The Usability of Everyday Technology—Emerging and Fading Opportunities

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Current work in the field of usability tends to focus on snapshots of use as the basis for evaluating designs. However, giving due consideration to the fact that everyday use of technology involves a process of evolution, we set out to investigate how the design of the technology may be used to support this. Based on a long-term empirical study of television use in the homes of two families, we illustrate how use continuously develops in a complex interplay between the users' expectations—as they are formed and triggered by the design—and the needs and context of use *per se*. We analyze the empirical data from the perspective of activity theory. This framework serves to highlight how use develops, and it supports our analysis and discussion about how design, the users' backgrounds, previous experience, and needs, and the specific context of use supports or hinders the development of use. Moreover, we discuss how the characteristics of the home settings, in which the televisions studied were situated, represent a challenge to usability work. The concluding discussion leads to a set of hypotheses relevant to designers and researchers who wish to tackle some of the aspects of usability of particular importance to development in the use of home technology.

Categories and Subject Descriptors: H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*evaluation/methodology; input devices and strategies (e.g., mouse, touchscreen); training, help, and documentation*; J.7 [**Computers in Other Systems**]: Consumer products.

General Terms: Design, Human Factors

Additional Key Words and Phrases: Activity theory, case study, design, development in use, domestic technology, TV set, usability

1. INTRODUCTION

As new technologies penetrate our lives at an increasing rate, we no longer know what functionality to expect from our refrigerator, our television, our car, our heating control system, etc. There is a trend toward product integration and we see an increased complexity of especially domestic technology. Thus our

expectations become challenged in the meeting with new products and they are formed and modified as we gain experience with using the new technology. This exploration does not stop after the first hours or day of use. Our use continuously develops over time, new possibilities emerge, and others fade away. Unfortunately, present usability engineering methodologies provide little support in understanding how use develops right from the first meeting with the whole product till we later discover small facets of the technology and more importantly how this development in use may be supported by the design of the technology.

Activity theory provides a solid starting point for implementing designs tailored to supporting development in use by offering a framework that accounts for the dynamic nature of artifacts in use, right from motive formation to the detailed interaction with the material artifact. From the point of view of activity theory, computer applications are artifacts that mediate human activity [Bødker 1991]. In this article, we apply the perspective developed by Engeström [1990] where artifacts are seen as accompanied by several kinds of learning artifacts, which reflect and provide guidance for the use of the artifacts. We use this framework to interpret the processes of use as seen in a case study and we report on some of our findings with regard to what actually happens in the process of system appropriation over time and how the design supports the development in use. The study presented in this article should be seen as a part of a more extensive series of efforts in using human activity theory as a theoretical basis for human-computer interaction (HCI) and design work [Bannon and Bødker 1991; Bødker 1991; Bødker and Petersen 2000; Bardram and Bertelsen 1995; Bardram 1997; Bertelsen 1998; Nardi 1996].

Others have studied development in use, but much of this work has been limited to the area of text editing or other kinds of office work, and much has focused on relatively short studies carried out under laboratory conditions. The work of Carroll and Mack [1996] is an example of conventional work within this area. This study involved office personnel spending four half-days learning to use a word processing application in a laboratory environment. Through their study, Carroll and Mack [1996] identified three different learning strategies: learning by doing, learning by thinking, and learning by knowing. Some studies of ways of supporting development in use have taken the form of controlled experiments designed to shed light on the optimal design of a specific aspects, for example, Wiedenbeck's experiments with icons [Wiedenbeck 1999]. Rieman's studies of exploratory learning in an office environment [Rieman 1996] were carried out in a natural setting covering all available technology but only lasted a period of 4 days. Draper and Barton [1993] pointed to the work by Gibson [1986] on affordances in support of learning by exploration. The focus of their study was the first 40 min of novices' use of MacPaint.

Our case study, in contrast, concerns a long-term study of two families' use of a new television set with an integrated video recorder. This technology represents the trend of product integration and the increasing complexity of domestic technology. We paid our first visit to the families in their homes at the time their new televisions were delivered, and subsequently visited them three times at intervals of approximately 1 month. With our analysis, we seek to move toward

an understanding of how the design of technology can support the development in use—thus broadening the scope of usability and design work to encompass the use of interactive technology as it develops dynamically in the context of the home.

The progression of the paper is as follows: first, we present the methodological rationale behind our field study followed by an introduction to the concepts of activity theory that form the basis of our subsequent analysis of the development of use. The main body of the article is an analysis of four series of episodes from the field study, which we have found to be particularly successful, problematic, surprising, or difficult to relate to. The concluding discussion leads to a set of hypotheses relevant to designers and researchers who share our concern for supporting development in use in the design of home technology.

2. METHODOLOGY

Activity theory emphasizes the fact that artifacts can only be understood when in use [Bannon and Bødker 1991]. Therefore, we can understand neither use nor artifacts in isolation, and, as a result, we need to investigate specific situations involving artifacts in use in order to understand how development in use occurs. However, we face a number of methodological challenges to the study of development in use of everyday artifacts in the context of the home. Our approach to the subject is defined by considerations of privacy issues in particular [O'Brien and Rodden 1997]. In addition, the fact that a good deal of leisure and home technology is used only sporadically makes it difficult for researchers studying the use of such technology to be in the right place at the right time. The methodological challenge of this study is thus to find ways in which to mirror and condense the families' focus on and interaction with the products in the limited amount of time that was available to us during our visits to their homes.

2.1 Research Methods and Rationale

We wish to study how products with increasing complexity are handled by their users. Especially, we are interested in understanding how the design of interactive technology can support users in developing their use over time. To do this, we need to tackle the *process* of developing use, rather than concentrating on its results. Consequently, we focus on how users handle the technology, how they learn to use it, and what the motives are that drive the processes.

Further, several investigations have shown the importance of the context of the use of new technology [Greenbaum and Kyng 1991; Kyng & Mathiassen 1997; Beyer and Holtzblatt. 1998]. To address this, we find a qualitative approach to such an investigation extremely relevant. We have used a case study approach, where we have followed the adoption of new television sets by two families over periods of 4 and 6 months, respectively. We visited each of the families four times each, in their homes, during the evenings, and at intervals of approximately 1 month. The frequency of our visits was determined largely by our expectations about the frequency of use of the television sets. Following only two families allowed us to study the adoption processes in depth, given the resources we had. Moreover, due to the demands placed on the Bang & Olufsen

customers, as well as for practical purposes, we had to stop our investigations after studying 6 months of use.

In focusing on how use evolves, we are interested in the process as a whole— that is, starting from a time before the users even buy the new equipment. The initial phase of this process involves the first motivation, the idea of purchasing a new television, discussions within the families and with friends, and visits to a distributor. The intention of our study was therefore to enter into this process as early as possible. For practical reasons, we became involved in the process at the time when a technician from the store installed the televisions at the customers' homes, at which point we conducted initial interviews concerning the users' reasons for buying the televisions and their expectations about their purchases. As we were interested in defining the users' motivations for buying the televisions, the families we followed were Bang & Olufsen customers who had decided to buy the products in question independently of this study.

A further consequence of our interest in studying the development in use and how design supports this development was our decision to ask open-ended questions that did not disclose any facilities of the technology. In this we were inspired by Hammond, [1996], who wrote about how to conduct interviews and investigations related to the responses of the interviewees. As a result, rather than systematically providing the users with tasks to perform or with function-alities to try out, we took the users' own actions and explanations, as revealed during the initial interviews, as the basis for our subsequent visits. Subse-quently, during each visit, we followed up on the aspects raised by the users by constructing scenario-framed hands-on use sessions [Bødker & Grønbæk 1991]. This technique has previously—at least in the workplace—proved to be fruitful in establishing situations where users actively cooperate in the design process through assessing existing designs and envisioning future ones [Bødker and Grønbæk 1991]. We are not aware of others having used this technique before in users' homes. We also experimented with role playing as an approach to gain-ing insight into the users' current understanding of the televisions and their possibilities without influencing the adoption processes. Our study can be seen as a form of iterative investigation seeking to understand the evolution in use by following up on the same use situations as well as investigating new facets of use as they are encountered by the users.

