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Beyond the Interface: Encountering Artifacts in Use

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"Strictly speaking, nothing is a tool unless during actual use."

"The essence of a tool, therefore, lies in something outside the tool itself. It is not in the head of the hammer, nor in the handle, nor in the combination of the two that the essence of mechanical characteristics exists, but in the recognition of its unity and in the forces directed through it in virtue of this recognition. This appears more plainly when we reflect that a very complex machine, if intended for use by children whose aim is not serious, ceases to rank in our minds as a tool, and becomes a toy. It is seriousness of aim, and recognition of suitability for the achievement of that aim, and not anything in the tool itself that makes the tool."

(Samuel Butler, Notebooks)

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Prolegomena

This paper is written by two people who come from rather different backgrounds, yet who, at the same time, share similar concerns about the human - computer interaction (HCI) area. One of us has a background in computing and cognitive science, coupled with a long-standing interest in helping users in their interactions with technology. He became uncomfortable with the gap between current cognitive theories and their utility in designing better interfaces to computer systems. The other person has a background in software engineering and computer systems design. In her search for a deeper understanding of issues in HCI, she came across the cognitive science framework, but she too felt that its methods did not provide much help for concrete design in real life situations.

In many ways our personal histories reflect some of the developments within the HCI area - the search for more theoretical frameworks, and the subsequent realization of the gap between current theoretical formulations and actual situations of use. We can be seen as both insiders and outsiders to the mainstream, primarily Anglo-American, HCI - cognitive science tradition in several respects: one of us is trained in cognitive science, one is not; one did studies in Scandinavia, one primarily in North America.

As both of us are concerned with making more useful and usable computer applications we decided to look further for frameworks to help us. In this paper we shall try to expose some of the problems that we encountered in our joint effort to understand the HCI area and contribute to it, and to discuss some of the tensions and alternative viewpoints that we met on the way. The paper does not contain a solution to the problems of HCI. Rather, it contains a dialogue with ourselves about the matters of our concern, and we invite the reader to join this dialogue: our focus is on technology in use, where we emphasize the setting in which a piece of technology is used. We do not think that artifacts per se can be usefully studied in isolation. They need to be studied in their use settings. These use settings are developed over time - historically - they are not static and unchanging. For this reason the history of technology as well as of the organization of work become very important to us when we consider the (re)design of computer artifacts for people. What we do here is similar to Christiane Floyd's enterprise in her paper on software engineering perspectives. She invites us to join her in a comparison of what she identifies as two perspectives in software engineering, and a discussion of the limitations as well as the utility of these differing perspectives. We do not think that it is possible to uniquely identify the voices raised in this paper. They are all of us, or part of our mutual discussion. We invite readers to share with us their experiences in the field, their practice, and any examples of how theory has influenced their practice.

1. OUTLINE OF PAPER

In this paper, we provide a brief overview and critique of the descriptions and concepts that are currently used in the HCI area coming primarily from the cognitive science tradition, as they seem to embed within them certain assumptions which are overly limiting. Then we look at some recent arguments for re-organizing our conception of the field, or extending the field, coming primarily from within the field itself (as presently constituted). Section 4 then presents a more elaborated "activity-theoretical" framework as one possible alternative, or perhaps complementary, framework that may give a richer depiction of the HCI field. In Section 5 we return to look more specifically at the different theoretical viewpoints, especially in regard to their re-framing of issues in the field, relating the different emphases to another field, software engineering. This section tries to summarize some of the main points made in the paper in a form that can serve as a basis for future discussion.

2. SETTING THE SCENE: THE CURRENT FRAMEWORK OF COGNITIVE SCIENCE AND HCI

2.1 The Current State of Cognitive Theory

Over the last 30 years, the dominant view of human nature portrayed in psychology and allied disciplines, at least in the English-speaking world, has been a *cognitivist*, rather than a behaviorist, physiological, or phenomenological one. Cognition is seen as "information-processing psychology". People are regarded as "informavores" to use George Miller's term, and the study of human thinking and problem solving is commonly regarded as being concerned with representations in the head and the processes that run over them.

The idea of a distinct multidisciplinary research programme labelled Cognitive Science has a somewhat more recent origin, though its principal proponents come from within the cognitive psychology discipline, with some support from artificial intelligence research, linguistics, and philosophy. Although other disciplines such as anthropology, sociology, and neurophysiology are also mentioned, their influence has been marginal. Enough authors have been exploring this field of Cognitive Science recently that we can simply quote a spokesperson for this new field. Bernsen (1988) talks of this discipline as follows: "*It consists in the general idea that intelligent agents should be looked upon as information - processing systems, that is, as systems receiving, manipulating, storing, retrieving and transmitting information.... A central tenet is that there exists a level of description of intelligent systems at which the organization and use of knowledge is described functionally in computational or in-*

formation processing terms independently of the nature of the physical implementation of the system."

From this definition we see an emphasis on a multidisciplinary activity, spanning a wide variety of fields, that has supposedly in common an interest in the study of intelligence, and mechanisms whereby it can be realized, whether in natural or artificial organisms. Thus a key idea is the essential similarity of processes that are behind human and artificial "reasoning". Pylyshyn (1984) is most explicit about this: "...my proposal amounts to a claim that *cognition is a type of computation*" (Preface, pg xiii) (our italics). This view has lead many researchers in the field to build computer models of human thought processes that are taken to be strongly equivalent to the actual processes that are used by people in their comprehension and understanding of the real world.

A number of people from within the cognitive science community have admitted there are problems in the cognitive science approach as outlined above. Donald Norman, one of the pioneers in the field, as early as 1980 wrote a paper that outlined some of the shortcomings of the newly-formed cognitive science "discipline" (Norman, 1980). Despite the fact that the paper was written almost a decade ago, we think it is well worth re-visiting today, to look at some of the questions raised, as many of these issues have not been satisfactorily addressed by current cognitive science theories.* Norman's paper argues that the human information processor is an animate organism and that this places constraints on what kind of cognitive system we have evolved. In all likelihood this natural cognitive system will thus be very different from the kinds of AI models we have been building to represent human thinking. In discussing his growing dissatisfaction with the model human information processor which lies at the heart of the cognitive science tradition, he notes: "*The problem seemed to be in the lack of consideration of other aspects of human behavior, of interaction with other people and with the environment, of the influence of the history of the person, or even the culture, and of the lack of consideration of the special problems and issues confronting an animate organism that must survive as both an individual and as a species...*"(pg.2). Despite this admission, the rest of the paper does not really develop these themes. However alternative materialistic theories of human and societal development exist that *do*

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* Norman has recently returned to this issue with a paper at the 11th Cognitive Society Conference (August, 1989) entitled "Four (More) Issues for Cognitive Science"- viz: connectionism, the relation to biological and clinical issues, the role of applied cognitive science, and the deficiencies of a disembodied theory of cognition. We do not have the space to go into these themes here, but the last two show a continued shift towards a more central role for social and environmental influences on cognition. See also his paper in this volume.

take these issues into account (see, for example, Section 4 of this paper), but such approaches, with a couple of notable exceptions (e.g. Wertsch, 1985, Cole et al. 1978) have not had much support within the academic cognitive community in North America and England.

