Socio-Technical Environments and Assistive Technology Abandonment

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Introduction

This chapter will explore the use of socio-technical analysis in design of assistive technology. It starts out with a discussion of assistive technology (AT) and the various user types (roles) that are involved in AT development and adoption, with particular focus on the high rate of abandonment of complex AT. It continues, contrasting the conventional approach of studying system design and adoption with a socio-technical perspective in work environments, with using the same tools in a context of voluntary use. Of course both of these environments are, in a fundamental way, voluntary – employees can always quit; but in the case of AT the motivation is not so much economic and psychological (e.g. job satisfaction) as literally functional (i.e. ability to perform Activities of Daily Living (ADL)[1] or Instrumental Activities of Daily Living (IADL) [2]).

The discussion begins with defining and exploring the dimensions of assistive technology in design and use, with particular attention to the process of adoption and abandonment. Following this is a short review of the traditional process of socio-technical systems and environments[3], looking at it from the perspective of typical domains studied and the evolution of the field. Within this section are presented several practices or tools used in socio-technical evaluation and design.

The process of using socio-technical principles to inform design of assistive technology is illustrated by discussing MAPS, a ADL task support tool for persons with cognitive disabilities. The chapter continues by following the design process from participant designer selection and study thru adoption of a prototype system and finally presenting the lessons learned. Then follows a more formal comparison between 'traditional' STE study and AT based STE work, decomposing the elements of the MAPS system. Finally the chapter concludes with some suggestions for further work

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[1] ADLs refer to refers to six activities (bathing, dressing, transferring, using the toilet room, eating, and walking) that reflect the patient's capacity for self-care.

[2] IADLs are tasks that enable people to live independently in the community. Examples include shopping, cooking and house cleaning. IADLs support ADLs

[3] A note about the various permutations of socio-technical-<networks><systems><environments>. IN this chapter the term socio-technical environments will be used in all cases, except in direct quotations. There is a valid point in discrimination between the three terms but it was felt that the values in retaining the original notations would be overwhelmed by the confusion that using different terminology might create.

Assistive Technology

Assistive technology (AT) is defined in the US as:

> Any item, piece of equipment, or system, whether acquired commercially, modified, or customized, that is commonly used to increase, maintain, or improve functional capabilities of individuals with disabilities. [50]

Assistive technology devices can be as simple as a extender for door handles to allow opening of doors by people with reduced manipulative ability or as complex as a alternative and augmentative communications device to support communication by persons with speech disabilities, like Steven Hawkins. This chapter will be discussing high –level computer based AT, in this case for leveraging existing ability by persons with cognitive disabilities to perform tasks that they would not be able to do without assistance. This discussion of AT is focused on the adoption of complex AT because the successful adoption process for such items 1) takes a longer time (weeks or months) and involves multiple roles (e.g. end users and caregivers and 2) since AT is designed for direct use by the end-user rather than being a component in a solely technological system (e.g. a planetary gear in a transmission), studying AT in use must involve including in investigations all the direct and indirect stake holders. These stakeholders include, besides the direct end-user of the AT, the family of the person with cognitive disabilities, professional caregivers, familial caregivers, medical personnel, the AT designers, product salesmen and technical support, persons and organizations involved with funding the (often very expensive) AT devices, and the legal and regulatory personnel and system designed to protect and respond to the needs of persons with cognitive disabilities. Studying the long-term adoption process must necessarily include looking at the environment of adoption (and use) as well as other parameters which will be explored in the section on de-constructing elements in a STE.

AT for persons with cognitive disabilities

A unique aspect of software and systems for persons with cognitive disabilities is that, while the focus is on the end-user, the person with cognitive disabilities, design and evaluation must involve their caregiver; in fact it may be taken as an axiom [10, 32] that every system is used and must accommodate a dyad – the end user and a caregiver. In MAPS design the end user was described as a dyad, one person with two roles, the person with cognitive disabilities and a caregiver, requiring two interfaces using one set of data. Typically the caregiver assists in the setting up and maintenance of assistive technology systems, as they often are too difficult for the person with cognitive disabilities to setup and keep up to date. Also pertinent and contributing to the success or failure of a design being adopted or abandoned are the lesser stakeholders discussed above. Often the motivation and goals of these different stakeholder roles can be divergent and even conflict.