To address the challenge of sporadic use of technology in the home, we devel-oped an incident diary form for the family members to fill in whenever some-thing interesting happened. However, due to a combination of the characteris-tics of the relaxed and private situation on the sofa in front of the television, the complexity of the specific form, and possibly an insufficient preparation of the users, the form failed to work in this study. See Kjær et al. [2000] for a more elaborate discussion about this aspect.

Finally, as we were visiting people in their private homes, we restricted both the number and the duration of our visits and were careful in our use of video recording in their homes. Whereas video recording equipment is often accept-able in a workplace, such technology is considered much more intrusive in a home setting. We found Mackay's [1995] precautions concerning the use of video extremely relevant also in the home. Due to considerations of respecting

private space, we decided only to videotape the situations where we explicitly asked the users to perform some tasks with the technology. See Kjær et al. [2000] for a more detailed discussion of our methodological approaches and experiences.

While others have studied technology in homes, they have most often been driven by motives other than that of designing specific new technology. For instance, most of the papers presented at an early home IT conference concerning home telematics [Rijn and Williams 1988] dealt with the social implications of the introduction of various technologies into the household. Although social implications are, to an extent, taken into consideration when designing new technology, we agree with O'Brien and Rodden [1997] that the design of new technology requires more detailed insight than that available from surveys. In order to form a platform for design improvements, we need to understand the motives behind the specific instances of use of technology, and we need to gain insight into the actual interactions with the technology. Moreover, it is generally acknowledged from the use of technology at workplaces that great differences may exist between how people talk about their use of technology and how they actually use it. Therefore, rather than choosing a quantitative approach involving a large number of users and centered around a questionnaire, for instance, we have chosen to present the experiences of a detailed qualitative study. As such, we offer a perspective that complements much of the other research available within the area of domestic technology.

2.2 Products and Participants

The product we have studied is a Bang & Olufsen integrated television and video recorder operated through a single remote control (unit), and as such it represents the trend of product integration. The integrated television and video can be part of a larger linked system, where all audio/video sources are linked together and controlled by the single remote control. The complex functionality offered by the remote control is provided through its different modalities. As an example, after having pressed the "TV" button, it is the same sequence of key presses that selects channel number 7 as when selecting track number 7 of a compact disk after having pressed the "CD" button.

In contrast to other interactive systems that have formed the objects of studies of learnability, we chose to look at a system that comprises a relatively simple set of metaphors and a simple menu structure. This gave us the opportunity of studying the changes in use, and thereby we got an indication of the learning process.

The two families each consisted of four members—a husband, a wife and two children. One family consisted of Paul and Sarah, a middle-aged couple with two adult children, while the other consisted of, John and Karen a younger couple with two small children. While Sarah and Paul had previously owned Bang & Olufsen products and as such were familiar with the company line, John and Karen were new Bang & Olufsen customers. Both families had just acquired the new Bang & Olufsen integrated television and video system. In Paul's and Sarah's home, this system formed part of a larger system comprising surround

sound and other audio-visual technology produced by Bang & Olufsen. At John's and Karen's home, the new system was not linked with other technologies.

All the field studies (interviews, etc.) were conducted in Danish, which means that quotations, etc., in this article are translated into English.

In summary, our case study concerned a long-term study of two families' use of new integrated televisions and video recorders. We paid out first visit to the families in their homes at the time when their new televisions were delivered, and subsequently visited them three more times at intervals of approximately 1 month. During each visit, we interviewed the family members and provided scenarios to for hands-on use sessions with their televisions.

3. ACTIVITY THEORY AND LEARNING ARTIFACTS

Bødker [1991] has described how computer applications are successful mediators when they allow users to act through them and maintain a focus on the objects of their activities rather than making the artifacts themselves the focus of their attention. However, breakdown situations inevitably occur when a user is learning to use a new artifact, and the artifact itself comes into focus. This means that creating designs for development in use includes providing support for returning the user's focus to the object(s) of interest.

Through a set of dynamic concepts, activity, action, and operation, the framework of activity theory provides a perspective that allows us to discuss how development in use takes place through transitions and formations of these, and it makes us focus on the context of use instead of seeing computer use, for example, in isolation. As artifacts usually mediate several activities, they may be seen as being situated within a web of activities. Each activity is conducted through actions of an individual directed toward a specific object or another subject. Activity is what gives meaning to our actions, although actions may have their own goals and the same actions can appear in different activities. Each action that a human being conducts is implemented through a series of operations. Each operation is connected to the concrete physical or social conditions for conducting the action, and is triggered by the specific conditions of the situation. Operations are often transformed actions, that is, we consciously conduct them as actions to start with. We transform them into operations by learning, but when the conditions we encounter change, we may have to reflect on them consciously once more, and what were once operations become conscious actions again. Learning in terms of operations that are formed and break down is one aspect of learning seen from the point of view of activity theory.

Artifacts also need to support the development of a repertoire of purposes of use of the artifact. This repertoire of purposes concerns the development of the motives for what we do. As pointed out by Bardram and Pedersen [1994], the formation of actions and the progression between levels of actions and activity are equally important to the learning process, and our understanding of these is far less well developed.

Furthermore, design in turn is complicated by the fact that an artifact always implies more possible uses than the original operations that led to its creation [Engeström 1990, p. 174]. Thus, the presence of a designed artifact does not

Human activity	Learning artifacts	Examples of learning artifacts
activity (motive)	where-to artifacts	visions of future use experiences
action (goal)	why artifacts	general principles and hypotheses
	how artifacts	ad hoc models
operation (conditions)	what artifacts	the artifact *per se*

Fig. 1.   Human activity and corresponding learning artifacts.

determine the way it is actually used and perceived by users. Further, the manuals and instructions accompanying a product, that is, the whole "system image" [Norman 1987], plays a role in forming the users expectations or model of the artifact. This applies to a wider class of artifacts than traditional computer applications and, as Engeström [1990] pointed out, artifacts are implicitly or explicitly accompanied by models that reflect and provide guidance for their use. Accordingly, we have found it useful to look at both the artifact in itself and the models that surround it as learning artifacts, artifacts that will be studied in greater detail in the following sections.

3.1 Learning Artifacts

Adopting the work by Wartofsky [1979], Engeström [1990] has pointed out that from the perspective of learning artifacts, all artifacts can be seen to include elements of *what*, *how*, *why*, and *where to* artifacts (see Figure 1). As a result, designing for development in use is a matter of designing artifacts so as to involve all four in appropriate ways. Taking a particular use situation as our starting point, we may also choose to study the models, other artifacts, etc., that form part of the users' web of activities and help users learn about the artifact in question. The different learning artifacts are closely related to the concepts of human activity [Engeström 1987].

   What artifacts are the artifacts *per se* with the limitations and conditions inherent in the artifact itself. They are the conditions that frame the formation of the subconscious operations through trial use of the artifact. As an example, the buttons on a remote control can be a *what* artifact. *How* and *why* artifacts deal with the formation of actions and goals. *How* artifacts are ad hoc models of how to use the actual artifact, the *what* artifact. Procedural instructions as they are commonly found in instruction manuals can, for instance, work as *how* artifacts. Such artifacts are not easily transferable to other conditions and situations because they are merely specific instructions offering no ground for understanding why they work. *Why* artifacts in turn are more general models and principles that offer explanations of how the artifact works. The use of general interaction principles, such as the use of modes on a remote control, is

an example of a *why* artifact. *Where to* artifacts are the imaginative artifacts, the visions, which help change and redefine a person's understanding of the change in the overall activity. An example of a *where to* artifact is the desire to experience being in a movie theater when watching television at home. This motive encompasses a vision of changing the existing situation, which makes a difference to the person or persons involved. *Where to* artifacts are manifestations of the motive of change. They need not manifest collectively, but contain an element of change, which could influence more than an individual person.