A common reply to this call for a richer understanding of human cognitive functioning from others in the community has been to claim that we can't study everything at once, that we have to decompose problems, and simplify situations so that the power of our experimental methods can be brought to bear on these issues.The importance of actual practice is not recognized, the individual is still set up against the social, much cognition is still regarded as "in the head", and the laboratory is still seen as the appropriate place to learn about how people understand and act in the world. We continue to parcel out aspects of "problems" as defined by the traditional disciplines, to different disciplinary studies, in an effort to "divide and conquer". The argument we wish to make is that our most widely accepted methods for "carving Nature at its joints" have hacked our "person acting in a setting" (Lave, 1988) into a disembodied ratiocinator that bears little resemblance to a person acting (often co-operating with others) in a situation in the world, which is what we wish to understand.

Exemplars of the kinds of problems investigated by the psychological research community in this tradition concern laboratory investigations of puzzles, games, etc (Newell & Simon, 1972). Their "protocol analysis" research methodology, involving subject's talking aloud during the problem session, provides a rich corpus of material from which the subjects representation of the problem, and steps in solving the problem can be deduced. However, these studies tend to analyze the individual without reference to their community, or their history, performing on a task designed by the experimenter in an unfamiliar environment. The "problem" is defined and valued by the experimenter, not by the subject, who is then expected to perform in certain ways. In some experimental manipulations, even the very nature of the task, or the required behavior, may not be clear to the subject. The question of how "subjects" make sense of the game in which they are playing, trying to discover the "rules of the game" i.e. what the experimenter is after, is often not explicitly discussed in these studies. Performance is measured relative to a certain "ideal", rational model of problem-solving, and the deviations of subjects from this abstract logic is noted.

It is presumed that the fundamental mental mechanisms posited to underlie human behavior in such prescribed domains can later be extended, without major modification, to more real-world activities. So the assumption is that "problem-solving" is a generic cognitive activity which has a similar form across a wide variety of domains, from acting in a psychology experiment to everyday cognitive activities. It is also usually assumed, implicitly, that this activity is located "in the head" of the individual. These assumptions, which have been continually rejected by certain "borderline" groups, have once again come under serious attack from a variety of researchers. (For a major critique of the framework surrounding much experimentation in human-information processing psychology, see Lave, 1988). Our purpose in this paper is not to develop these arguments as to how the accepted paradigm is flawed, but rather to note that this conceptual framework has often been imported into the applied cognitive research on human - computer interaction without question, limiting the utility and usability of many HCI studies that are grounded in these assumptions. To the extent that mainstream theory does not give an adequate account of how people think and act in the everyday world, basing the design of artifacts on such limited research studies may not be the most fruitful approach to adopt.

Concern for a more integrated, holistic approach to human thought and action in the world has lead some people to search for a different theoretical framework as the basis for our experimental and observational studies. Some psychologists have found inspiration in the materialist philosophy expounded by Marx and Engels that emphasizes praxis as the basis for human development. The work of the Russian psychologists Vygotsky and Leontiev are examples (Vygotsky, 1978, Leontiev, 1978, Leontiev, 1981). In this paper, we will try to say a little more on some of these issues. However, before presenting this framework, let us investigate how the cognitive science tradition has influenced the applied field of human-computer interaction, as it is this topic which we wish to develop through theoretical reformulations.

2.2 The Field of Human Computer Interaction

What constitutes the field of Human-Computer Interaction (HCI) ? Our concern stems from the problem of where the boundaries of the field are, or should be, and why it might be of importance (Bannon, 1985). The HCI label appears to be self-explanatory, i.e. anything to do with *people interacting with computers*, yet it has been interpreted more narrowly as simply the study of user interfaces, which seems an extremely limited view. Carroll & Campbell (1989) discuss a number of claims as to what HCI is, and end up with the claim: "*HCI exists to provide an understanding of usability and of how to design usable computer artifacts...*". We support this switch from viewing HCI as a domain, to thinking of it as more of a design discipline that has as its goal the provision of more usable (and hopefully useful) artifacts.

From the point of view of the software practitioner, or designer, in the workplace today, HCI is often viewed as the province of human factors, or ergonomics personnel, who might be involved in user task analyses and perhaps later in display and layout considerations. Within this framework certain design guidelines might be taken into account, and basic physiological and perceptual capabilities of the person recognized as forming constraints on the ultimate system. But this role of traditional human factors is very limited. Research emphasis is on evaluation of existing systems, and not on supporting the whole process of design, or suggesting new designs.

A more recent view, as shown in the development of the Xerox Star system, is to involve people concerned with human-computer interaction from the outset of the design phase. Rather than the interface being an afterthought, it is seen as an integral part of the whole system, determining the whole design. "*We have learned from Star the importance of formulating the fundamental concepts (the user's conceptual model) before software is written, rather than tacking on a user interface afterward....It was designed before the functionality of the system was fully decided.*" (Smith et al., 1982) They also note "*..the crucial importance of a task analysis — the analysis of the task performed by the user, or users prior to introducing the computer system. Task analysis involves establishing who the users are, what their goals are in performing the task, what information they use in performing it, what information they generate, and what methods they employ.*" (Smith et al., 1982). Such task analyses do not always appear to be successful, and the standard acceptance of the utility of task analyses in the design of computer systems has been questioned by many researchers on systems development, particularly in Scandinavia (Ehn & Kyng 1984, Bødker 1987). Since the issue has theoretical as well as practical ramifications, we will pursue the topic briefly here.

A Critical Look at Task Analysis

Task analysis, as it has traditionally been conducted in HCI, as well as in traditional systems design more generally, is based on the idea that a description, containing all necessary information to build the computer application, can be made of the sequence of steps that it takes for a human being (in interaction with a computer) to conduct a task. This task analysis contains a detailed description of each step of the individual user's interaction with the computer application, e.g. as inputs and outputs.

Similarly, in traditional systems design, the total information processing of the organization is described this way. What we often hear, when a computer application fails to function according to the needs and wishes of the users, is that the initial task or flow analysis was "not good enough". In our experience there is always something more that ought to have been included. Therefore, we might ask ourselves whether it is the very idea of making these kinds of specifications that is the problem (see Ehn & Kyng 1984, Bødker, 1987) rather than inaccurate or incomplete analyses*. The major issue is exactly *what* we can describe in such a description, a problem that has different impacts in the design process. When we make task descriptions we make observations or perhaps interview workers about what they are doing. In the first case we often make observations without knowing the *practice* that we are studying, and in the second we capture people's *explicit knowledge* (breakdown knowledge in Winograd & Flores' (1986) terms). In neither of these cases are we capable of catching the tacit knowledge that is required in many skilled activities, or the fluent action in the actual work process, i.e. *we believe that we will never be able to give a full description of a task*. Nor can we ask the person to predict how she might act in a possible future situation. She will not know until it is done; it is, if you will, "triggered" by the actual conditions met at the moment of acting, by the meeting with the real environment, not by any quantifiable set of conditions determined beforehand.