Advanced and complex AT for the cognitively disabled can take several forms, which can be classified according to the function that is being supported. Missing or deficient executive functionality and mnemonic lack can be addressed by systems that support task completion [1, 7]; mnemonic difficulty can be alleviated using scheduling systems Peat [29]; missing or deficient communication functionality is addressed by a wide range of augmentative and alternative communication (AAC) devices [5]. A harbinger of future AT for those with more profound cognitive disabilities is an application and environment that aides elders with Alzheimer's in properly washing hands, COACH [34] used video recognition, an instrumented bathroom and AI to detect deviation from proper handwashing process and guided the end-user back on track.

AT: Adoption and Abandonment

Device rejection is the fate of a large percentage of purchased assistive technology [23, 24]. Caregivers report that difficulties in configuring and modifying configurations in assistive technology often leads to abandonment[1] [26], an especially poignant fate considering that these sorts of systems may cost thousands of dollars. Some experts estimate that as much as 70 percent [33, 42] of all such devices and systems are purchased and not used over the long run, particularly those designed as a cognitive *orthotic* [31] . Causes for abandonment have many dimensions; a study by Phillips and Zhao reported that a "change in needs of the user" showed the strongest association with abandonment [39]. Thus, those devices that cannot accommodate the changing requirements of the users were highly likely to be abandoned. It then follows logically (and is confirmed by interviews with several AT experts [6, 25]) that an obstacle to device retention is difficulty in reconfiguring the device. A survey of abandonment causes lists "*changes in consumer functional abilities or activities*" as a critical component of AT abandonment [20]. A study by Galvin and Scherer states that one of the major causes for AT mismatch (and thus abandonment) is the myth that "*a users assistive technology requirements needs to be assessed just once*" [45]; ongoing re-assessment and adjustment to changing needs is the appropriate response. A source for research on the other dimensions of AT abandonment, and the development of outcome metrics to evaluated adoption success is the ATOMS project at the University of Milwaukee [41].

Successful AT design for this population must support the interface requirements for users with

[1] There is another kind of abandonment, which is not using the system or device because the need no longer exists. This "good" abandonment of AT is not in the purview of the current study.

cognitive impairments as well as view configuration and other caregiver tasks as different and equally important requirement for a second user interface[15]. One proven approach applies techniques such as task-oriented design [30] to mitigate technology abandonment problems. Research [17] and interviews [25] have demonstrated that complex, multifunctional systems are the most vulnerable to abandonment due to the complexity of the many possible functions.

*Abandonment Based on the "*Universe of One*"*

People with cognitive disabilities represent a *"universe of one"* problem [17]: a solution for one person will rarely work for another. The "*universe of one*" conceptualization includes the empirical finding that (1) *unexpected islands of abilities* exist: clients can have unexpected skills and abilities that can be leveraged to ensure a better possibility of task accomplishment; and (2) *unexpected deficits of abilities* exist. Accessing and addressing these unexpected variations in