Engeström [1990] suggested that these different artifacts are useful in understanding use and development in use. However, Engeström [1990] argued that we can never predict how use will develop and that artifacts never predetermine use. He used learning artifacts for developing work practices in general without focusing on technological tools in particular. Therefore, in our analysis we extrapolate Engeström's learning artifacts to the situation with which we are concerned, namely the understanding of the development in use of interactive technology.

In the following sections, we present four series of episodes from our case study concerning development of use from the perspective of activity theory. In our approach we have been inspired by the anthropological way of doing field studies. We have made field studies in situ, collected our data (observations, interviews, video recording, etc.), and then have looked through the material several times to identify themes of interest from the material itself, rather than from a predefined set of categories. Some of the themes also developed through the interest of the family members, where it was coupled to their motives for buying the TV. Further, we have selected episodes that were particularly successful, problematic, or surprising and difficult to tackle. The episodes are: the cinema experience; programming video recordings: sticking to old procedures; programming video recordings: new opportunities; and, finally, consistency creating confusion.

4. THE CINEMA EXPERIENCE

Sarah is a member of a family that recently bought an integrated television and video recorder from Bang & Olufsen. The family previously owned a 10-year-old Bang & Olufsen television, so they are familiar with the brand. We analyze how Sarah came to use the new television over a period of 6 months, with a special focus on how she pursued the cinema experience offered by the new system.

4.1 Installation: Forming the Cinema Experience

When the product is being installed, Sarah and her husband Paul explain excitedly how they look forward to obtaining what has been labeled a "cinema experience" in their living room. This experience refers to the possibility of connecting multiple loudspeakers to obtain surround sound and the opportunity to adjust the format of the picture on the screen in order to watch wide-screen movies on a wide screen. This was one of the prime motives for buying the new television set.
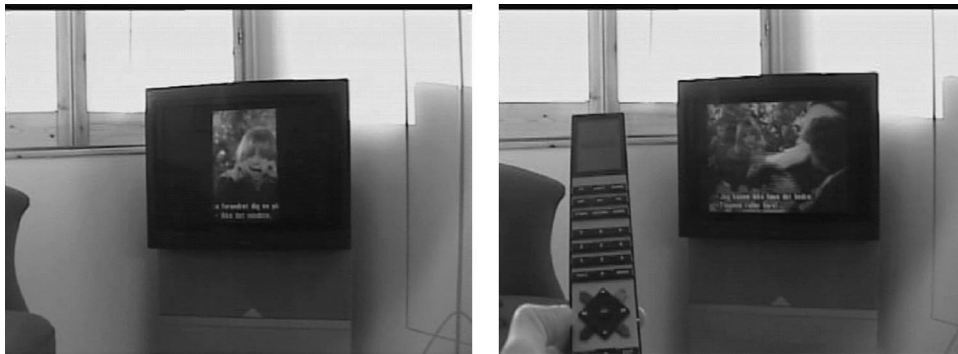
Fig. 2.   The electronic curtains of the Bang & Olufsen integrated television and video.

Several mediating artifacts play a role in forming both Sarah's and Paul's expectations with respect to the cinema experience at this time, when neither yet has any experience with using the product in their own home. Sarah refers to her visit to the cinema to see *Titanic* as an event that has served to form her expectations regarding the new product. Moreover, she has experienced the same system at her sister's house and in the special Bang & Olufsen boutique where they bought the television. By using the term "cinema experience" in their sales brochures and in the sales situation, Bang & Olufsen introduces the analogy between the television and the cinema, thus making visits to the cinema a point of reference in the encounter with the Bang & Olufsen television. This analogy is followed up in the design of the actual television. As electronic curtains rise and fall as the television is turned on and off, daily encounters with the television feature a direct reference to the cinema experience (Figure 2).

In terms of activity theory, the cinema experience as used by Bang & Olufsen in the sales situation and the sales brochures act as *where to* artifacts for Sarah and Paul in that they helps them to envision the new television set providing them with a new kind of experience. The concept of cinema experience and a real-life demonstration in the shop trigger experiences they have had elsewhere, for example, in the cinema. In this way, these artifacts provide an overall indication of what it means to watch television using this Bang & Olufsen product. The cinema experience analogy is also expressed in the product itself, as illustrated in Figure 2. The electronic curtains act as a *what* artifact, supplying a context for the *where to* artifacts in the appearance of the product. Thus, at this point in time, the cinema experience and the electronic curtains act as *where to* and *what* artifacts in forming Sarah's and Paul's expectations. As illustrated by the "-" symbols in Figure 3, no *why* and *how* artifacts have yet come into play in the context of the cinema experience.

4.2 One Month After Delivery: Efforts to Obtain the Cinema Experience

Sarah explains that she primarily uses the remote control from their old television to operate the new television. This works for basic purposes, although it is not possible to use the old remote control to access the special features of the television, including the cinema experience setup. Sarah is well aware of

where to artifacts
    The cinema experience as it is formed in the shop, in sales brochures, in the cinema, and at Sarah's sister's house.

why artifacts
    –

how artifacts
    –

what artifacts
    The electronic curtains rising and falling.

Fig. 3.   Learning artifacts at the time of installation: forming the cinema experience.

this, stating that the new remote control "is the future" and that she needs to familiarize herself with it at some point.

Before detailing how Sarah uses the television at this time, we would like to present a short explanation of some central features of the new remote control, which is illustrated in Figure 4. A distinguishing feature of this remote control is that it is highly modal. At the top, there is a display showing the mode selected—in this case the television. Moving down the remote control, we find nine buttons whose principal use is to select the source (TV, RADIO, CD, etc.). Further down, we find the number buttons. When the remote control is in television mode (as it is in Figure 4), pushing number button 5 selects TV channel number 5. Then there are some other buttons that have no bearing on this particular case, and, finally, there are six buttons including the LIST button. The LIST button is used to switch the mode of the remote control.

Repeatedly pushing the LIST button scrolls between different modalities. Thus, when the remote control is in speaker mode (with the word SPEAKER shown in the display of the remote control), pushing number button 5 would result in turning on the five loudspeakers to obtain surround sound.

During this second visit, we ask Sarah about what she would like to do with the new remote control:

> Sarah: "...what I can't do now and what I have not learned or asked about or read myself, that is to make the screen...if I'm watching a video...to make...what is it called...to enlarge or reduce the size of the picture...I can't do that...I mean it would take a long time for me to sit and experiment, it would be easier to read the manual, but it would be even easier to ask someone, if there was someone to ask."
> [Some discussion about whether Sarah would use the manual or not]
> Question: Are there any other things that you would like to do with the new remote control?
> Sarah: "I can operate the video, but there is still the thing about making the picture bigger and smaller and then there is surround sound, too. I have not worked it out...I know it is [she studies the new remote control in her hand]...no I don't know...yes LIST...I know it has something to do with LIST."

Sarah sets out to try to use the new remote control to connect all the loudspeakers to obtain surround sound. She experiments for some time, pushing the LIST button and some other buttons, but eventually she gives up. However, as she is experimenting, she accidentally succeeds in finding a way to manipulate the size of the picture. From conversations with her family, she knows that she needs to do something with the LIST button, but she cannot extrapolate this

Fig. 4.   The new remote control.

where-to artifacts
    The cinema experience as it is formed in the shop, in sales brochures, in the cinema, and at Sarah's sister's house.

why artifacts
    –

how artifacts
    Something to do with the LIST button on the remote control.

what artifacts
    The electronic curtains rising and falling.

Fig. 5.   Learning artifacts one month after delivery: efforts to obtain the cinema experience.

into a wider context, or make the connection between the LIST button, the cinema experience, and the loudspeakers. "Something to do with LIST" becomes an incomplete *how* artifact that cannot be connected to the other learning artifacts. Figure 5 provides an overview of the learning artifacts active for Sarah at this time.

