Journal of Universal Computer Science, vol. 14, no. 16 (2008), 2614-2629
submitted: 9/7/07, accepted: 15/10/07, appeared: 28/8/08 © J.UCS

Cognitive Ergonomics in Interface Design – Discussion of a Moving Science

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Abstract: Cognitive Ergonomics is discussed as a systematic base for user interface design. The history of the discipline, explicitly existing now for about 25 years, is discussed, from participatory design, through various flavors of user centered design, to contextual design. Several persistent misunderstandings regarding the need for user interface design are analyzed. The concept of activity centered design is proposed as state of the art approach, and several techniques that support this paradigm are mentioned and illustrated.

Key Words*:* Cognitive Ergonomics, User Interface Design
Category: H.5.2, K.6.1, H.1.2

1 Introduction: Positioning the Discipline

In many cases we label our discipline "Cognitive Ergonomics". We obviously view our domain as an applied science. We apply knowledge, methods, techniques, and tools from human sciences towards problems of human use of artifacts. Ergonomics, in general, seems to focus on several directions of application. At the one side, artifacts are considered in an existing situation of use, and actual problems of use are approached local to that situation. This type of application I label "curing". At another, in fact opposite, site, problems are approached from the point of view of human needs and design of a solution includes design of a new situation and envisioning new artifacts in context. This type of application I will label "envisioning design". Obviously, ergonomic practice often can be located somewhere between these extremes.

Cognitive Ergonomics as a discipline is a restriction of Ergonomics, where "Cognitive" as a label indicates the focus on human knowledge and understanding. Both curing and envisioning design mainly consider cognition: either trying to help users of artifacts solve their problems of understanding, or designing artifacts that fit human cognitive competences and needs. But cognition as such should not be interpreted too narrow. Immediately related to understanding the aspects of acceptance, emotion and behavior have to be considered. And, moreover, cognition should be understood in a broader sense than (only) the Psychological meaning of the concept. In that respect, labels like "social ergonomics" and "distributed cognition" have been applied, indicating the variety of human science disciplines that should be considered basic to the applications in our domain. A general characteristic of Cognitive Ergonomics is the focus on information systems, information technology, and, more recently, multimedia as the core of the artifacts considered.

The label "Cognitive Ergonomics" seems to be used mainly in Europe. For the same domain of applied science several alternative labels prevail in the Western world, like "Human-Computer Interaction", "User Centered Design", and "Usability Engineering". Depending on who is using any of these labels, there may be subtle differences in meaning. Again, there are extremes that aim at curing local problems (e.g., focusing on help systems or instruction), or, alternatively, at envisioning and designing future smart, or adaptive, environments. In this sub-domain of Ergonomics, however, envisioning design seems to be more on the forefront of state of the art approaches, in comparison to curing efforts. The rapid development of technology seems to have forced a choice here.

Cognitive Ergonomics, with whatever name, is a rather young discipline. Both in Europe and in North America professional organizations celebrate this year their 25th anniversary (ACM SIGCHI, EACE), and INTERACT (IFIP TC13's "pre-marital" child) is not far behind. Systematic attention for the human user of interactive systems seems to be an accepted value. Look at the titles of educational volumes that have been published during these years [Norman, Draper (1986)], [Vredenburg et al. (2001)], [Garret (2002)], [Holzblatt et al. (2004)], [Lazar (2006)], [Lambropoulos, Zaphiris (2006)], and look at names of courses in Computer Science Curricula and at keywords in Computer Science conferences. But we are not there yet. On of my colleagues, Computer Science Professor, recently told me:

"My students do not need to talk to people".

What is the discipline of Cognitive Ergonomics, or Human-Computer Interaction, in 2007? The year should be mentioned since the domain is being redefined continuously and the methods change as well. Technical possibilities of information technology still grow according to Moore's Law (and are applied by industry immediately before optimal application for human users has been considered). The application domains broaden: more people, more non-experts, more applications in complex social and organizational settings, more application outside the work situation.