Even though it is possible to get to know something about the tacit knowledge of a person for certain purposes, neither the person herself nor any observer can predict which knowledge comes into play in a specific activity of use. This means that when we make task descriptions they will only be of future explicit - but not tacit - knowledge. Even these descriptions are problematic, however, as often the users often can't understand their own work from these descriptions! In the UTOPIA** project in the early 1980's, for instance, we spent several hours explaining WYSIWYG computer text composition to a typographer (we of course didn't have such a system available), who was otherwise well trained in computer-supported composition. After several hours he remarked that we had just forgotten one thing in our presentation: what did the formatting codes that went into the file look like - totally missing the most important point about WYSIWYG - that the codes were not there at all! Similar observations have been made by many people who work with user interface design, e.g. Wasserman (1981), who suggests that users try out *prototypes* to experience what the design is about. At the same time, Wasserman's idea is to do separate design of the user

* Critiques of task analysis can be, and partly have been, made from different theoretical platforms: Ehn (1988) makes a critique based on the Wittgensteinian ordinary language tradition, Bødker (1987) from human activity theory. These analyses have been inspired by Winograd and Flores (1986) among others.

** This project was concerned with the development of quality computer tools to assist graphics workers in laying out text and graphics for full-size newspaper production.

interface, once the functionality of the system is established. This, we find, introduces yet another problem which will be discussed in the following.

The problems of Separating the User Interface from the Application

Wasserman's way of doing design is one contribution to the larger question: According to what principles should user interfaces be designed, and who should do the design - software engineers, psychologists, perhaps the users themselves? Some have argued for the need to separate the interface design, for consistency and efficiency reasons, from the rest of the design, and perhaps hand it over to user interface specialists (see e.g. Draper & Norman, 1984). On the surface this might have certain advantages. One could concentrate expertise about human-computer interaction, one could ensure a consistent interface across applications, one could experiment with a variety of interface styles without affecting the functionality of the system, etc., but there are serious dangers to it, as we are now beginning to realize.

What makes a good interface, viewed from the user's side, is often the fact that there is a good conceptual model behind the system that is made apparent in the system image (Norman, 1986). This requires a good understanding of the task domain for which the application is being developed, and for how users currently conceptualize the domain. Getting this part of the design right is the key to a usable system. A danger is that "user interface experts" may not have the required domain knowledge to be able to form these good domain models, and spend their time on much narrower issues, such as dialog style choices, etc. *Good design should come from an understanding of how the application will be used* and thus there is a danger in further separating the application designer from the user, which could be the logical outgrowth of the approach favoring separability.*

Designers of User Interface Management Systems (UIMS's) are also becoming aware of problems in the separation of the interface from the semantics of the application. The issue is that we may neglect the importance of the semantics of the domain in determining how the interface needs to be, and concentrate on lexical and syntactic features that are (to the user) not as important (see Bødker, 1987, & Tanner & Buxton, 1984). An experience from the Utopia project (Ehn & Kyng, 1984, Bødker et al. 1985) illustrates this: In the page make-up tools designed by the UTOPIA project, the following examples of requirements for the computer application were given:

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* As we will see, an activity theoretical framework supports the notion that the application should determine the interface, which is the point argued here.

1. Text can be represented as characters if the font size is over 14 points, otherwise it is to appear as gray lines on the screen.

2. The page is to be shown in a limited number of distinct reduction/magnification scales. (This is intended to help the user judge the appearance of the page on the basis of what can be seen on the display screen)

3. An article can be placed on the page ground in a variety of ways. The user can use a new kind of tool, the "ruler", which allows the text to "float" into the empty space on the page under direct control of the user, or use various kinds of "paper paste-up" techniques.

Requirements 1-2 above are clearly about the interface. At the same time, they have strong implications for which functions the typographer has to do, using the tool, e.g. whether he can do proof-reading of text at the same time as he is working on the overall page. Requirement 3 is apparently about functions. At the same time, if we did not apply some kind of direct manipulation interface, the first of the mentioned functions in 3 would not be possible. The design of functions and the interface cannot be separated from each other in this example. And similarly, the hardware and software choices are equally important.

There is a lot of talk about the user interface, but what exactly *is* the interface? Where do we draw the boundary? We allude to this in the title of our paper - *Beyond the Interface*, as the goal of building usable systems may be better served by focusing on the task domain, and not on the details of the interface per se.* Being provocative, perhaps the very concept of HCI as a distinct topic or discipline concerned with user interfaces needs to be re-thought, and emphasis moved from surface similarities of systems, in terms of interaction style, to understanding their use! Are there ways, in what is currently considered HCI, of achieving this?

3. Reframing HCI Issues from Within

In looking at work that falls under the HCI label, we can see a number of different premises, not always articulated. The HCI area can be seen as an applied domain for the testing of general cognitive theories. The focus is on the theory or model, rather than on building better interfaces *per se*. Other researchers, especially those in com-

* Interestingly, Rosson, Maass, and Kellogg (1988) in their interview survey of software designers quote some designers angrily replying to this question of interface separability, as follows: "never separate the user interface and the rest of the application. There is no module for the interface, that's stupid...the computer should never make the user feel that there is something between him and the things he is dealing with".

mercial settings, are more driven by applied concerns, and wish to make a difference in our design of interfaces now, whether or not there is a clear "theory" behind the changes. The idea that solid theory spills down into applied practice, a not uncommon belief, has been shown to be quite untrue for many domains (see Carroll, 1989, for examples). To date, the HCI research contribution has been more to criticize current design practice for not paying enough attention to users e.g. Gould & Lewis (1985), or to offer rather general and often not very usable guidelines, e.g. Shneiderman (1987), Rubinstein & Hersch (1984), or to speculate on alternative ways of doing things in HCI without much practical grounding (e.g., many of the articles in Norman & Draper, 1986).

It is generally accepted today that "*Design is where the action is*" to quote a memorable phrase of Allen Newell's. This is echoed in a comment by Carroll & Campbell (1989): "*..impact on design practice is the touchstone of a successful approach to HCI*". So how can cognitive science HCI work impact design? Newell & Card (1985) argue that what is needed to really help designers are specific calculational models of users that can be utilized in practical design. The argument about the practicality and utility of such calculational models in general, and especially the claim that this is the the most important, if not the only way in which psychology and cognitive science can contribute to design, has been rather exhaustively discussed (Newell & Card, 1985, Carroll & Campbell, 1986, Newell & Card, 1986) and we will not re-hash it here, other than to voice support for a "science" of HCI that is broader than that conceived in the path-breaking, but limited work of Card, Moran, & Newell (1983).

Many cognitive science-oriented HCI groups are currently active in "user modelling", looking at the structure, content and dynamics of user cognition at the interface. Much work in the area continues the GOMS model tradition of Card, Moran, & Newell (1983), extending it in various ways. While meeting with limited success in very narrow domains, there are acknowledged to be a number of rather serious problems in trying to extend the technique. The question is whether these problems are ones that can be overcome, or whether they are fundamental barriers to the use of such an approach in actual design situations. Our view tends towards the latter, as these are ideal models, of what users should do, not what they actually do, and they cover a very narrow range of user activities (see the Chapter by Greif for more detailed comment).

