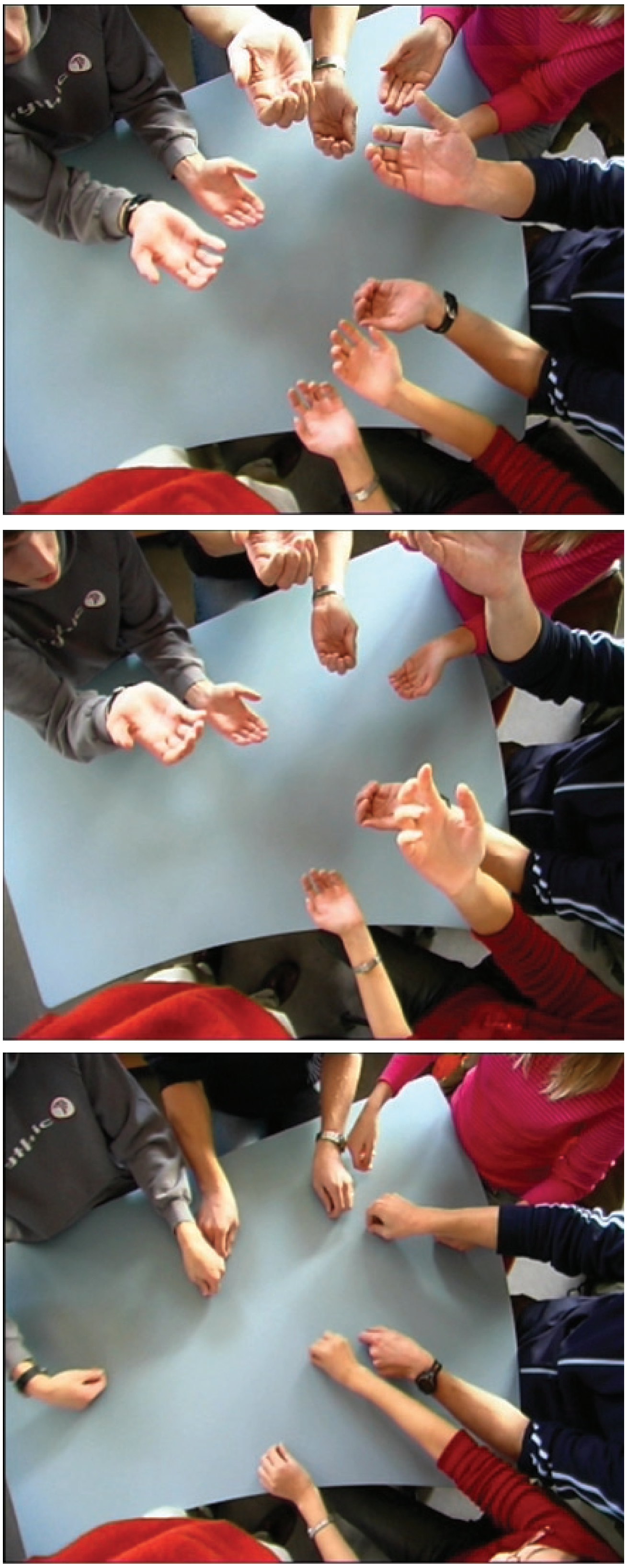

Figure 4a: Hands-only scenario without product. The students act out a sequence of movements, inspired by their use of everyday objects. The actions are mapped to specific functions of the product to be.