I will show what is changing and what should be changing and I will point to relevant new approaches. And I will focus mainly on the prevailing efforts of design, leaving curing to "traditional" Ergonomists. In addition, I will omit in my analysis the development in the basic sciences that contribute towards Cognitive Ergonomics: the experimental Psychologists that study the characteristics of human behavior in relation to information technology and the requirements for usable multimedia based on human information processing.

2 Users and the Design of Interactive Systems

Let me sketch a brief history of design of interactive systems from the point of view of the human partner. The main issue is the location of the user in the design process.

2.1 Participatory Design

Enid Mumford (1924-2006) was one of the pioneers. In the 70s she was a member of the Quality of Working Life Group; in 1983 she won the American Warnier Prize for her contribution to Information Science. The ETHICS approach [Mumford (1983)]

towards software development is based on user participation. She mainly intended to solve the problem of introducing new systems. She advocated a holistic vision on the organization resulting in both a social and a technical solution. Mumford made a distinction between three categories of user participation:

- consulting, where the user was interviewed for each decision but the responsibility for design was left with the analyst;
- representational, where users are allowed a vote for each decision;
- consent, where employees of each department participate and where the workers in decide.

Mumford's approach was an evident success at a time where computers were used by computer experts and task professionals, e.g., at the introduction of the first stand-alone word processors, early applications of computer technology in offices. IBM invented the concept in the 60s and discovered that the introduction in its own offices was only successful after the users were involved from the start. These users were experts in their task domain and they knew the previous technology first hand. For the introduction of spreadsheets in the domain of professional accounting the same was found to be true. Nardi and Miller [Nardi, Miller (1990)] in this case refers to "end user programming".

An import development, at least partially derived from Mumford, is often labeled the "Scandinavian approach" [Suchman (1988)], [Bødker (1996)]. The user should be included in all phases of the design and introduction, and in some cases this developed into a political right [Bjerkness, Bratteteig 1995)]. With the broader introduction of information technology in society, however, the "extreme" variant of user participation collided with the need for systematic analysis and specification of functional requirements and user interfaces, even though the need for consulting users in all phases of the design process remains [Carroll (1996)].

2.2 User Centered Design

In the 80s world wide attention developed for user centered design, an approach the can be characterized by systematic design methods applied by expert designers, from the point of view of the user. I will mention two important aspects.

2.2.1 Modeling the User Interface

Design is based on systematic (more or less formal) modeling the user relevant aspects of the system. Moran was one of the pioneers [Moran (1981)]. Tauber build on his ideas and introduced the concept of the "User Virtual Machine" (UVM) that referred to the total of relevant user *knowledge* of the technology [Tauber (1988)]:

- the task world – what are the goals of the prospective user of the system, what are the tasks to be delegated to the system;
- the semantics – what is the system offering the user to delegate tasks, in terms of system objects and actions on these;
- the syntax – how may tasks be delegated and how will the system provide feed back to the user;
- the representation – how does the information from user to system look like and vice versa (Moran labels this level as "key strokes").

The designer models everything the user needs to know or to understand. In this respect I like to point to a plethora of academic work on cognitive task analysis [Hollnagel 2003)], user-interface specification en modeling [Pfaff (1985)], [Card, Moran, Newell (1983)], [Baumann, Thomas (2001)], en systematic evaluation techniques [Jordan et al. (1996)]. Even though the label UVM never was adopted worldwide, the four aspects (levels) are: pragmatics (user task world); functionality (semantics); dialogue (syntax); and representation.

2.2.2 Systematic Design Process

The process mostly starts with a user and task analysis. Next steps are generally an iteration of envisioning of the future task world, and of specification, evaluation, and implementation phases [van der Veer, van Welie (2003)]. I will only focus on task analysis here, since this is the first phase where the user is in focus. Whatever the remainder of the process looks like, the task analysis phase aims at: mapping the users, their organization, the social and group structure, and task relevant individual differences. In addition, a detailed overview needs to be developed on the goals and tasks for using technology. A main issue in this process is the acquisition of all knowledge needed.