In this regard, the recent wave of interest in Programmable User Models (PUMs) (Young, Green, & Simon, 1989) which are based on a generalized architecture of human cognition seem to be also unduly narrow. Rather than moving designers closer to actual users, such a device, if it existed, would seem to support the view that real contact with users was unnecessary, as the designer could just program the PUM in order to understand the "human constraints"! The very vision of a PUM seems to us a rather abstract view of human activity in the world, and to imply a rather strange relationship between designers and users. As Reisner (1987) notes in her discussion of earlier modelling work, such user modelling can never replace prototyping and actual empirical user testing, although it might have a role at a certain stage in the design of a new system.*

Even within the Cognitive Science HCI world, there are voices raised in concern at the level of adequacy of our theoretical accounts, and the low level of generalizability of many experimental results. For a good example of this, we would note the comments of Gray & Atwood (1988) in their review of *Interfacing Thought*, (Carroll, 1987) a collection of papers on Cognitive Science and HCI. This is quite rightly seen as an excellent collection that captured the state of the art (and science!) not so long ago. They note that "*there are no examples of developed systems and no discussion of designing in the "real world" in this collection*". Perhaps particularly damning, in the light of our concern for developing theory that can be used by designers, is the comment by the reviewers that they are reluctant to encourage designers to read the book, as "*the book will not convince the skeptical designer of the relevance of the cognitive sciences*" (Gray & Atwood, 1988). Within the book itself, the comments of the discussants, Reisner, and Whiteside & Wixon, also sound some warning bells about the lack of relevance of much of the work for practical design activities. One positive step in linking cognitive science models to real situations is the recent Scenario work of Young and others (Young & Barnard, 1987, Young, Barnard, Simon, & Whittington, draft, see the Chapter by Barnard for more details).This attempt to make the very narrow cognitive theories more relevant to real contexts is an interesting one, though it should not be regarded as a substitute for actual testing, as there will always be abstractions from the real situation that may appear trivial yet have important consequences.

Besides the critique of the *limited applicability of the models* developed by cognitive science HCI research to date we also have had critique of our *experimental manipulations* from within the field. For example, in several recent papers, Landauer (1987a, 1987b) has decried the poverty of many of our experimental manipulations, and attempts to push psychology out of the laboratory setting in order to

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* Our focus is on how to design usable artifacts that are satisfying for users to work with, and we believe that this requires design to have its origins in the work process. Of course there may be some benefit to having a designer program a user model, our argument here has to do with how central a role these models should play in the overall design process, relative to other activities.

be more directly relevant to human needs in the workplace. He notes: "*There is no sense in which we can study cognition meaningfully divorced from the task contexts in which it finds itself in the world*". Yet, this admission is not followed in practice. Whiteside & Wixon (in Carroll, 1987) give some nice examples of how far removed some of the cognitive science work is from real world situations. It is this lack of appreciation of the use setting that is, in our view, a major problem with much of the cognitive science HCI work to date.

3.1 A first look at artifacts

Recently, Carroll and his colleagues have developed an account of HCI that focuses on the nature of the computer artifacts created for use, and they analyze the psychological theory "embedded" in the artifact (e.g. Carroll, 1989a, 1989b, Carroll & Campbell, 1989, Carroll & Kellogg, 1989). It is claimed that this approach overcomes the problems with the earlier "human factors" and "cognitive description" paradigms in HCI (Carroll, 1989a).

Carroll argues that we should view the artifacts created by designers as HCI theories, which can be abstracted from the artifact (see Kellogg, this volume for further details on how this is done). In our view, the idea that artifacts embody theories is not as novel as is suggested in Carroll & Campbell, 1989.* However, Carroll & Kellogg (1989) go on to develop this idea in more detail than has been done elsewhere, in trying to show the specific psychological claims made by specific artifacts. While the idea is interesting, the results of this approach, or the example analyses so far presented, of Hypercard and the Training Wheels approach, do not seem to us particularly enlightening. We think this is partly due to the form of the analysis that is done, trying to fit the psychological claims into a very general Goals, Planning/Acting, Evaluation framework. We are not at all clear on how such analyses can contribute to inventing better artifacts, which is one of the claims made for this approach. Indeed, despite the claim that these analyses are done in the context of the "task-artifact" cycle, it appears that the analyses are too focussed on the artifact, and not on the artifact in use. The extension of the analyses to actual use situations, besides the earlier generic analyses, is, we believe, a step in the right direction.

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* For example, Buxton (1986) gives an amusing account of the underlying model of the human user that might be inferred from an analysis of existing artifacts - at the perceptual-motor level, and in the same collection Bannon (1986) notes how all artifacts contain a theory of the user (and of of the task domain) with reference to the KISS (Keep it Simple, Stupid) and "idiot-proof" design philosophies that were implicit in some HCI work.

Can we put an artifact under the spotlight and discern its uses, never mind its design rationale? We think this is extremely problematic. For the artifact reveals itself to us fully only *in use*. A good example of this point comes from an area such as archaeology, where people must try and make up a theory of what a thing is, apparently based only on the object itself. A closer analysis however shows that this is not usually the case. Despite the inability to observe the artifact in actual use, researchers pay particular attention to the local context of the artifact, in terms of the location of the artifact on the site (e.g. the kitchen, garbage dump) and the objects that are physically co-present with it. This is why archaeologists are so concerned about NOT removing objects from their setting until all such analyses are completed.* They also consult old manuscripts for references to uses of the object, for drawings of activities with the tool in use, etc. The artifact is thus interpreted always as an object that is used by people to perform activities. Without analyzing it in its setting we are bound to overemphasize other aspects of the artifact that may not be crucial in the use setting. Thus, as many authors have argued, *a tool is what it is used for.*

In understanding artifacts, we would also like to emphasize the importance of studying the development of the artifact over time. Artifacts rarely spring into existence all-at-once, but are shaped by previous experiences over the years. Indeed, a general criticism of much HCI work is that it neglects developmental aspects, both of user competencies and of the tools themselves (See the Chapter by Campbell that elaborates on the first of these aspects). The framework adopted by Carroll and colleagues for analyzing artifacts, while informative, seems to undervalue, in our view, analyses of the history of the artifact, and of the actual situations of use, both intended and perhaps even more important, unintended (from the perspective of the original designer). To summarize, aspects of the "artifacts as theory" argument seem to fit into our own conceptions of what a reconstituted HCI field might usefully contribute to design, though we are not as optimistic as Carroll and others that such studies will inevitably lead to an important role for psychologists in *inventing new ideas* for artifacts (Carroll, 1989a) based on these analyses.