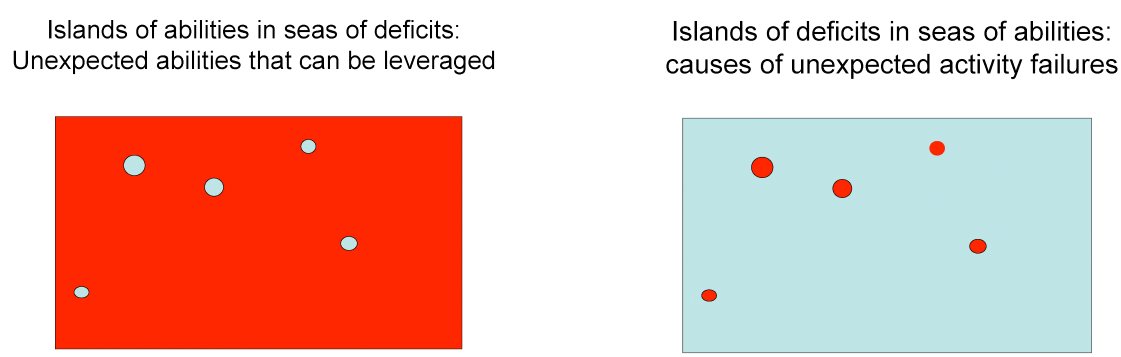

Figure 1 - Universe of One

skills and needs, particularly with respect to creating task support, requires an intimate knowledge of the client that *only caregivers* can provide [16]. The consequence of the high rate of device abandonment [39] is that the very population that could most benefit from technology paying for expensive devices that end up in the back of closets after a short time.

AT for cognitive disabilities (and to a lesser degree all AT) presents unique design challenges stemming from being in the intersection of assistive technology and cognitive science. One aspect of this is that due to the distance between the experience of the designer and the end-users systems are often inappropriate or ineffective in real context of use. In attempting to understand the needs of the user and the task to be performed the system designer can take one of two naive approaches: he can extrapolate from his own personal experience of someone who needs support in their day to day life because of cognitive disability, say a child or parent or perhaps a cousin. Through daily contact the designer produces a cognitive support that perfectly fits their end-user. The problem here is that since the universe of one property characterizes the solution space of this population, the system does not generalize will and can easily fail to be adopted by others. Another class of designers may approach the problem theoretically and gain understanding of the needed system through formal and academic studies of cognition and cognitive disability. The result is often elegant, intricate systems that often were abandoned or not even brought to market due to unfamiliarity with the complexity and environmental demands. One could label these two problems “I've got a cousin and I’ve got a theory”.

Socio-technical enviroment (STE) development and theory

The development of the socio-technical approach to technology system design is well-documented [14, 37]. Looking at technology and its use in STEs came out of the Tavsitock group in post war England. STE’s are composed of two basic elements, the technical part and the social part. The technical subsystem comprises the devices, tools and techniques needed to transform inputs into outputs in a way that enhances the economic performance of the organization. The social system comprises the employees (at all levels) and the knowledge, skills, attitudes, values and needs they bring to the work environment; additionally the socio element encompasses the relations between the social roles, including authority and legal dimensions. By looking at the world of work as a whole system and placing equal emphasis on productivity and ethics the early advocates of the socio-technical method were able to elicit detail and dynamics of the elements of the system that previous Taylor [49] oriented industrial engineers had missed. Further by utilizing a psychological perspective without class bias they were able analyze the system with a raw honesty that the earlier industrial researchers missed owing to their allegiance to using only an emic (the story that the management tells about the institutions operation) perspective in contrast to the STE's more etic (the actual behaviour of the system as perceived by an outsider) examination style.

By explicitly concerning themselves with the human values, STE practitioners included as part of evaluation of a work environment, items such as this list from Albert Cherns as reported in Mumford [36]:

> Principle 8 “Design and Human Values” High quality work requires':
>
> - Jobs to be reasonably demanding
> - An opportunity to learn
> - An area of decision making
> - Social support
> - Opportunity to relate work to social life, and
> - A job that leads to a desirable future

By also concerning themselves with the more operational aspects of work systems, such as proper location of boundaries where knowledge are shared and the need for minimal yet adequate design of the process advocates of the STS approach argues that ethical concerns and efficiency were not mutually exclusive goals in work process design.