The user will know only fragments of what is relevant. Jordan and Henderson [Jordan, Henderson (1995)] show that we need to approach four sources: only part of the knowledge is the expertise of the people concerned (all users and stakeholders should be considered experts in their own domain) and part of the knowledge is in the situation (post-it notes around the screen, memos on the poster board, how-to-use-it notes with the coffee machine). Moreover, only part of this knowledge is explicit (an expert will speak about it, or it can be read somewhere), and part is implicit (the expert shows evidence of expertise without being able to explain this, the team shows a “silent” division of tasks). We developed an adaptation of Jordan and Henderson [Jordan, Henderson (1995)], where the cells show the main techniques for acquisition of knowledge [see Fig. 1].

sources of knowledge	(individual) expert knowledge	group knowledge, knowledge in situation
explicit knowledge	interviews with different types of users and stakeholders	analysis of documents, stories, and artifacts
implicit knowledge	registration of expert behavior, interview based on this, hermeneutic interpretation	ethnography, interpretation through interaction analysis

Figure 1: Sources of task knowledge and knowledge collection techniques [after Jordan, Henderson (1995)].

For all techniques the best approach is to find an analyst who is not an expert in the domain. Otherwise there is a risk of knowledge being unnoticed. This is more so for implicit knowledge. Ethnography will takes most time since the analyst is a "participant observer" who participates as an apprentice in "normal" activities. To start with the ethnographer will have to register everything that is surprising and not understandable. If one waits till things are clear, there will be nothing that seems worth while to register.

Only after collecting and understanding all relevant knowledge of users and stakeholders and the situation, the systematic design may continue. From this moment the client of design will be a partner to negotiate with. And in many cases this is not the main "end user". All users and stakeholders will have to be considered further during all phases of design, especially when design decisions have to be made.

The methods and techniques sketched in this section on "user centered design" will remain to be relevant in the future.

2.3 Contextual Design

This label has been coined by Beyer and Holtzblatt [Beyer, Holtzblatt (1997)], who continue in the direction pointed to by Jordan and Henderson. They show that expert knowledge only gets its meaning in an actual context. Only is a situation people decide on their goals and on what they consider their actual task. It is interesting to note the full title of their book is: "Contextual Design: a Customer-Centered Approach to Systems Designs". However, in practice "customer" may be read as "user or stakeholder". This broad approach is currently developing into a mainstream design vision.

3 Misunderstandings

In the world of design for users there are still some common misunderstandings:

3.1 The User Can Do It

Since many years not all users are experts or nerds. And even if they were they do not want to be. Systems are increasingly complex and users do not get extra memory.
The dispatchers of the service desk of our University keep statistics of calls received regarding basic services. For 2005 we show the statistics [Fig. 2]. The highest frequency is for category "reset of a password". And all those poor users are convinced of the need to protect the security of their boss' system.

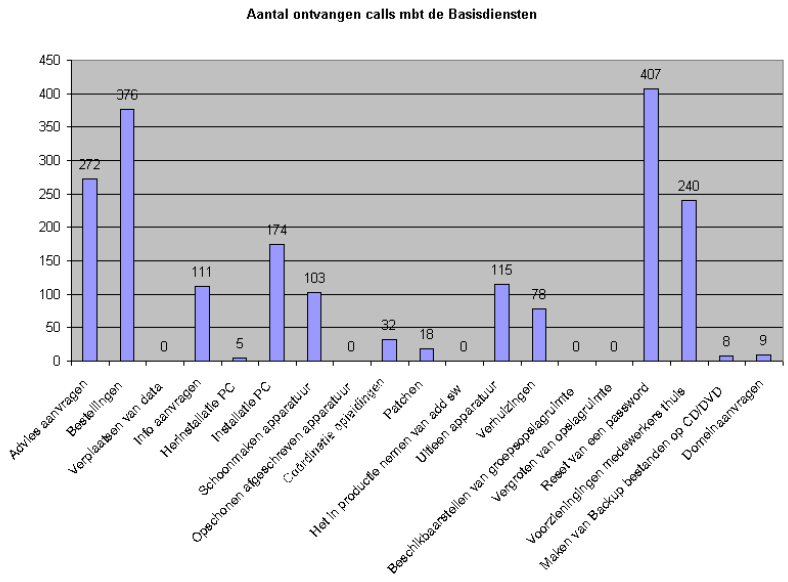

Figure 2: Overview of calls for basic services received by the Service Desk of the Open University Netherlands in 2005.