During our subsequent discussions with Sarah's husband, Paul, about how he operates the television, Sarah discovers a principle of action, a new learning artifact, which is of relevance to connecting all the loudspeakers to obtain surround sound:

> Paul: "Now I would like to have the right size of the picture and the surround sound on. If we start with the size, we do. . . ."
> [Paul does this without problems]
> Paul: "Then, when we want surround sound, we must connect all five loudspeakers. Then we need to go over to what is called 'speaker' mode and you do this by pressing LIST . . . there we have speaker mode [the text 'speaker' appears in the display of the remote control], then we press number button 5. . . ."
> Question: And you pressed 5 because you remember . . .?
> Paul: "Well there was some logic involved as I know that you have five speakers in surround sound, right?"
> Sarah: "Oooohh, yes of course . . . that is a strange kind of logic isn't it! It's so simple really!"

In this way, the principle of connecting the loudspeakers by selecting the number of loudspeakers to be connected becomes a *why* artifact for Sarah. As she realizes this general principle of interaction, she identifies a kind of logic behind the interaction. However, according to activity theory, a tool only unfolds in use and Sarah still needs to employ this learning artifact herself before it becomes active for her. She has accomplished this by the time of our next visit.

4.3 Two and a Half Months After Delivery: Finally Establishing the Cinema Experience

Sarah proudly explains that she has now succeeded in connecting all the loudspeakers to obtain surround sound. It turns out that she has accomplished this using the CD player. We ask her to demonstrate to us what she did when she first succeeded. The CD player works in the same way as the television as regards connecting multiple loudspeakers, the only difference being that the CD has to be selected as the source (see Figure 4) instead of the TV. Furthermore, when

where-to artifacts
  The cinema experience as it is formed in the shop, in sales brochures, in the cinema, and at Sarah's sister's house.

why artifacts
  Press number button for number of loudspeakers to be connected.

how artifacts
  Press LIFT [LIST] a few times.

what artifacts
  The electronic curtains rising and falling.

Fig. 6.   Learning artifacts 2 months after delivery: finally establishing the cinema experience.

using the CD player it is only relevant to connect four loudspeakers instead of five—as Paul did when he demonstrated surround sound on the TV—because the loudspeaker in the television is not connected to the CD player. This challenges the generality of the principle of interaction discovered by Sarah as a *why* artifact during our previous visit.

> Sarah: "Then I turned on the CD player. And then I wanted to connect the loudspeakers—all five of them."
> Question: What did you do then?
> Sarah: "Well, then I needed to start by turning up the volume [she turns up the volume]...and then...hmm...[Sarah studies the remote control]...I put on...I pressed twice on...hmm...on lift...LIFT!...and then I pressed number button 4 and now they are on" [the surround sound is on].
> Question: When you experimented with this yourself, do you remember how you found out that this is the way to do it?
> Sarah: "Well I recalled that I needed to press...that LIFT button...that one I've always remembered...a few times [actually twice], and then there is nothing to it apart from pressing up to...you see, I knew we have up to five loudspeakers, right !?...and then I pressed number button 4 and the lights [on the loudspeakers] turned green" [she points to the speakers].

This situation is interesting from a number of perspectives. To start with, when Sarah connects the loudspeakers to obtain surround sound, she starts out by turning up the volume—most probably with the cinema experience as her point of reference for her action. A breakdown occurs as she needs to find the LIST button, with which she is still not confident. This time she refers to it as the LIFT button, perhaps indicating that the term "LIST" does not mean anything to her. Furthermore, the principle she discovered last time in terms of pressing a number corresponding to the number of loudspeakers has now become operational for her as a *why* artifact. In addition, her previous *how* artifact in terms of "something to do with LIST" has now been refined to "press LIST or LIFT a few times." Thus mediated by the learning artifacts shown in Figure 6, Sarah's efforts to obtain the cinema experience in her living room finally bear fruit.

4.4 Six Months after Delivery: The Cinema Experience has Turned into the Concert Experience plus Watching Movies Without Glasses

Interestingly, when we visit Sarah and Paul 6 months after the delivery of their new Bang & Olufsen system, Sarah's use of surround sound has consolidated into a concert experience. Sarah is now fully familiar with the use

where to artifacts
    The concert experience.

why artifacts
    Press number button for number of loudspeakers to be connected.

how artifact
    Press LIST two times for the CD, then press number button 4 to connect four loudspeakers.

what artifact
    The electronic curtains rising and falling.

Fig. 7. Learning artifacts 6 months after delivery: the cinema experience has turned into the concert experience.

of the LIST button, but she primarily uses the surround sound facility when listening to music via the Bang & Olufsen CD player, which is linked to the rest of the system. She has found out that she does not really enjoy watching movies with surround sound on, as she does not like the sudden, sometimes very loud, sounds—for example, those made by a flying object coming from behind her—as reproduced by the cinema experience. At this time, both Paul and Sarah appreciate the use of the wide-screen format, which also formed part of the cinema experience, because it enlarges the subtitles with the result that they do not need to wear glasses to read them.

In terms of learning artifacts, Sarah has now, due to the specific circumstances in terms of her needs and preferences, molded the cinema experience into a concert experience (see Figure 7). The previous *why* and *how* learning artifacts have become refined, and Sarah is generally more confident in the way she handles the remote control. However, she still cannot manage to adjust the format of movies on her own. Paul does this when they are watching movies together.

We find that the experiences revealed by this series of episodes point in the direction of a number of implications for designing home appliances to support development in use. In this case, we saw how the concept of the cinema experience, as it was formed in the shop and sales brochures and triggered by the physical design of the television, guided Sarah's exploration of the Bang & Olufsen television. During her two-and-a-half month struggle to obtain the cinema experience, she repeatedly referred to this vision of future use as the point of reference in her exploration of the television set.

In her exploration, Sarah particularly focused on how to adjust the size of the picture and how to obtain surround sound as the next steps in her process of learning to use the new television. Arguably, the television contained other functions that were also highly relevant to her way of using the television. As an example, Sarah explained that she used teletext a lot, especially to see weather forecasts. Thus the opportunity to access frequently used teletext pages directly was a useful functionality for her—an opportunity that the television set provided. However, she was not aware of this option and the television did not remind her of its presence.

Interestingly, Sarah had some specific expectations about the things she wanted to do with her new television even before the time of installation, that is, before she had interacted with the television herself. In this case, this was

largely due to the learning artifacts in terms of *where to* artifacts introduced during the sales situation through the presentation of the concept and the real-life demonstration of the cinema experience in the shop. Moreover, it was also referred to in the sales brochures. Thus in creating designs to encourage learning through use of home appliances which users buy themselves, this case points to the potential in designing learning artifacts which come into play even before the users lay their hands on the products.

Furthermore, the cinema experience presented in the sales situation was elegantly referenced in the *what* artifact of the electronic curtains, which acted as a constant reminder of the vision of the cinema experience to be pursued by the user.

Our analysis also suggests that one reason for Sarah's problems in obtaining the cinema experience was the lack of support for her interaction with the product in her search for the cinema experience. There was limited support in her progressing from expectations toward accomplishment. Nothing in the design of the remote control or its display supported her in making the connections required to achieve the expected experience.

Furthermore, this case exemplifies Engeström's [1987] argument that the design of artifacts does not prescribe use. As we saw in the example of Sarah's learning progression, artifacts will indeed always be modified and shaped through use, possibly in ways unanticipated by the designers and, as our case clearly illustrates, also unanticipated by users. This case suggests that, by designing *where to* artifacts, we may motivate users to set out to explore the new technology, and, as this case demonstrates, users will then mold their use of the artifact (the television in this case) with respect to their specific preferences, needs, and context.