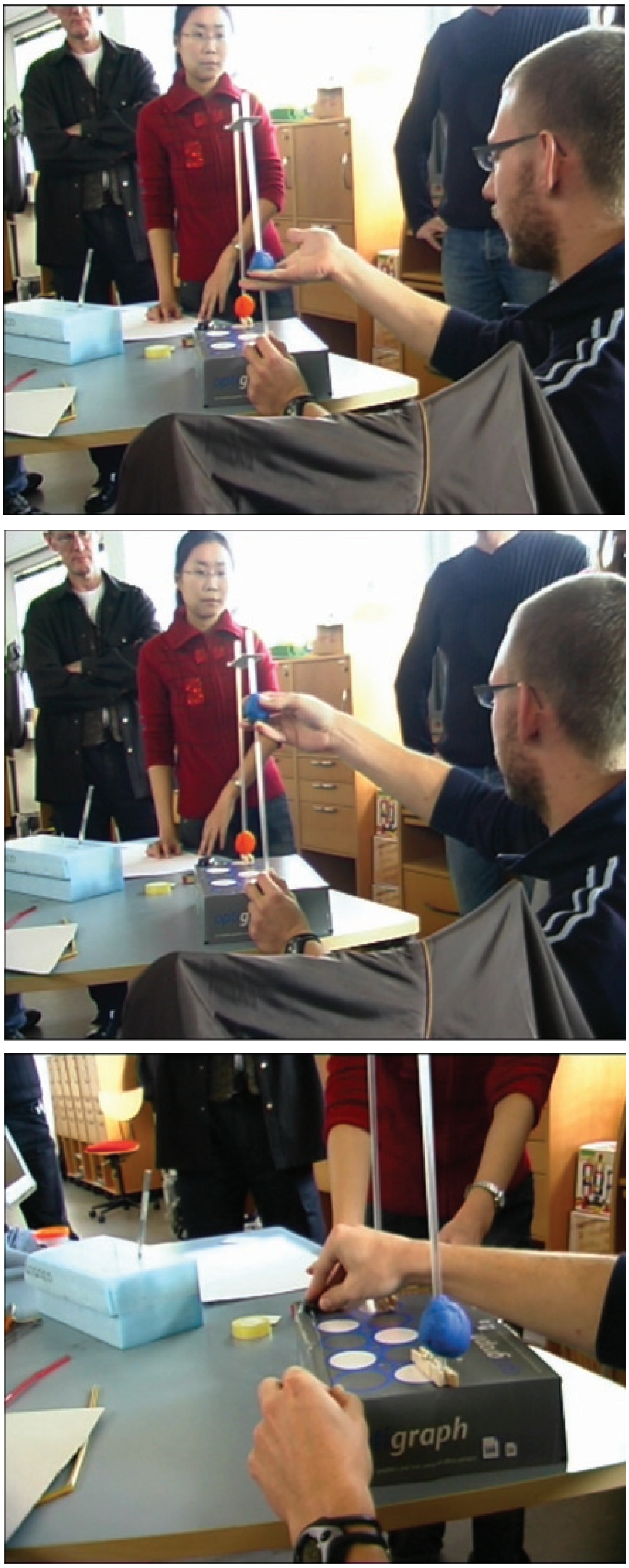

Figure 4b: Interaction scenario with tinkered mock-up. The mock-up is designed to support rich actions. A juggling action is used for play and fast-forward and a 'tape measurement action' to set the timer.

6. VIDEO ACTION WALL

To understand and discuss quality of actions it is essential to be able to compare actions. As actions are highly temporal, we have experimented with a technique of multiple video loops running on the same screen. This technique we have coined *video action wall*, and it takes inspiration from Mackay's 'Video Mosaic' (Mackay and Pagani 1994) and our own 'Video Card Game' (Buur and Søndergaard 2000).

On the screen 12 – 20 small-size (160x120 pixels) video clips show the actions to be discussed. Each clip runs a loop of an action, therefore the video wall not only shows dynamic information that still images cannot convey, but also shows this information in parallel, providing an opportunity to compare actions that normal video does not. Moreover, similar to post-its, the video clips are freely movable across the screen, allowing the participants to collectively group and regroup the actions, to create clusters that emphasize differences and similarities, see Figure 5. As the video action walls work with live videos, it is almost impossible to do them justice and convey an adequate impression in a printed media.

6.1 Quality of Everyday Actions

As button pushing is such a commonly accepted mode of interaction it requires a conscious effort to abandon fixed notions of what user interfaces should look like, and focus on the rich potential of human actions. We have found that taking people's own experience with handling everyday objects as a starting point, works well as an eye-opener and provides a rich source of action inspiration.

At the DIS 2002 workshop (Djajadiningrat et.al. 2002) we invited the participants to bring along an everyday (non-electronic) object, which they found themselves confident in handling. The participants brought along objects like can-opener, yoyo, necktie, pencil sharpener, CD-cover, pencil. In a show-and-tell session all participants got an overview of the actions, and we videotaped them to feed into the video action wall session. The looped videos were projected onto a whiteboard to allow participants to freely add text. An assistant used a mouse to move images around the screen on the participants' commands. The task was to create a map of the qualities of hand actions. The video action wall triggered participants to discuss qualities by comparing, grouping and re-grouping the video clips