3.2 If You are User Friendly

The label "user friendly" did not die, and to many customers of design it seems that a system that looks "nice" to its user is easy to use. The best known is Microsoft's paperclip). But this is not a single incident. Recently a web search with the term "user-friendly" resulted in an unexpected series of companies that advertised with this label, including universities! Some authors of this prose refer to representation, lay out, or usability tests. But in many cases one should wonder what the methods are that are responsible for accrediting this label.

3.3 All Users Want the Same Thing

When we really start with a user and task analysis we find a different situation [Norman (2005)]. I will show some examples of research we did with PhD students in various European countries [Chisalita (2006)]:

- The Dutch police force new information systems were designed. Ethnographic studies showed a large difference between the category "cops" and the category "detectives". The former were obliged to collect all kinds of information and put this in a system (a time consuming task they hated) without knowing the purpose. The second group was allowed to decide what information was relevant to input, and had access to all kinds of additional sources. In the first group this lead to resistance to the system, in the second group this resulted in a negative image of the ethics of the other group.
- In an international bank the business goals changed from client centered to maximizing profit. This changed the goals of the stakeholders in the central

management, and sometimes, but not always, of the branch managers. A new intranet based systems was implemented that offered, among other things, functionality for desk-tasks. Many desk clerks, however, kept their service oriented approach and were in some cases passively supported by their branch managers who allowed the old desk systems to be kept available.

- For a government body in a European country we analyzed the directorate that controlled the expenses of other directorates. Transactions were supported by a system that reported the state of the process. Based on this negotiations were initiated to change budgets. Decisions were made by managers who themselves did never touched the system. The actual users implemented the decisions and collected information for reports. When these users made a mistake (and subsequently had to correct their actions) the system kept traces of this. For many of these users the system was an archive of errors. Others reached a level of expertise that allowed them to program around these problems, which the management was unable to detect or control.

Analyzing complex systems shows that it serves different goals for different people in different situations. And not all goals are explicit and clear to all stakeholders.

4 Who are the Users?

Managers are users as are desk clerks and bank customers, cops are users as are detectives. But their goals differ. Design should take all different user groups and different goals into account. Moreover, a client of design does not necessarily wish to support all types of users and their goals. I will point to an interesting example from the domain of games. The free of charge available computer game "America's Army" reached in 2005 six million registered players [Boyd (2005)] with 100,000 new registrations a month. The original goal, different from many popular games, was not commercial. America's Army intended to be an advertisement and at the same time a selection instrument to solicit recruits for the American army [Observer (2005)]. In the meantime it is, in addition, considered a serious training tool for the army focusing on "teamwork, integrity and leadership". Most players consider it a challenge or just fun, in many cases in (geographically spread) teams. The designers aimed at selection and advertisement, and the owner currently aims at preparation for actual combat. It seems that now Taliban, Sunnite and Shiite groups should be considered additional stakeholders. This points to interesting ethic aspects of modern design.

Norman [Norman (2006a)] criticizes the concept of "user centered design" for still different reasons: it concerns multiple people that use a system in actual situations. These people are alive; they are not stuck in a single location and a single role. Consequently, they might, over time, want to use the same system for different purposes: internet banking, watching a movie, communicating with friends). The term "user" suggests too simple a world with a single environment and culture.

5 Activity centered design – a new paradigm

We need to keep the approach to analyze all kinds of goals for the system and to detect who are the stakeholders. With existing modern interactive systems there is often nobody who knows precisely and completely what the possibilities are and what purpose these serve. The analyst will have to use all of the aforementioned knowledge acquisition techniques to get an overview.

Organizations have business goals, which change, and which will not, by default, be shared (or even known) by all stakeholders in the organization.