Notably, it is the flexible design of the link system, linking the different hi-fi technologies in Paul's and Sarah's house together, that allowed Sarah to find new ways of using the system, having realized that she did not like the cinema experience after all.

5. PROGRAMMING VIDEO RECORDINGS—STICKING TO OLD PROCEDURES

The second series of episodes concerns programming video recordings.

5.1 The Installation: Easier Programming of the Video Using Teletext

When the television is installed in their house, Paul explains that he expects it to become easier to program video recording due to the integration of the television and the video recorder in their new Bang & Olufsen system. Paul explains that he has learned from the demonstration in the shop as well as from brochures that all you need to do is to highlight the appropriate program in the teletext display. If the program is delayed, the system will automatically adjust the recording time.

In terms of learning artifacts, the demonstrations of the improved integration between the television and the video exemplified in terms of using teletext to program video recordings leads Paul to expect that the system will be easier

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where-to artifacts
    The expectation of a more integrated system.
    Easier programming of video recordings.

    Automatic adjustment in case of program delays.

why artifacts
    -

how artifacts
    Direct selection of a program in teletext.

what artifacts
    The physical integration of the television and the video into one piece of furniture.

Fig. 8. Learning artifacts at the time of installation: easier programming of the video using teletext.

to operate due to improved communication between the television and video. He is thus supported in forming a general vision of future use, a *where to* artifact, covering the overall expectation of a more integrated system. Finally, the physical appearance of the television, in terms of the integration, acts as a *what* artifact, signaling improved integration and communication between the television and the video recorder. The way the television comes into play for Paul at this time is summarized in Figure 8.

5.2 One Month After Installation: Conventional Video Programming

One month after the delivery of the new television set, Paul still programs the video using the conventional approach of specifying the channel and the planned start and stop times for the program in which he is interested. When asked why he is still doing it this way, he replies that this is the way he used to do it on his old system. Talking to him about this issue, it actually seems that he has forgotten the existence of the new way of programming the video. As Paul is specifying the start and stop times for the program, the television displays a reminder of the alternative programming strategy offered by the system in the form of a textual reference: "Press MENU for teletext programming" at the bottom of the bar on which he is working (see Figure 9). However, it seems that Paul does not notice this reference, and it certainly does not cause him to change his strategy.

Thus the learning artifacts in play at the time of the installation of the television—that is, those suggesting this overall vision of a new way of programming the video—are not active for Paul in his use of the television at this time. Instead, he draws upon his experiences from their previous video recorder, which come into play as a *why* artifact in this case, due to their generality and transferability between different products. However, Paul also has to learn to use the new remote control (it is late summer, and the weather has been so fine that they have not been watching much television). In fact, he has not yet used the option of programming a recording at this time, when he is still learning to "handle" the remote control. The physical design of the new remote control differs from the old one, and he is "fumbling" with the registration of the start and stop time. He uses his understanding from the old system (as a *why* artifact) to guide him through the process of programming on the new system. At the

Fig. 9.   The conventional video programming menu on the television.

where-to artifacts
    -

why artifacts
    Specification of program in terms of start and stop times, date, etc., using the numeric buttons on the remote control
    as known from the old video.

how artifacts
    -

what artifacts
    The menu on the screen and the couple's previous remote control.

Fig. 10.   Learning artifacts one month after delivery: conventional video programming.

same time, he is experiencing the difference at the physical level (*what* artifact) as regards both the shape of the new remote control and the way in which the different elements are displayed on the screen; see Figure 10.

5.3 Two and a Half Months After Delivery: Still Programming the Video in the Conventional Way

After $2\frac{1}{2}$ months, Paul still uses the programming strategy he knows from their previous television. Again, he achieves the task but the way he is handling the situation illustrates that he is not very familiar with programming recordings. He focuses on the remote control and its relationship to what happens on the screen. Interestingly, at one point he accesses teletext to find the right start and stop times to specify in the conventional menu-based programming process, but not even the teletext display is sufficient to remind him of the presence of the teletext programming facility. As such, no change appears to have occurred since the previous visit in how the television acts in terms of learning artifacts Figure 11.

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where-to artifacts
-

why artifacts
    Specification of program in terms of start and stop times, date, etc., using the numeric buttons on the remote control (known from the old video).

how artifacts
-

what artifacts
    The menu on the screen and the couple's previous remote control.

Fig. 11.   Learning artifacts two and a half months after delivery: still programming the video in the conventional way.

5.4 Six Months After Delivery: Remembering the New Facility but Not Using It

At the final visit, Paul is still applying the conventional strategy of video programming. When asked whether he can think of a different way to program the video, he now mentions the teletext programming facility. He argues that since the other, more conventional strategy was mentioned first in the manual, this has been his preferred approach. Besides, he was familiar with this process from their previous video recorder. When we ask Paul to program a recording using the teletext programming facility, he has problems completing it and eventually gives up. Sarah, Paul's wife, explains that during the 6 months they have owned the television, they have used the programming facility approximately four times. They have typically used it when they have been going out, and there were problems with the recordings on every occasion, resulting in parts of the movie or show being cut. Ironically, Paul continues to argue that one of the advantages of teletext programming, apart from the fact that it is easier to use, is its automatic adjustment of recordings in the event of programs being delayed. This means that if he had used this programming strategy, the quality of the recordings would presumably have been better.

We see several possible explanations to this paradox. First of all, the design itself does not contain any reminders in terms of *what* artifacts that appeal to Paul and trigger his knowledge of this easier way of programming the video recorder (*where to* artifact). Apparently, the *what* artifact of the integration between the television and video is not specific or strong enough in terms of reminding Paul of the availability of this possibility.

Second, the textual reminder in the menu bar (the *how* artifact; see Figure 9) does not have any effect on Paul—partly because it is written in English and partly because it does not address the goal that Paul is seeking to achieve when this reminder is displayed. This means that the learning artifacts in play at the time of the installation of the television, which suggested the new possibilities offered by this system, are not sufficiently attractive for Paul to exploit this way of operating the new system. Moreover, teletext programming is generally somewhat concealed in the present design of the television.

Third, when Paul is trying to program a recording, the challenge he faces involves not only learning a new way of doing this, but also handling the new remote control. Again, there is nothing in the general-purpose remote control, nor in the menus on the television that comes into play in the form of *how* and

where to artifacts
   Demonstration of teletext programming facility in the shop allowing Karen to envision her own improved potential
   with the television—that is, being able to program the video on her own.

why artifacts
   –

how artifacts
   Programming a recording by selecting a program directly from the teletext display.

what artifacts
   -

Fig. 12.   Learning artifacts at the time of installation: a new "division of labor" in the family.

what learning artifacts, to follow up on Paul's initial expectations, which were
supported by *where to* and *what* artifacts.

   Fourth, the situations in which Paul has programmed the video to record
have typically been a little stressful. In most cases, he and Sarah had just
dressed up to go out and then a few minutes before leaving they suddenly re-
membered that there is a program they would like to record, and so Paul rushed
into the living room to program the video. In such situations there is no incen-
tive to experiment with new ways of accomplishing tasks, and the speed of
operation becomes the critical factor. Thus the complexity of the learning arti-
fact needs to be designed with respect to the characteristics of the use situation
in which the learning artifact should come into play.

   A final factor concerns Paul's need to deal with the programming of video
recordings. As it is primarily Sarah who wishes to watch the movies afterwards,
Paul has no direct incentive to spend time investigating how to make use of the
new, improved programming facility. The lack of exploitation of the new facility
even after 6 months of use and the problems Paul and Sarah have experienced
are probably due to a combination of—and complex interplay between—the
above-mentioned factors.

6. PROGRAMMING VIDEO RECORDINGS—NEW OPPORTUNITIES

The third series of episodes concerns the programming of video recordings as
it unfolds in the case of the second family.