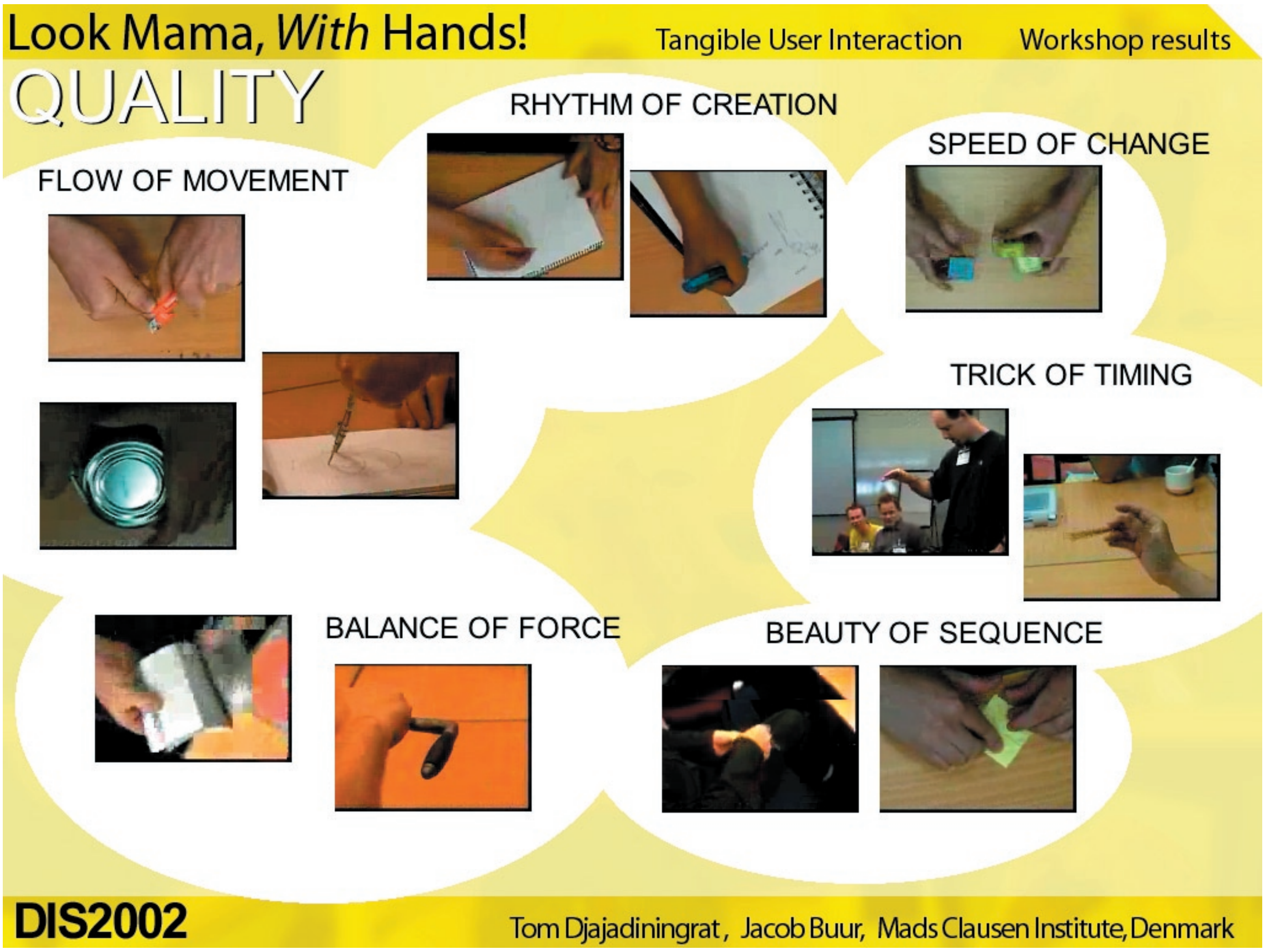

Figure 6. A video action wall mapping qualities in everyday actions, produced at the DIS 2002 workshop (Djajadiningrat et.al. 2002)

and naming each group. The outcome is shown in Figure 6. In the presentation, one participant briefly reported on the discussions they had in their group about the structure:

– ’This is more like you really know a lot about the object you are trying to interact with here; to make something happen. We thought about, its like surgery and its about having control over the situation. Know about the water level in the can, when you use [the can opener], so it doesn’t spill outside the can.’