Humans have goals, often several at any time, and in natural situations these might well be implicit. Goal priorities depend on:

- the individual history (do I know the customer at my desk?);
- the culture that is experienced as actual (do I consider myself an employee of bank X, or do I consider myself a tem member of bank branch Y?);
- the context (my branch manager aims at keeping a client friendly image);
- actual needs (how can I get rid of the cue at my desk).

Norman introduces the label "activity centered" [Norman (2006b)]. In an actual situation people choose what goal is most important and aim at performing activities that support that support that goal.

A designer should aim at detecting what may be needed for supporting / mandating / delegating stakeholder activities, and combine this into a design space:

- what are the opportunities of available or expected technology;
- what does the client of design want to pay for;
- and sometimes: does the designer want to participate in this.

Balancing of stakeholder interests cannot be avoided (an issue already with user participation). And each solution will have to be validated in the actual use of context because only there the user or stakeholder will decide on actual goal priorities.

6 Techniques for Activity Centered Design

Even though the unit of analysis is changing from "the user" to the situated activity, we still need the same well established techniques. Their aim may change somewhat, so I will provide a sketch of "old techniques for new purposes". It makes sensed to recollect the general design process: (1) if at all possible, start with an analysis of the current task situation including the users and stakeholders; (2) envision the future task world for the case where the new technology-to-be-designed is implemented and in use; (3) specify details of the technology in the sense of the UVM (task delegation, functionality, dialogue, and representations); (4) early, as well as late, evaluate design decisions against understanding and acceptance of users and other stakeholders and against established knowledge of usability experts and state of the art design patterns. Designers, of course, will keep in mind that each of the mentioned processes might trigger a (new) phase of any other one. Overall the design of interactive systems is an iterative process, though there should be a generic start in task analysis and finally a well assessed set of specifications that will function as requirements for the engineers implementing the design.

6.1 Analysis of Current Task Situation

We did mention already the four groups of techniques needed for acquisition of task knowledge. In the new era of activity centered design the techniques are still valid, but the focus does change:

- location of task performance, where the situation will trigger the relevant knowledge of the situated activities. Recording the physical environment may well add to understanding, and, at the same time, trigger the analyst to probe for additional information about details and conditions for action.
- Hermeneutic understanding will, as in the old days, require the analyst to picture the situation as well as the stakeholder background and current motives. Not too much will change here. Especially mental model analysis, like using teach back procedures [van der Veer, Puerto Melguizo (2004)], needs to explicitly refer to stakeholder history and context of use.
- Registering and analyzing documents and other artifacts needs a clear focus on validity of the information. A major question to ask is in what situation of use and what type of user (culture and motives) the meaning should be understood.
- Ethnography will, in all cases, consider the situation as a whole, from the viewpoint of the "aboriginals". This technique needs to be kept as it is, even though time and opportunity are a condition of application. As a last resort, techniques of ethnography by proxy might be applied, where original stakeholders are asked to keep a diary, collect stories, or take pictures in well specified original situations, and feed back the data collected to the analyst. Obviously, the specification of the situation to collect material is crucial here, and should aim at understanding the precise context of activities to be understood. Even if by proxy, this type of ethnography will result in an iterative process of deeper understanding.

6.2 Envisioning the Future Task World

Envisioning the future task world should be based on a task model approach that allows for activities as a unit. Approaches like GTA [van Welie, van der Veer (2003)] serve the purpose, allowing roles to be defined in relation to a responsibility to perform each activity. Roles (and activities) can be mandated or delegated to agents (people, groups of people, or interactive systems). This leads to a finer grained task model and a view on the task world that allows freedom to consider role allocation in relation to (situational) conditions for starting or stopping activities. Obviously, the modeling of the situation should be considered a major aspect of task modeling.

6.3 Specification of Technology

Specification of technology will, as previously, consider the various users as well as the context of use.

- Functionality will in most cases be defined separately for different roles, even if many users and other stakeholders may take various roles in different occasions. Sometimes a wrist watch is a device to delegate time telling, at another moment is takes the role of a stop watch, or a device to alert me on

an appointment. Separating the functionality aspects of system objects (pre set clock times, pre set periods, running clock times in relation to time zones) as well as operations on these objects will help the user to easily understand when delegating various tasks to various roles.