6.1 Installation: A New "Division of Labor" in the Family

At the time of the installation, Karen explains that she is looking forward to
being able to program the video on her own. Previously, this has always been her
husband's "job." Her expectations stem primarily from the shop, where she was
very impressed by the demonstration of the teletext programming facility. This
demonstration acted as a *where to* artifact in allowing Karen to envision a new
role for herself in the use of the television set within the family (see Figure 12).

6.2 One Month After the Installation: Successful Programming of Video
   but No Need

Karen has not been in a situation where she needed to program a recording
since the time of installation. However, she still remembers the presence of the

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where to artifacts

    Demonstration of teletext programming facility in the shop allowing Karen to envision her own improved potential
with the television—that is, being able to program the video on her own.

why artifacts

    –

how artifacts

    Programming a recording by selecting a program directly from the teletext display.
Pressing the MENU button twice to display the menu bar.

what artifacts

    -

Fig. 13.   Learning artifacts one month after installation: successful programming of video but no need.

---

where to artifacts

    Demonstration of teletext programming facility in the shop allowing Karen to envision her own improved potential
with the television—that is, being able to program the video on her own.

why artifacts

    –

how artifacts

    Programming a recording by selecting a program directly from the teletext display.

what artifacts

    –

Fig. 14.   Learning artifacts two and a half months after installation: fading opportunities.

facility and, when asked to program a recording, she programs the video using teletext without any significant problems. She explains that she remembers the demonstration in the shop, which showed her that she needed to press the MENU button on the remote control twice (see Figure 4) to access the "highlight programming bar," which is a precondition for being able to program a recording. This instruction becomes an ad hoc *how* artifact for Karen in that she remembers this instruction without being able to position it in a more general interaction principle (see Figure 13).

6.3 Two and a Half Months After Delivery: Fading Opportunities

Once again, we ask Karen to participate in a scenario that involves her programming a recording. Karen still remembers that she can use teletext to program the video, but she no longer recalls exactly how to accomplish this. In some way, the previous *how* artifact has faded and there is nothing in the design to remind her of how to do this (see Figure 14). The only way to access the information required is to consult the manual. However, Karen never uses the manual on principle. She believes that "the technology should simply work." Finally, her husband guides her through the task, but even here, there is no recognition or consolidation of the approach she uses.

6.4 Four Months After Delivery: Need for Video Programming but Lost Opportunity

After 4 months of use, the time has come for either Karen or her husband John to record the Christmas series on show every day in December, which their

---

where to artifacts
  Karen expects to be able to program the video on her own thus obviating the need for her husband to program
  recordings for her (demonstration in the shop).

why artifacts
  –

how artifacts
  –

what artifacts
  –

Fig. 15.   Learning artifacts 4 months after installation: need for video programming but lost opportunity.

children like to watch over and over again. Karen therefore makes recordings rather frequently during this period of time. However, as she still does not remember how to use the teletext programming facility, she ends up making direct recordings manually by pressing the RECORD button when she remembers to. This results in her taping a lot of superfluous recordings between the daily shows.

Again we see a number of factors interacting in a complex manner and exacerbating the problems Karen experiences. Interestingly, Karen still remembers the presence of the facility, but again, she seems to experience problems with performing the actions involving the system. An interpretation in terms of learning artifacts could be that Karen is lacking a *why* artifact (see Figure 15). As such artifacts are by nature more general than *how* artifacts, they may prove to be more robust and less prone to fading away as easily as in this situation. Moreover, when Karen was struggling to find the way to use the teletext display to program a recording, there was no visible reminder on the television itself to guide her through the process. As Karen does not use manuals on principle, she was stuck in this situation.

This example further highlights the need for designing with respect to the frequency of use of a facility. In the early stages of use, Karen did not use the video programming facility very often. However, after a period of use, when she suddenly had an incentive to program the video, she no longer remembered to "press MENU twice." Had this been an action she had performed daily, she probably would not have forgotten it despite the fact that it lacked a relation to the purpose of her action or to any *why* or *where to* artifacts active in this situation.

7. CONSISTENCY CREATING CONFUSION

During the second visit to John and Karen, John states that something about the way the teletext programming works confuses him. From the demonstration in the shop, he expects feedback in the form of programmed start and stop times for the recording once the programming has been completed, but this feedback never appears. The problem here is that John confuses two items on the menu with one another (TIMER RECORD and TIMER PLAY; see Figure 16).

On our fourth visit, we return to the discussion of TIMER PLAY and TIMER RECORD, this time revealing the difference to John. John explains that he has

Fig. 16.   The main menu of the Bang & Olufsen integrated television and video.

vague memories of reading about the option of programming the television to turn itself on and off at specific times in the manual around the time when they purchased the television. However, he never pursued this theme. No aspect of the television reminded them of its presence since the term TIMER PLAY never worked as a learning artifact for them.

8. THE NATURE OF LEARNING ARTIFACTS

Before discussing the implications of experiences from our case study for the design of domestic technology, we would like to point out the limitations of our study. The generality of experiences from this case study should be seen in light of the specific domain of home appliances and the limited number of families visited, and of the episodes discussed above. The following conclusions and discussions should therefore be seen as hypotheses for what may constitute important factors in creating designs for development in use.

8.1 *Where* to Artifacts as Guides for Development in Use

In our empirical study, we saw several examples of how the design, when it came into play as a *where to* artifact, served as a guide and triggered the users' exploration of the television. In the story about the cinema experience, we saw how the concept of the cinema experience—as it was formed in the shop and triggered by the form of the physical design of the television—guided Sarah's exploration of the Bang & Olufsen television. During her $2\frac{1}{2}$ months of efforts to access the cinema experience, she repeatedly termed it her "point of reference" in her exploration of the television. Our study therefore suggests that with carefully designed *where to* artifacts, use does not need to "start out

with bloomin', buzzin' confusion" [Carroll and Mack 1995, p. 699]. Instead these *where to* artifacts may sow seeds that users may subsequently develop on the basis of their needs and wishes.

In the stories about how the facility of programming the video came into play in the two families, we see that, depending on the background, adoption process, and life-situation of the users, the same design worked in quite different ways as a *where to* artifact in terms of motivation and visions of future use. Whereas Paul was fascinated by technology that offered greater ease of operation and improved recording quality via teletext programming of the video, Karen, when presented with the same facility, envisioned a new role for herself in operating the technology. She imagined that she would now be able to program the video herself, independently of her husband, who had previously done all the programming.

These two cases also differ with regard to use over time. To start with, Karen actually managed to use the new facility, but for reasons which we will discuss below, this ability faded with the passing of time. Paul, on the other hand, spoke excitedly about the facility in the beginning, but never actually managed to make use of this facility during the 6 months of the survey. In these cases, the design of the system in terms of the integration of the television and video recorder into one system, and the radical new way of programming the video, worked well as a *where to* artifact. The subsequent disappearance of the awareness of and the ability to use the opportunity seems to have stemmed from other factors, as discussed below.

This case study thus makes clear how positioning *where to* artifacts in context allows us to consider expectations of a more emotional and visionary character than is conventionally considered in cognitively inspired usability evaluations. These are typically more concerned with how the design of the technology actually supports the goals of the users (the action level; cf. Figure 1) [Kaptelinin 1996]. Furthermore, as argued by Engeström [1990], the long-term projection into the future offered by the perspective of *where to* artifacts is not normally considered part of system design. In this study, we point out how the long-term development of use is also an important matter for understanding the usability of a product.