Later, we have used the same activity with students on several occasions, and we have confirmed that it indeed opens a fruitful discussion of qualities of actions rooted in personal experience. We have noticed how the words in which participants describe actions differ significantly across teams: Some descriptions are very mechanistic, some metaphoric. One group of students, for instance, brought together the four actions of tooth brushing, turning a screwdriver, drawing circles, and flipping hamburgers. They described the activities like this:

’Controlled effort: Making repetitive circular movements and adapting the force to the feedback’.

In contrast, another group found a metaphor to describe their actions of spinning a Frisbee, juggling two balls in one hand, playing with a coin, moving a rubber band between fingers:

’A dog continuously chasing its own tail – actions to pass the time’

In a comparison of the skill of weaving string baskets among the Telfol people of Central New Guinea, and the nest building skills of the male weaverbird, Ingold (2001) investigates this phenomenon of choosing metaphorical descriptions of human actions:

‘Human beings, it seems, differ from other animals in that they are peculiarly able to treat the manifold threads of experience as material for further acts of weaving and looping. In so doing, they create intricate patterns of metaphorical connections, such as – in the Telfol case – between the movement of hands and flowing water.’

As the main purpose of the video wall activity is to establish understanding of qualities and inspiration for design, it appears that the poetic, metaphoric expressions serve the design process much better, than a mechanistic, factual one.

6.2 Quality of User Actions

Once the focus on action qualities is established, it is easier to discuss the quality of *user actions*, i.e. of actions that you observe in real context or on video. In a project with graduate students on video techniques, we asked the students to visited 8 different traditional crafts to observe actions with real people: Blacksmith, watch maker, taxidermist, florist, baker, massage therapist, violinist, hair dresser. The reason for choosing these sites was that we wanted the students to focus on people and their actions rather than on problems they may solve with new technology.

As a first step in the analysis we asked the students to edit a 3-minute portrait of each of their crafts person and his/her work. Then we used the video card game (Buur and Søndergaard 2000) to find common themes describing hand actions across the crafts: ’Hands as tools’ – ’Two-handed actions’ – ’Gestures as-if-tools’ – ’Forceful actions’. Each student team produced a collage video expanding one themes.

When we felt the students were sifficiently familiar with the material, we selected 20 video sequences showing characteristic movements acreoss the crafts for the video action wall session. Based on about 20 video loops, the students made an effort to group actions according to how they percieved action qualities. The looped videos provided the students with an opportunity to concentrate on action rather than on purpose or function of the action. The main difficulty that students encountered was to actually describe *qualities* (the experience of an action), rather than the actions themselves. Two of the resulting video action walls are shown in Figures 7a and 7b.

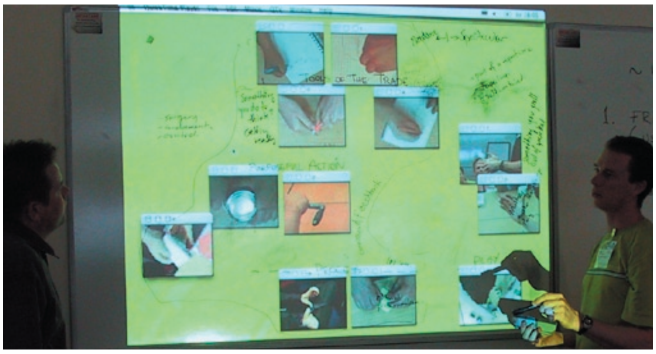

Figure 5. Participants at the DIS 2002 workshop work to describe the quality of everyday actions on the video action wall.

In this case the video action wall ran on conventional computer screens as the students worked in teams of three, see Figure 6.

7. CONCLUSIONS

Based on a string of design experiments with graduate students, researchers and industrialists, we have developed two preliminary design methods, which support our strategy of ‘designing actions before product’. This strategy – although in itself a contradiction – helps designers move beyond the one-eyed focus on cognition and computers to a sensitivity towards hand actions and physicality.

The Hands-Only Scenarios focus the design team’s attention on understanding user actions and on designing products that afford rich actions. The Video Action Wall encourages the discussion about the quality of actions (both designers’ and users’) and thus the formulation of values for the user interaction design.

These methods should be regarded as activity suggestions that support a particular approach to tangible interaction design, namely the focus on user actions. They are not procedures that produce predetermined results. Our experience with the 100 or so involved participants is that the methods work as powerful eye-openers - they make people see that there is more to tangible interaction than tokens and projections.