- Dialogue means the physical exchange of information between an inactive system and a user. The relevance and feasibility of the physical exchange depends heavily on the actual situation (noise, light conditions, presence of other people, current occupations of the user including attention, requests to senses and physical behavior). In many cases multiple dialogue styles (commands versus choice of options versus "direct" manipulation) as well as physical actions should be provided. Increasingly technical developments allow devices to be context aware and help users to choose the optimal settings depending on the context.
- Representation indicated the actual shape of the physical signals exchanged, including language, sound, visuals, gestures and tactile feedback. Both the conditions for feasibility and the growing possibilities for context aware support of the user are comparable to what has been indicated after the previous bullet.

6.4 Evaluation

Evaluation should consider the context as well as the situation of the user (current needs, history, and actual cultural identity). The well known standard evaluation techniques in fact serve this purpose well [e.g., Jordan et al. (1996)]. In most cases of expert evaluation it just requires the analyst to keep the right mind set. An example of such a technique is Cognitive Walkthrough:

Cognitive walkthrough is best performed by a small (3 – 4) usability experts, who consider an early prototype of a mock-up that simulated the intended interactions. They should start with understanding the goal and relevant characteristics of the user. For each user step in a dialogue process they answer a small number of questions, considering (a) what would be the user's next goal; (b) what would be the user's next action; (c) what would be the actual reasons for the user to make decision b; and (d) what would the user expect the system to do. The main "change" (or fine tuning to activity centered design) would be to start with including the actual context of use and the actual needs and goal priorities of the user. Subsequently, in step (a) they need to consider explicitly the goal for an activity, in step (c) the context as possible trigger for a reason, and in step (d) the meaning of system state in relation to this context and to the user's current needs.

In cases where early evaluation requires confronting stakeholders (including users) with the system under construction, we need to represent our preliminary design ideas to them. In an early stage a static "sketch" is the only possibility, and it makes sense to show the sketchy character, in order to elicit free comments and allow multiple interpretations of specifications that are not fixed yet.

A 2-dimensional drawing [Vyas, van der Veer (2006)] is shown [see Fig. 3], but 3-d representations of foam and cardboard are relevant as well and allow actual handling in simulated activities. In a later stage, when preliminary decisions of the dialogue need to be assessed, an interactive representation makes sense, whether this is in fact a powerpoint simulation or an early prototype [see Fig. 4].

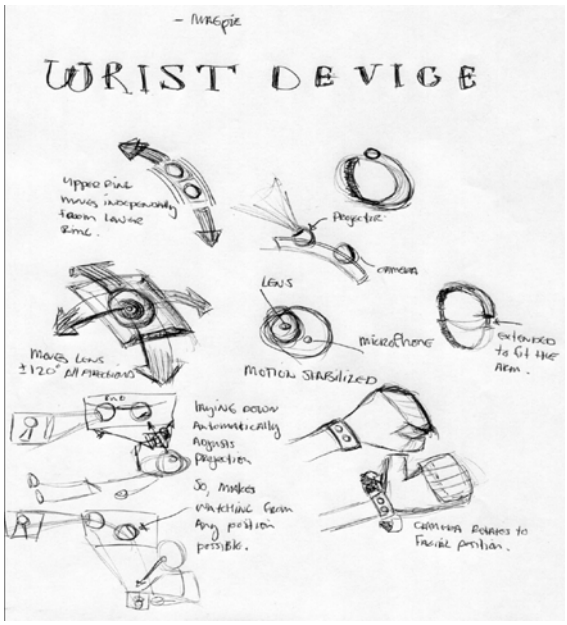

Figure 3: 2-D sketch of a wearable communication device.