Interestingly, our study suggests that *where to* artifacts may be a powerful resource in creating designs for development in use in that they help users identify their motivation for using an appliance, which may thus encourage people to explore the capabilities of a product in specific directions. We believe that by analyzing and designing in terms of *where to* artifacts, we may answer some of the criticism presented by Blyth [1999] and others. Blyth [1999, p. 44] argued that "designers tend to think about consumers in a rather narrow way. They are strongly inclined to see consumers as economic entities with clearly definable needs. Instead, in the words of the sociologist Bourdieu, designers ought to think of themselves as 'cultural intermediaries'—playing an active role in attaching to products particular meanings and lifestyles with which consumers will identify." As we have seen, people begin using appliances in different ways, depending on how they identify and see themselves in the visions stimulated by the products. For instance, Karen saw an opportunity for herself

in her perceived ability to program the video on her own, whereas Sarah, with her background and experience with technology, did not see a role for herself in this respect. Thus we find that the actual use of the technology occurs via a complex interplay between the design of the technology, the users' backgrounds, their previous experience, their needs and goals, etc. In line with Engeström [1990], we do not believe that the final goal should be to design for predicted ways of using and adopting the technology, nor do we hope that this will be the case. However, we find that the design of *where to* artifacts helps users to identify directions of use along which they wish to set out, or in Blyth's [1999] words "with which they identify." Users will then inevitably find their own paths in accordance with their own needs, situations, and backgrounds.

Nevertheless, this is not the whole story. Our case study reveals that users still have problems in achieving their expectations in spite of successful *where to* artifacts. The framework of activity theory provides a basis for discussing why this happens, in that it provides a perspective which relates the discussion on *where to* artifacts to more detailed aspects of the interactive design and physical design of the technology through the *why*, *how*, and *what* artifacts. This is discussed in the following section.

8.2 *Why* Artifacts Provide Robustness and Consolidation of the Interaction

Our study points to the fact that, on the one hand, *why* artifacts support the robustness and consolidation of the interaction. In the example of the cinema experience, we saw how Sarah was struggling to establish an understanding of the general interaction principles of the product—the highly modal design of the remote control, for example—and how she made some discoveries during our interview with her husband. Thus, in her case, it was not the design itself that revealed to her the principles she required. In the cases of video programming, we see a striking absence of *why* artifacts. In Karen's situation, her ability to program the video diminished, and after $2\frac{1}{2}$ months she was unable to use the teletext display to program the video despite her need to do so. Our analysis suggests that part of the explanation of this is that the previous *how* artifact "press MENU twice" had faded away in her use of the TV, and there was no general principle in the form of *why* artifacts nor any other immediate clues in terms of *what* or *how* artifacts to support her in reconstructing this artifact. In contrast to this situation, when Sarah was asked to discuss how she would connect surround sound in the case of the television (even though she primarily used this feature with the CD player), she was able to infer from the general *why* artifact "press the number button for the number of loudspeakers required" that she needed to press the number button 5 to connect surround sound for the television (where the TV loudspeaker was included). This contrasts with pressing the number button 4 in the case of the CD player. Similarly, when Sarah had identified the general principle of the modality of the remote control, and had established that the current mode was always indicated in the display on the remote control, she was able correct her own behavior. This happened in a situation where Sarah wanted to connect the loudspeakers, and her first attempt was unsuccessful. She tried once more—looking at the

display to ensure that she had accessed the correct mode—and this time she succeeded.

These studies thus suggest that *why* artifacts in the form of general interaction principles—or, in Paul's words: "the logic behind"—strengthen and consolidate the users' way of operating the technology. However, creating designs for these artifacts represents something of a challenge. Consistency in design could be one approach, although, with our interest in the development in use, we need to understand how people actually identify these consistencies in order to understand how we can use design to support this process. Our study revealed the fact that those who referred extensively to the manual often identified *why* artifacts in this way. As an example, Paul identified the principle of "press the number button for the number of loudspeakers required" in this way. A second approach to designing *why* artifacts involves making the visual layout of the screens in submenus consistent. However, in some cases this resulted in the users erroneously perceiving themselves as doing one thing while they were really doing something very different. This happened in the final series of episodes reported, when John programmed the television to turn on and off at specific times, while he actually thought that he was programming the video to record during a certain period.

8.3 *How* Artifacts Providing ad hoc Guidance

Viewing the mediation of the Bang & Olufsen television in terms of *how* artifacts, we find that the names of the menus—which could potentially act as *how* artifacts—often fail to come into play as such. One example of this is John's confusion between TIMER RECORD, which allows users to program the video to record at specific time intervals, and TIMER PLAY which provides a facility for programming the television to start and stop at certain times. We see other examples where designed *how* artifacts, for example, small help prompts, were overlooked or not perceived as meaningful in the situations for which they were intended. This happened in the case of Paul, who continued to program the video in the conventional way, even though a message appeared on the screen reminding him of the opportunity to program the video using teletext (see Figure 9).

8.4 *What* Artifacts Materializing Learning Artifacts

The role of a television in terms of *what* artifacts is the story of how the television restricts the interaction, and how it physically meets the user. Our experiences suggest the importance of learning artifacts to be materialized as *what* artifacts. In the case of the cinema experience, the *where to* artifact presented in the sales situation was elegantly referenced in the *what* artifact—through the electronic curtains that acted as a daily reminder of the vision of the cinema experience to be pursued by the user (see Figure 2). However, we also find examples where missing *what* artifacts may have played a role in eliminating intentions. For instance, when, during our second visit, we talked to Paul about the feature of programming the video using teletext to which he and Sarah had referred at the time the new television was installed, it turned out that at that time he did not recall the existence of this option. In terms of artifacts, this possibility

was referred to only vaguely as a *what* artifact through the physical integration of the television and the video into one product. However, this abstract representation and expectation of "easier programming of the video" was possibly too abstract to act as a trigger for the option of programming the video using teletext. Thus our study suggests that, when learning artifacts are placed in context and materialized specifically as *what* artifacts, which can act as a visible reminder, they become points of reference in the process of development of use.

9. IMPLICATIONS FOR DESIGN

9.1 The Design of Learning Artifacts at All Levels

When establishing the four kinds of artifacts—*where to*, *why*, *how* and *what* artifacts—Engeström [1990] argued that the context of the artifacts should be positioned both upward and downward in such a way that they are represented in all four forms. In adopting these artifacts as learning artifacts for analyzing how development in use is supported by the design of technology, our experiences suggest that a similar recommendation seems appropriate in this area. From analyzing our study, we can see why Sarah had problems accomplishing the task of turning on the loudspeakers in the surround sound system to establish a surround sound experience, since she lacked some learning artifacts on the intermediary *why* and *how* levels. Only when we created a somewhat artificial situation, where we asked her husband to explain how he did the same task, did Sarah discover an essential *why* artifact which later enabled her to successfully reach her goal. Our analysis suggest that this, in some respects simple interaction principle of pressing a number for the number of loudspeakers required, was not intuitive to Sarah. The design itself did not help Sarah to understand it, and Paul, her husband, only knew it because he read about it in the manual.

A further example of this is revealed in Karen programming her video via teletext. To start with, she had no problems with this process, but as time passed the *how* artifact "press MENU twice"—which enabled her to accomplish the task—diminished, and as nothing in the television itself (a *what* artifact) or any general design principles (a *why* artifact) were active for Karen in her use, there was no firm foundation for her ability to exploit the new facility, and we saw it fading away over time.

As we see it, the challenge is thus to design learning artifacts at all levels and preferably as close to the product and the sales situation as possible. In the cases of Sarah and Karen, we never saw any evidence that they consulted the manual and used this as a learning artifact.

9.2 Coherence Among Artifacts at All Levels

In addition, our study provides some indication that the interplay and contradictions between the different levels of artifacts may contain openings for design or for redesign. Ideally, coherence between the artifacts at the different levels would support the users in embodying learning artifacts at all levels. In episode 1, we saw that there was no way in which Sarah could establish a

reference between the cinema experience and the LIST button on the remote control in the form of *why* or *how* artifacts. Thus, in Engeström's [1990] terms, positioning artifacts in context at different levels seems to be an important design goal when designing for learning by use. The predominance of the cinema experience as expressed by Sarah suggests that in our case a more task- or experience-oriented design of the remote control, that is, representing *why* and *how* artifacts in these terms, could be an interesting path to explore. To express it differently: conflicts between the different levels as identified through evaluations of the design constitute openings for design modifications.