3.2 Bridging the Gaps

Other recent work in HCI, for example the paper by Thomas & Kellogg (1989) has attempted to bridge the gap between current HCI

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* See Larsen (1987) for a more extended account of archaeological methods that supports our description above. His paper is concerned with the role of the archaeological metaphor in human memory studies, but the descriptions of archaeological work are quite relevant for our context here.

work and practical design. They acknowledge the problems of traditional human factors studies conducted in the laboratory, and discuss how to extend them into the world.* They talk of the "ecological gaps" caused by bringing studies into the lab, both by omission of factors in the real world, and by the addition of new elements in the testing situation that do not correspond to real world eventualities. They discuss the "user gap", based on individual differences, and motivations, which is often not addressed, and the "task gap", where the laboratory task may not generalize to actual work situations. But that's not all! There is the "problem formulation gap", which has to do with how the user realizes that a particular tool is appropriate for a task. There is the "artifact gap" where the application may not fit into other applications. The "extensionality gap" refers to the difference between brief laboratory use of a tool in an experiment and continuing use over perhaps years in a work setting. And perhaps one of the most important kinds of gaps from our point of view, due to their importance and diversity, what Thomas & Kellogg refer to as "work-context gaps" concerning the social setting, the culture of the workplace, etc.

Our interest in this particular paper here is not simply from the identification of the particular problems, useful as these are, as we believe that most of them have been stated before by a number of people in different contexts, but rather for other reasons, e.g. - the fact that it was written by people from within the HCI culture itself, and was published in the widely read IEEE Software magazine, and the way the authors try and "bridge the gaps" they have identified by offering some hints to researchers and designers. While we support the general concerns expressed in the paper, we are interested in whether another perspective on the "problems" of HCI might throw a different light on some of these issues, by reframing some of the questions. This need not imply the abandonment of existing techniques and theories, but rather the willingness to consider other theoretical frameworks and how they might re-cast some of the HCI questions. To keep to the "bridging" metaphor, if we walked up the road a little, maybe we would find some stepping stones across the "gaps", and thus not need to build all of the bridges in the first place. The next section gives a brief introduction to one such alternative approach, and attempts to show how it might be a useful basis for theory and practice in a reformulated HCI discipline.

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* We do not mean to imply that nobody in the HCI community had addressed this issue before. The earlier work of people such as Gould, Lewis, and others at IBM and Whiteside and his colleagues at DEC should certainly be noted. See the Chapters on usability by Gould and by Whiteside, Bennett and Holtzblatt, both in Helander (1989) for a review of some of this work.

4. Reframing HCI Issues from Without

As we have seen, many attempts have been made to reframe issues from within the field of human-computer interaction. For us, the problem seems to be that most of these attempts appear to be "add-on's" or minor revisions to the traditional theoretical basis, driven by a growing concern for practical use of the theory. The question we are raising here is whether it is possible to come up with alternative theories that might give a coherent framework for understanding human-computer interaction as something inherently social, as an example of an aspect that traditional cognitive science-based HCI does not seem to be able to handle. What we are looking for are frameworks that start out from the *praxis* of a certain community, at the same time as they allow for an analysis of aspects that have been found of importance in traditional HCI. There have been a number of critiques of standard information-processing psychology and artificial intelligence research as a suitable framework for understanding human activity. For example, Lave (1988) provides a strong critique of the underlying assumptions in both cognitive psychology and anthropology and argues for a new understanding of human cognition that sees it as distributed across people and settings. Her account emphasizes the importance of praxis in understanding cognitive activities. From a somewhat different perspective, Suchman (1987) provides an insightful critique of various models of human reasoning which assume that a planning framework is adequate to understand human actions in settings. The book by Winograd & Flores (1986) presents yet another critique of current theoretical frameworks, arguing from a hermeneutic perspective that totally rejects the commonly accepted Cartesian, rationalist position underlying most Western theoretical frameworks.

As an example of an alternative framework, we will look at human activity theory as developed most thoroughly by the Soviet psychologist A. N. Leontiev, with its roots in the earlier work of the polymath L. S. Vygotsky. Vygotsky was, just like we are, developing his framework in reaction to the empiricist tradition that treated the human as a passive, reactive organism. More precisely, he wanted to develop a psychology that charted its way between the Scylla of Behaviorism and the Charybdis of Mentalism. In Hegel and Marx he found elements of a social theory of human activity, a historical view of human consciousness, and the concept of human praxis, that served as a basis for his theoretical re-formulation of the field. (See Kozulin, 1986, for a useful historical account of the "activity theory" concepts which we utilize here). The first thing to note is that this "theory" is a very general philosophical framework for understanding the development of human culture and individual personality based on dialectical materialism. It has ontogenetic and phylogenetic aspects. For these reasons it has also been referred to as the socio-cultural or socio-historical school.

There are many interpretations and also some more specific elaborations of human activity theory.* Raeithel (in press) provides a useful, more philosophically-oriented introduction to the central tenets of this school. The books by Wertsch (1981, 1985) and Cole & Maltzman (1969) provide a useful introduction to this framework for Anglo-American readers. Also, for further background on the work of Vygotsky, the collection of papers in Vygotsky (1978) is a useful starting point. Our interpretation is primarily inspired by the writings of Engeström (1987), Karpatchof (1984) and Hydén (1981).

4.1 Central tenets of human activity theory - mediation and praxis

The fundamental concept in Soviet psychology as presented by Leontiev and others is to understand the dialectical relations between the development of the individual and the society in which the person exists. Aspects of the individual are not granted privileged status as they are within the Western rationalistic Cartesian model, but are to be explained as outgrowths of primarily social forces, some of which may become internalized over time. The theory takes its starting point in *human activity* as the basic component in purposeful human work.

In human activity theory, the basic unit of analysis is human (work) activity. Human activities are driven by certain needs where people wish to achieve a certain purpose. This activity is usually mediated by one or more instruments or tools (the concept of mediation is central to the whole theory). According to Kozulin (1986): "*the main thing which distinguishes one activity from another, however, is the difference of their objects*".

Because of the abstractness of these concepts, or rather their relative unfamiliarity in the Anglo-American context, we have attempted to give a rather simple set of examples in the next few pages to try and give some insight into how the theoretical framework makes us view the world and human activity in the world in a different light to that of the standard view. It must be realized that what follows is a gross oversimplification, and interested readers are referred to other texts for elaboration of the theoretical perspective.

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* For example, the work of the German action theorists Hacker, Volpert and others, is a case of a specialization of the general activity theory framework that focuses on actions as the central organizing level for understanding human behavior but is compatible with the general framework of activity theory as we outline it here. See the articles in Frese & Sabini (1985) and Greif (this volume) for further information on this action perspective.

As an example, the carpenter uses a saw and a hammer to produce a house out of wood and the like, the teacher uses language, books, pictures, maps etc. to teach her pupils geography. However the carpenter building a house is not alone in the world. He works together with other carpenters, as well as with other building workers. The ensemble of carpenters divide their work between them. The ways of doing work, grounded in tradition and shared by a group of carpenters, nurses or the like, we call practice or praxis. When getting trained as a carpenter or nurse one gets to share this praxis. At the same time each individual who holds a praxis continues the praxis, and he or she changes it as well, by coming up with new ways of doing things. *It is this praxis that allows us to talk about more than just individual skills, knowledge and judgement, and not just about a "generic" human being.* In other words, we can talk about the appropriateness of a certain tool for a certain praxis.