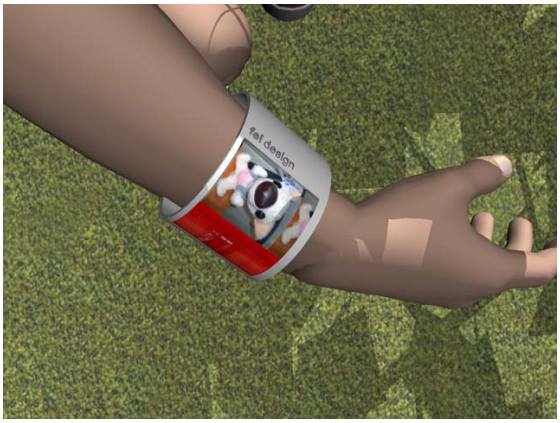

Figure 4: Slide from a powerpoint "interactive" simulation.

Once there has been a first set of decisions on the technology, the prospective application in context can be illustrated and assessed with stakeholders. The well known techniques of scenario analysis remain a good choice:

A set of personas will be a first requirement. In the case of activity centered design we may well need to start with a list of all types of human agents that might be candidates for taking a role to perform (or delegate to interactive systems) an activity.

"Types" refers to types of agents that can be distinguished from other types by characteristics relevant for performing or delegating activities we consider. As an example, take the domain of scientific authoring. In a current research project [Vyas, de Groot, van der Veer (2006)] we identified several types of human agents:

- Expert authors, like full professors;
- Specialist authors who are expert on certain sub-domains and tend to write specialist sections guided by an expert author;
- PhD students;
- Support staff with relevant supporting expertise, like librarians, graphic designers, or statisticians.

Claire
36, Librarian
Goal
- Making sure the scientists get the information they need
- Create awareness about publications amongst scientists

Tasks
- Perform searches
- Work on the local library and departmental pages
- Write guidelines for web versions of databases
- Maintaining the database
- Archiving e-prints

Professional Background
- Claire has an MSc in information sciences.
- She has worked as a librarian for 11 years.
- She is currently working with the Psychological, Pedagogical and Social Sciences department for one and a half year.
- She has a lot of contacts with publishing companies.

Work Activities
- She performs searches for faculty members through various databases. For a few faculty members, she has set up search alerts based on a set of keywords they have provided her.
- She normally gets requests from users who can not get access to the full text document online or at the departmental library.
- She also spends some proportion of her time developing trainings materials and giving classes to students and faculty about where and how to find relevant information.
- She is responsible for a project on digitizing all the historical documents.
- She is involved in the "business information" working group. The group is looking at useful commercial databases and is doing a lot of evaluations of databases.
- She is currently a product manager for an application to provide free managed web space to faculty to store their digital work.
- She doesn't do a lot of research but she has done quite some research on chat in the past and is currently interested in studying the question of usability of web-based tools.
- She is involved in the vision and strategic planning for the library. One of the plans is to build a learning resource centre.

Tools Used
- She uses PsychLit as the main tool for searching. She is also familiar with the Social Science Citation Index.
- She is a strong proponent of the use of thesaurus; she works a lot with MeSH. She considers not having thesaurus support as a huge drawback for products.

Figure 5: Example of a persona representation.

In addition there are “non human” agents like “the library”, “the secretariat” and Google. These agents tend to perform activities less situation dependent. For each of the human agent types it makes sense to analyze relevant characteristics and “picture” persona to provide guidance for stakeholders to consider the people that would use the system in their context.

The first step in developing personas is to survey the task and domain model for identifying relevant distinct types of users and other stakeholders. With the distinction the relevant variables will emerge that can be used to describe the various personas (e.g., goals, tasks, professional background, work activities, tools used). We show a representation of one of the personas that we used in our assessment study [see Fig. 5].