Another example was revealed in episode 4, where John misunderstood the differences between programming TIMER PLAY and TIMER RECORD. This may be explained by the use of a foreign language, but there may be another explanation. On the one hand, the interaction was designed in a way that allows the user to program a video recording and to program a start time for the television in the same way. There is consistency in the design of the interaction, in that the same principle was used in the two situations. However, we also see that John may have needed some kind of reference to tell him that he had accessed the wrong mode or part of the menu. He needed some indication of the difference. Actually, he did remark that something was different, but this difference was not strong enough to make him investigate whether something was wrong or not. In relation to our discussion, the problem may be that he needed a stronger *what* artifact indicating the difference between these two functions. The point in relation to design is that consistency in the design of *how* and *why* artifacts is appropriate, but there should also be references marking the differences at the *what* level.

9.3 The Transformation of Artifacts

In the cases described above, we see how learning artifacts are not static but develop, become modified, and fade away over time due to factors both inside and outside the design.

In the example of Karen, when her *how* artifact "Press MENU twice" was removed from its context, it faded away as it was hard to relate to any of the other learning artifacts of this situation. Furthermore, since she had no need for this facility to start with, she used it very rarely. Paul's initial vision of the easier way of programming video recordings also faded away over time, probably because of a combination of limited need and limited reminders, in terms of *what* artifacts, of the presence of the facility. In the cinema experience example, Sarah continuously refined her *how* artifact through her exploration of the television. She started out with a vague idea that, in order to connect multiple loudspeakers to obtain surround sound, she needed to do something with the LIST button. Through her exploration of the television, and through overhearing our interview with her husband, she laboriously refined this into the idea that she needed to press LIST a couple of times.

As argued previously, our goal is not to prescribe use nor development in use through design. In our study we saw examples of how use, although being triggered by the visions expressed in the design and the sales situations,

actually ended up as something totally different once the vision was realized and adopted into the context of the specific users and their needs and in the specific settings of use.

We saw an example of this in the case of Sarah's initial expectations of the cinema experience finally transforming into a concert experience. It is important to note that the transformation of the cinema experience into a concert experience in this situation was made possible only by the flexibility of the interlinked technology of their home, that is, the surround sound equipment that could be used with both the television and the CD player. As pointed out by O'Brien and colleagues [1999], flexibility of technology is an important design criterion for domestic technology. This case confirms this finding and also suggests that, in the interest of supporting the learnability of domestic technology, it is important that the design of the technology offer itself to the user—in the form of visions of future use—as *where to* artifacts, which users may react to, identify with, discard, or pursue and mold according to their specific situations, interests, and needs.

9.4 The Context of Learning in Use

In addition, our case study points to the importance of considering the context of learning in use. It is not enough to be motivated to learn: users have to be in a situation where the conditions support the occurrence of learning. As an example, we heard about Sarah, who learned how to access the surround sound feature by using the CD player. Sarah stated that she used the manual if there was something she needed to find out, but when visiting the family we did not see her use it nor did we hear her talk about using it in specific situations. What we found was that she was driven by her motivation to hear music. Having learned a principle of interaction from her husband, she used this general principle one afternoon to find out how to obtain surround sound from the CD player. Sarah was in a situation where she had the time to experiment with and explore the technology on her own.

In the case of Paul programming the video recorder, he still used the "old procedure," and although he was aware of the teletext programming option, he did not use it. His wife explained that he typically had to program the video when he was in a hurry, on the point of leaving the house to visit friends, for example. Paul's strategy for learning new ways of using the television typically involved reading the manual. He read the manual and followed the processes described. Naturally, he did not have the time to do this when he was about to leave the house, but why did he not learn it some other time? An explanation could be that he was not motivated. Part of the explanation is that it was Sarah who wished to see the program being recorded, but she did not set out to record it herself. Her unwillingness to do this outweighed the fact that the recordings were incomplete all four times Paul programmed the recorder on the new television.

In another case, which we have not reported in this article, John described a situation where he came home from work and one of this children showed him a teletext feature that allows users to recall predefined teletext pages. He

investigated how he could program the system to open on predefined pages. He sat on the sofa, read in the manual, and found out how to do it. He took the time he needed.

One point of this discussion may be that learning by use is more likely to occur if it is driven by motivation (an active *where to* artifact). Another could be that learning by use is not always possible. If users are under pressure of any kind, they will handle the situation in a way they think they know. This is particularly the case if the preferred learning strategy is reading a manual, as in this case users have to arrange a situation for detached learning.

The implications of these aspects for design are that designers should reflect upon which learning strategies different designs support as well as the connection to the potential situation of use.

9.5 Learning Artifacts Both in and Around the Product

In conclusion, our study suggests that, at least in the case of home appliances, there is potential for designing learning artifacts both in and around the product itself. Our study points to how the process of development in use starts even before users start utilizing the product itself, provided that the resources for design outside the artifact *per se* are exploited, as they were in the case of the Bang & Olufsen television we studied. We have seen how, at the time that product was installed, the users already had some specific expectations of the things they wanted to do with their new Bang & Olufsen systems. Sarah looked forward to the cinema experience, Karen envisioned being able to program the video independently of her husband, and Paul looked forward to exploiting the easier way of programming the video and to watching movies in wide-screen format with surround sound. These expectations were largely due to the learning artifacts in terms of the *where to* artifacts introduced in the sales situation through the language used and experiences provided, to which the sales brochures also referred. Furthermore, the manual played a role in supporting two of the four users in achieving the experiences they chose to pursue.

Thus, in creating designs for appliances that users buy themselves, there is a potential in designing learning artifacts that come into play even before the users lay their hands on the product, through considering the presentation and demonstration in the shop, the design of sales brochures, and the design of manuals. When well designed, the learning artifacts are followed up and referenced by the design of the technology itself, creating coherence that provides users with an image of the experiences available through the new technology, and that allows them to pursue their own paths of development in the use of that domestic technology.

10. CONCLUSION

In the particular setting studied, we have documented how a technological artifact like a TV set is appropriated and how the use of technology involves a process of evolution. We have highlighted how learning artifacts guide development in use and how artifacts may consolidate the use of technologies in different ways. Moreover, we have demonstrated how activity theory may be

productive in terms of formulating a set of design recommendations including the notion of designing different kinds of learning artifacts as part of designing a technology. These artifacts need to be coherent and designed with respect to the context, and designers need to be aware of the resources outside of the product itself when designing for development in use.

In work contexts of technology use, it is generally acknowledged that use changes, though often only slowly, and it seems obvious that similar studies like the one we have conducted should be conducted in workplace settings in order to find better ways of supporting development in use there. Many of the characteristics of home information technology (IT), for instance, being shared and being integrated parts of physical devises with unique kinds of interfaces, are becoming important characteristics of IT at workplaces, in particular outside the office environment. Given, for instance, the privacy issue of the home, the specific methodological approach will most likely be different in a workplace context, but many of the issues concerning development in use will be similar.

When it comes to products for the mass consumer market, like interactive TV and Internet appliances, it is particularly important to consider the motivational factors as reflected by *where to* artifacts, not in isolation, but in conjunction with way people may interact with the technology, including the physical form of the product. The concept of motivation refers in this context to the reason to buy a product in terms of the user need it fulfills. Our study suggests that one product fulfills several different needs and that motivations are created and modified through extended use beyond the messages communicated through marketing and sale. This nature of motivation and product identity seems to be new to some strands of marketing. The implications of this are worth studying in the future.

New usability issues are emerging for the design of a vast range of novel technologies—for example, handheld devices, technologies with embedded software, mechatronic products (i.e., integrated mechanical and electronic products), and game machines—which all challenge how to support development in use. We suggest an awareness of the physical characteristics, the interaction principles, and the motivational factors of these new technologies, as illuminated by the categories of learning artifacts presented in this article, as the way to move usability from design for snapshots of use to design for development in use.

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