Human beings always participate in various activities. If we look at a nurse working in a ward, she is part of the activity of getting the whole organizational machinery of the hospital going, the activities of caring for certain individuals, of doing research into better treatment for certain kinds of patients, etc. These collective activities are structured according to the praxis of the particular society in which they take place. We need not go back many years to note that much of the caring done in hospitals today was done earlier by individual families at home. In most societies the *division of labor* has caused a separation between the needs of the individual and the purpose of the activity in which the person takes part: The nurse cares for others to earn money to buy food, not because they are the people the nurse cares about *per se.*

Human beings mediate their activity by *artifacts*: The carpenter uses a hammer to drive a nail, the nurses use language and records to coordinate their actions towards the patients and each other, etc. Tools, means to divide work, norms and language can all be seen as artifacts for the activity: they are made by humans and they mediate the relations among human beings or between people and the material or product in different stages. One of the major contributions of Vygotsky was that he also viewed language and symbol systems as psychological tools for developing the human condition. Artifacts are there for us when we are introduced into a certain activity, but they are also a product of our activity, and as such they are constantly changed through the activity. This "mediation" is essential in the ways in which we can understand artifacts through activity theory.

Comparing this view to the view of artifacts in traditional HCI we see two important points: if we want to study artifacts we cannot study them as *things*, we need to look at how they *mediate use*. Artifacts are not just means for individuals, they also carry with them certain ways of *sharing and dividing work*. Furthermore the artifacts have no meaning in isolation, they are given meaning only through their incorporation into social praxis (Ilyenkov, 1977). It is not until they have been incorporated in praxis that they can be the basis for thought and reflection.

So far we have looked at the *collective* side of human activity. Each activity is conducted through *actions* of individuals, directed towards an object or another subject. Building a house takes place because the carpenters carry the plywood, drive the nails, cut the wood, etc. Nursing is done by the nurses feeding patients, giving injections, measuring temperatures, etc. An action such as measuring a patient's body temperature contributes to the research activity or the caring activity, depending on our perspective. Activity is what gives meaning to our actions, though actions 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*. To drive a nail means to hold and direct the hammer towards the nail, to hold the nail, to know the speed and angle of the hammer needed when hitting the nail, etc. Giving an injection means noting the condition of the patient, finding the vein, etc. Each operation is connected to the concrete physical or social conditions for conducting the action, and it is "triggered" by the specific conditions which are present at the time, e.g. we know, without being conscious of it that to secure a large nail (which is needed to hold a heavy piece of wood), we need a large hammer. These operations which allow us to build houses or do nursing without thinking consciously about each little step, are often *transformed actions*, i.e. we conduct them consciously as actions in the beginning. Through learning we transform them into operations, but on encountering changed conditions, we may have to reflect on them consciously again, and thus make former operations once more into conscious actions.

4.2 Two views on artifacts - as things vs. in use

Artifacts, in a human activity framework, have a double character: they are objects in the world around us which we can reflect on, and they mediate our interaction with the world, in which case they are not themselves objects of our activity in use. We use tools such as a hammer and saw through operations, where they are not *objects* of our activity.* Activity theory is not alone in this point of view. Polanyi

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* In this regard, it is interesting to note that the meaning of the word "tool" is more transparent in other languages. For instance, the Danish word for tool is *Værktøj* and the German *Werkzeug*, which means "work clothes" or "work stuff" (the category *tøj/zeug* being a more general one than clothes, encompassing also e.g. vehicles and military equipment).

(1956) talks about focal and subsidiary awareness, Winograd & Flores (1986) (borrowing from Heidegger) about ready-to-hand and present-at-hand. But what does it mean for our understanding of artifacts? In normal use situations our handling of artifacts is done through operations, and is not conscious to us. The carpenter focuses his attention on driving the nail, whereas he holds the hammer and moves it through operations. In certain situations the fluent hammering stops, the hammer does not respond to the actions of the carpenter, and it becomes an object in itself. To hold it and to move it requires conscious actions, which prevent him from focusing on the nail. To put it simply, an artifact works well in our activity if it allows us to focus our attention on the real object, and badly if it doesn't. However, even when we have difficulties with artifacts, people are adept at developing "new" operations that "work around" the problems, so that activities can be performed.

If we accept this perspective on the nature of artifacts we then need to study *artifacts-in-use*, not in isolation. And we need to study *specific use activities*, where the workers have a certain praxis. For example we do not get to know much about how goldsmiths hammer from studying ordinary household hammering. Taking an example from the HCI field, we need to study word processor use in the hands of skilled secretaries, not in the hands of undergraduate college students. The praxis of the users is important. Here is the real meaning of "user-centered" system design!

Within this framework, artifacts are seen as historical devices which reflect the state of praxis up until the time that they are developed. This praxis in turn is shaped by the artifacts used, and so on. Artifacts can be characterized as *crystallized knowledge* which means that operations which are developed in the use of one generation of technology are later incorporated into the artifact itself in the next. Continuing our carpentry example, we could imagine a world where the carpenters had only one kind of hammer. The skilled carpenters develop a repertoire of different ways of using this hammer, based on the size of the materials, the difficulty of striking the different nails, etc. Sooner or later they start teaching their apprentices that there are these different ways of doing hammering, and later again, different hammers and nails start to evolve. Thus to learn something about the present shape and use of an artifact, a *historical analysis of artifacts* as well as of praxis is important. Bærentsen (1989) gives interesting examples of how operations in one generation of weapon technology are reflected in artifacts developed in the next generation.

Switching focus back to HCI issues, we see that the activity approach puts emphasis on *the use of computer applications*, rather than simply the nature of the interface per se. The framework stresses that praxis within the application domain is important to understand the computer application, in design as well as in use. For example, as a psychologist or computer scientist, visiting a trade show, I am not able to "see" the user interface of a page make-up system, the way competent typographers who have been taught to use the system in their daily work do. The way we see the computer application, or the user interface if we like, is not primarily determined by our individualistic needs and understanding, but through the praxis, as typographer, psychologist or designer, that we have been trained into. It is this switch in focus that gives a very different flavor to the activity theory approach in contrast to traditional HCI studies of undifferentiated "users", where little or no attention is made to this aspect of the users experiences.