Figure 6. Graduate students discuss qualities of actions in the work of crafts people at a ‘screen-size’ video action wall.

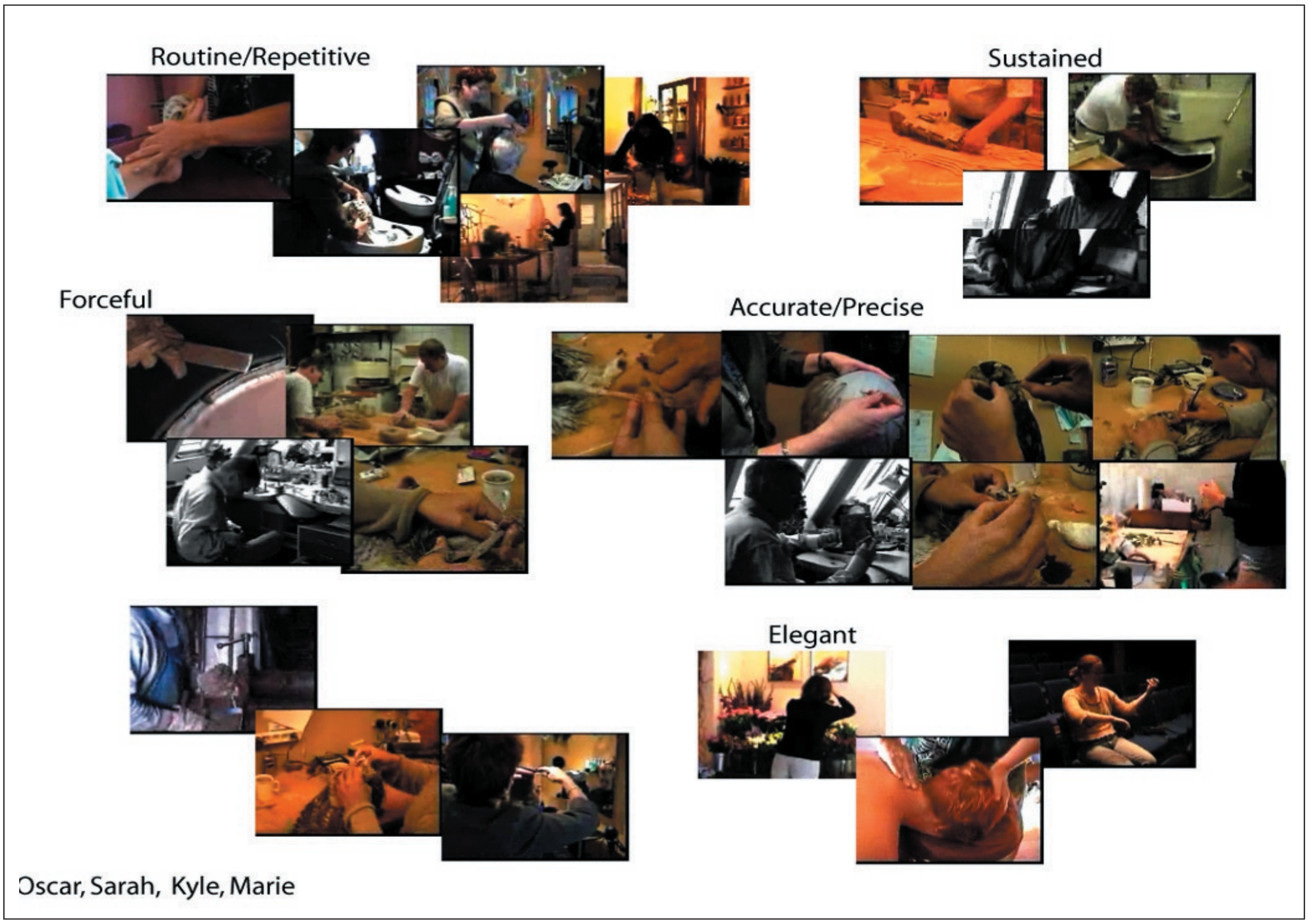

Figure 7a. A video action wall produced by a team of graduate students. It illustrates qualities of human actions in 8 different crafts.

The next step in our research is a proof-of-concept: To explore the rich actions approach in the design of real-world products. The main challenge will surely be to develop ways of ensuring that the fine details in user actions will survive in the design process

Acknowledgements

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Figure 7b. A video action wall produced by a team of graduate students. It illustrates qualities of human actions in 8 different crafts.

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