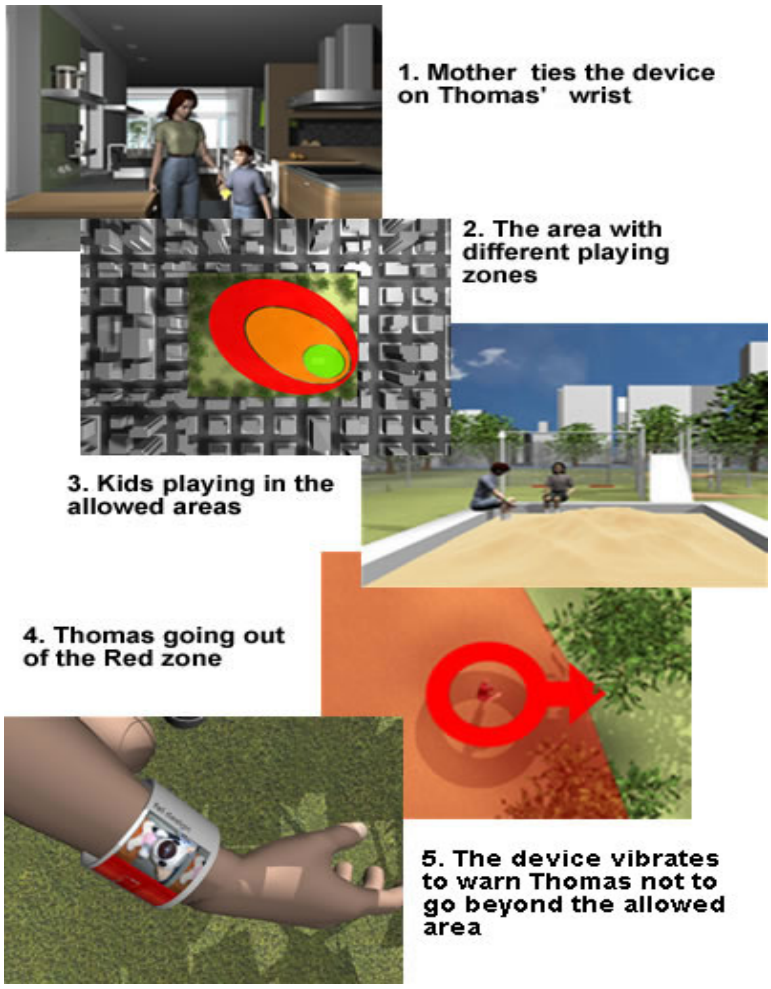

Figure 6: Fragment of a scenario.

Scenarios allow early confrontation of users with design ideas. In the case of modeling the future task domain scenarios will be global and focus on context and stakeholder understanding and goals. Later in the design process scenarios can be based on actual activities, and, in the case of delegating these to interactive technology, on "use cases" as used in Software Engineering. In all cases, scenarios could be based on the personas that have been identified and recognized by the stakeholders.

In fact, a scenario is a description of the intended delegation of activities, or interaction in the course of activities, dressed with a description of an actual context and an actual agent (or multiple agents) with an indication of current needs. We show fragments of a scenario [see Fig. 6] where stakeholders can help evaluate understanding, acceptance, and experience related to future implementation [Vyas, van der Veer (2006)].

7 Conclusions: Activities in the Focus of Design for People

Cognitive Ergonomics, as an important scientific base for user interface design, van now be characterized by 25 years of history. Where early design approaches were based on user participation, modeling the user interface, systematic design approaches, and recently contextual design have all shaped the design approach towards a methodologically driven enterprise based on theory, techniques, and tools that, even if originally based on different disciplines, are now readily combined.

Still, several persisting misunderstandings can be detected, like the continuing expectation that users can (and are interested to) manage technology just by themselves, like the focus on being "user friendly", and the naïve idea that all users want and need the same system. In fact the whole concept of users and stakeholders can be problematic, if we do not systematically model the various roles they play in relation to using the technology.

We adopt Norman's suggestion of activity centered design [Norman (2005)] where activities are related to goals that in turn will be dependent of users and stakeholders, their actual needs, the context, and the available technology support.

We provided examples of design techniques that can, and should, be adjusted to the new paradigm. For other techniques similar arrangements should be made, but in fact the general purpose, as well as the procedures, will not change too much. Designers should be aware of the fact that a new unit of analysis, the activities, should be considered in all aspects and all phases of design. And clients of design need to be convinced of this finer grain of analysis that will bring additional negotiation and choices to be made.

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