4.3 A second look at artifacts in use

A conclusion of our previous discussions is that a human activity approach to analysis of artifacts must include the actual praxis of use, as well as the specific material, social and historical setting of that use. Engeström (1987), looking more widely at change processes in organizational settings, presents the following type of analysis of a work activity. His starting point is in a *problem situation*, where there is a reason for somebody to want a change (in our case for somebody to want a new computer application). The idea is to look for *contradictions* within the activity and between this activity and surrounding activities, since they constitute the basis for change: he looks at contradictions in how tools, objects, subjects are seen, e.g. that a point-of-sales (POS) system is seen at the same time as a tool for the individual cashier to compute the total that the customer owes, and a tool for management to compare the cashier's work and wages with those of other workers. He suggests studying contradictions between for example, the tools currently used and the object created, or the norms that are part of praxis and the division of work - for instance when a secretary is trying to produce a report containing an advanced lay-out with pictures etc. using only a primitive text editor and some glue. Engeström discusses contradictions between this activity and a different desired activity, for example, the secretary, again, may not be allowed to do advanced lay-out although she wishes to do so, and about contradictions between this activity and one of the activities that produced the tools, or materials. These contradictions are not necessarily observable in the activity at the same time, but looking for them in an analysis seems useful. We have not yet seen developed a more detailed analysis of human-computer interaction based on these contradictions, but we find that certainly the above examples give hints to the relevance of such an analysis, they explain something about why the artifact may not work, which we would not have found out by just analyzing the steps in an actual interaction process: for instance, if we had just looked at the text editor out of context, we would never had understood that it was inefficient in use, exactly because the secretary actually used it (and wanted to use it) differently from what was originally intended by the designers. Based on the analysis of Engeström we claim that artifacts are used differently from the original intentions, and this is why the need for new artifacts arises.*

Returning to an analysis of artifacts, we can start out from what kinds of contradictions the artifact is involved in. The following questions can be asked for each artifact: What is the object of the activity/actions in which the artifact is used? What is the outcome produced to be used for? To what extent is the artifact primarily dividing work, an instrument or tool of the actual production, or an enforcement of norms that we live according to? Lets look at the POS system again: depending on our perspective, the object can be the serving of a customer, in which case e.g. the receipt that the customer gets is of importance, as is the service that the sales person is able to provide. A more Tayloristic look at the same situation could suggest that the object is to get as many customers through the sales line as possible with the least effort. The most efficient way of registering sales and producing bills becomes important. There is also the management view of this same system: management needs to divide work so that all customers get the same treatment, management may want to know which of the sales persons are too slow, relatively speaking. The outcome is a collection of statistics on percentage utilization of terminals and cashiers, etc. The analysis in other words is not just a psychological analysis, but an integrated one of social relations, division of work, etc.

As designers of computer applications, we also want a closer look at the artifacts in use, in particular at computer applications. In Bødker (1987, 1989) it is argued that when we look at computer applications, it is a good idea to look for conditions for the activity, which are set up through the artifact. The idea is that ideally, in the use situation, the user should direct operations, but not actions towards the computer artifact, in order to proceed smoothly, and not perform actions which require constant attention. In particular we should look for conditions for operations towards the artifact and for operations towards subjects or objects through the artifact. In the analysis where we are looking for these conditions, it is important to note where mediation breaks down and the user is forced to direct actions towards the artifact, because this will tell us where the con-

* This raises interesting questions about the nature of design, re-design-in-use, tailorability of systems, etc. which cannot be developed here. See Henderson (in this volume) for further discussion of this issue.

ditions are inappropriate. The conditions that we are looking for can be divided into physical conditions which support the physical adaption of the artifact to the user, e.g. the layout of the keyboard, handling conditions, e.g. the way menus work, and conditions for operations towards an object or a subject through the artifact, e.g. how formatting is done on a text document.

This approach focuses on how the computer application appears to its user in use. It suggests that we ought to talk about *human operation of a computer application* rather than that of human-computer interaction (Bødker, 1987)* . What we want is software and hardware supporting the human operation of the computer application in a specific type of use activity, constituting some of the material conditions for triggering specific operations in a specific use situation. This study must be done within the frame of certain activities carried out within a certain praxis. The role of praxis within groups or ensembles in the theory makes it possible to deal with human-computer interaction not just concerning an individual user but for groups who share a praxis.

Using human activity theory we see that there is a difference between the use situation where the computer-based artifact is operated while focusing on some other object or subject, e.g. when the secretary is using a word processor, and the design situation where the computer-based artifact is one of the objects and outcomes, e.g. when we are designing the word processor. What does this double role mean for the design activity?

4.4 Implications for design

Design of artifacts in this framework can be viewed as a process in which we determine and create the conditions which turn an object into an artifact of use. The future use situation is the origin for design, and we design with this in mind. *Use, as a process of learning, is a prerequisite to design.* Through use, new needs arise, either as a result of changing conditions of work or as a recognition of problems with the present artifacts. To design with the future use activity in mind also means *to start out from the present praxis of the future users.* It is through their experiences that the need for design has arisen, either directly through use of the artifact or through conflicts between the current use and demands from external forces, e.g. management, and it is their praxis that is to be applied and changed in the future use activity. Recognizing this, the UTOPIA project based its design strategy on the idea that computer support should be de-

* A further distinction between artifacts as tools and machines may be relevant for a more fine-grained discussion, but we must omit this discussion here as it would lead too far from our current focus.

signed to be a collection of tools for the skilled worker to use. "*A computer application is seen as providing the user with a tool-kit containing tools which under complete and continuous control of the user can be applied to fashion materials into more refined products. The user is seen as a person who possesses skills relevant within the domain. The development of computer-based tools is based on this; that tools are used by skilled users to create high-quality products.*" (Bødker et al., 1987)

Design of computer-based artifacts is a meeting place for many different practices, where sharing experiences is something which requires a deliberate effort. *Design is a process of learning*, both when viewed as a collective process and as an individual process for the participants. The different groups involved learn about the praxis of the other participating groups. For all groups the confrontation with practices of other groups contributes to learning about their own praxis. This, at the same time, brings to design an innovative character: the confrontation with different practices, and thus, with one's own, is opening possibilities for new ways of doing things, and transcending the traditional praxis of the users.

Design is trying to predict the future, without ever being able to fully predict it. We should note the never-ending "wheel of design" here (See Henderson, this volume), as design will change the activity and introduce new contradictions (which may in turn lead to new design, etc.) In particular, in relation to human-computer interaction, the human activity approach focuses on the character of the operations and their material conditions: operations and their conditions for a specific activity will change, and for that reason it is necessary to focus on both actual operations and conditions, and future changed ones. However, we cannot, by asking people to predict their future operations in a future action, get the full truth about these actions and operations; they are triggered by the material conditions, by the meeting with the specific socio-cultural situation, not by any quantifiable set of conditions: "*For a user to recognize a good tool from a bad one it must be tried out in the work process (...) This means that in the design process we need experiments.*" (Bødker et al., 1987) (By "experiments" here we mean experimental design where users try out prototypes and mock-ups, a different meaning to the traditional psychological idea of "experiments"). We agree with Engeström (1987) that when we, based on our investigations of the domain (the artifacts used, the use setting, the use of prototypes), design a new artifact, *we theoretically predict how the new use process will be.* But we will never be able to find the full truth - there is always a difference between the predicted new and how the situation actually is changed by the artifact - which in turn creates conflicts which leads to further design activities.

To design an artifact means not only to design the "thing" or device which can be used by human beings as artifacts in a specific kind of activity. As the use of artifacts is part of social activity, *we design new conditions for collective activity*, e.g. a new division of labour, and new ways of coordination, control and communication. *Design of educational support* is thus also important, because the artifact is to be integrated into an existing praxis. The introduction of the artifact changes not only the operational aspects of the artifact, but also the other aspects of praxis. A good educational process can facilitate this change.

Summarizing the discussions above, it seems that we have to take the use process, and not the artifact, as the central object for our study. The way cognition is viewed in human activity theory is socially and historically situated, and it is tied to the physical conditions in which it takes place. Whatever action a human being makes in the world, this action is mediated by artifacts. In this view, the study of mediation becomes essential for HCI.

5. Differing Perspectives: Some Lessons from Software Engineering

To a large extent we find that the traditions which we have presented in this paper constitute different, complementary and at times contradictory perspectives on human-computer interaction. In her paper on software engineering, Floyd (1987) compares two "paradigms" in software engineering, the traditional perspective which she calls *product*-oriented, and an emerging new perspective, called *process*-oriented. In this discussion she identifies a number of issues that the two perspectives deal with differently. We have found these issues useful in our attempt to discuss the different perspectives in and around HCI, because the focus in both areas, if we can at all talk about them as separate, is to build more useful and usable computer applications for people. It is neither Floyd's idea, nor is it ours, to claim that one perspective is *always* better than the other. Instead we aim to recognize the limitations as well as the utility in each of the perspectives. In many ways, though, her attitude is similar to ours: "*Taking the product-oriented perspective as the ruling paradigm, however, these problems (user acceptance, etc.) must be considered as additional aspects outside the realm of systematic treatment. They may influence how we proceed in actual projects, while the product-oriented perspective models are what we supposedly should aim for, ideally..... I hold that this situation is inherently unsatisfactory and can only be remedied if we adopt - in research, teaching and professional practice - the richer process-oriented perspective as our primary point of view*" (Floyd, 1987).

Floyd first discusses differing views on computer applications (which she calls *programs*). The distinction can be made between the traditional view, which holds that computer applications are self-contained objects which are derived by formalized procedures, the correctness being provable by formalized methods or models, and the alternative process-oriented view which holds that computer applications are tools for people, designed in a learning process, adequacy being established in a process of controlled use and subsequent revision. The traditional view that Floyd presents in software engineering fits closely to that of traditional cognitive science approaches to HCI, as we have discussed it here. The kinds of formalized procedures are somewhat different, aiming not at mathematically provable programs, but at mathematically-tractable user models and measurable, statistically significant experimental results. A more process-oriented view is represented not only in the human activity approach but also for example in the work of Whiteside and Wixon (1988).

Floyd makes a distinction between the traditional view which sees the user organization as static, with the interaction between the person and the computer as something fixed and predefined, and the designer appearing as an outside observer. Again, this comes close to traditional cognitive science frameworks. The alternative perspective notes that organizations are under continuous change, that human-computer interaction changes accordingly, and that the designer can't avoid being involved in these changes. This alternative perspective is partially represented from within a cognitive science tradition by e.g. Campbell et al. (1989), and by Engeström as a representative of the human activity tradition.

A static view of the user organization is behind the assumption that a task analysis is a sufficient basis for design, i.e. once uncovered, the tasks are assumed to remain the same throughout the design process. The idea of the designer (psychologist) as an outside observer is also inherent in many of the cognitive science positions we have seen (Whiteside and Wixon excluded). In opposition to this stands again the human activity approach where it is a fundamental belief that we cannot design the future totally, and that design is a learning and change process for *all* the involved parties, both designers and users.

Concerning the concept of quality, two points are important: in the product-oriented view quality is associated with features of the product, and moves, in a sense, from the computer application towards the user (e.g. user friendliness). From the process-oriented view, quality has to do with the *process of use*, and is defined in terms of relevance and adequacy for the user when dealing with the computer application. Notice the language we use in HCI: people as "users" of a piece of technology, rather than people who are doing real work. Our view of "users" may have progressed and expanded since the days when we discussed "idiot-proof" systems, but many current interfaces to systems have a very rigid underlying model of the human being who is expected to use the device. Our emphasis in many cases is still on "easy to use" systems, the lowest common denominator approach we could call it, that assumes most people are relatively dumb and need an interface to suit.

Floyd talks about *competence* in the product-oriented view in terms of operating the application, and errors as improper operation and incompetence. In the process-oriented view competence has to do with the work task being conducted with the help of the application, and errors are viewed as a precondition for acquiring new competence. Errors are thus inherently connected with learning. In many cognitive science studies the examples deal only with novices conducting very specific tasks, detached from any real work situation. The lack of concern with learning over time (weeks, months, years) is a serious neglect in many studies to date. What happens to the skills of the users as they master the new artifact, do the traditional skills atrophy, or remain stagnant, or are there new avenues for growth? From the human activity theory the continuous encounter with "errors" (breakdowns) are the driving force, both in understanding how a certain artifact works in real use, and in understanding how the artifact eventually gets changed. Even though human activity theory stresses that we cannot fully predict the future, designers (and activity theorists as well) are of course trying to predict the future all the time, and it is recommended to build into the computer application flexibility as to how objects can be treated through the application, depending on the repertoire of operations of the user.

Paradoxically most of the researchers mentioned under the "reframing from within" section in this paper wish to include many of the aspects covered by the process-oriented side, at the same time, though, as they maintain an ideal of being able to do design based only on analysis, not on interaction with real people conducting work. We find it necessary to take a more radical step out to where the users are, at the same time as we share Carroll's concern, namely to find a theory to explain what we are doing. What we have tried to show in this paper is that such theories exist, but that currently they are not nearly as instrumental for detailed studies of human-computer interaction. In other words, there is still work to be done both theoretically and empirically before we can give an adequate account of the HCI field within an alternative framework. We see this as a gap to be bridged in the future.

6. Conclusion

We have raised questions concerning the status of the HCI field, and the status of supposed underlying disciplines, such as cognitive science, and even cognitive psychology, as currently constituted, but our emphasis is on design issues. If our quest is to actually design more usable computer artifacts, than a better knowledge of the "users" is required as a part of our analysis; one that sees people acting in a situation, with motives, and intentions, in interaction with others and the environment. We subscribe to the idea that good design comes from an empathy with the work process itself, with possibilities for human growth as well. Taking this stance, we accept a more holistic, value-laden stance where we as scientists and researchers are not removed from, but are ourselves a part of the process. We argue for more design to be done in conjunction with those using the technology, but that does not mean that psychological methods have no role. We are concerned that the separation of a field of activity such as HCI may not be the best way to proceed, as it tends to emphasize aspects of the interface per se rather than how people can be supported in their work practice. Domain knowledge is crucial as we have noted. A framework such as activity theory, that looks at ongoing human interaction with the world, and encompasses relations with others, and the socio-historical mediation of learning and development, seems to provide an interesting alternative framework if we wish to develop a more comprehensive unit of analysis for our studies. Perhaps the real challenge we face is how to combine aspects of these different perspectives so that the end result, or more correctly, the continually evolving applications we develop, can utilize the knowledge gained from differing approaches.

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