Implicit in this approach is a belief in the importance of humanistic principles, and that one of the main tasks of the system designer is to enhance the quality of working life and the job satisfaction of the employee. In turn, they felt, the achievement of these objectives will enhance

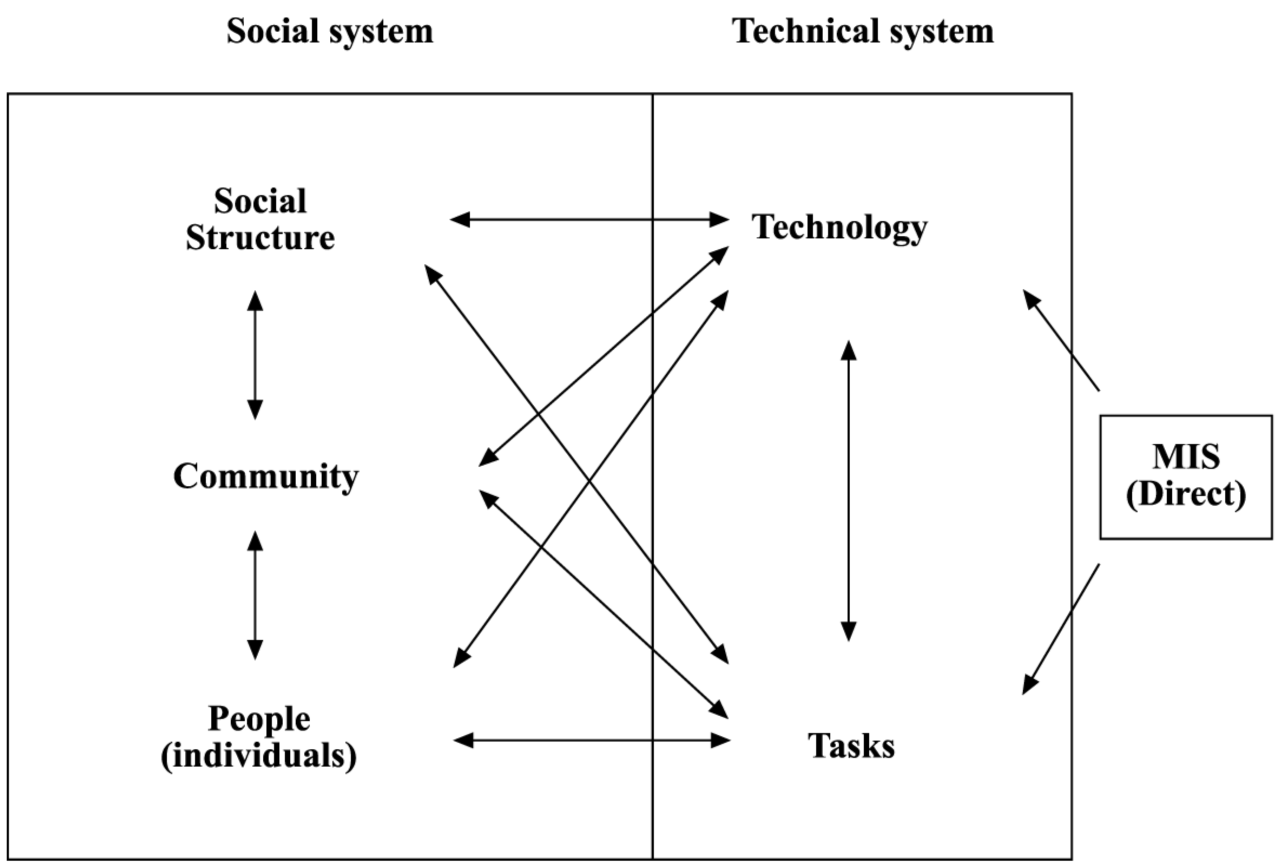

Figure 2 - The elements of a socio-technical system

productivity and yield added value to the organization. At root the contribution of socio-technical design was to place the rights and needs of the employee as high a priority as those of the non-human parts of the system. What resulted were diagrams like figure 2 above, where the employees are equal parts of the study rather than instruments of connection or as another machine to transform raw material.

Classical dimensions of concern to STE analysis are job enrichment, job enlargement and rotation, Motivation, Process improvement, Task analysis, and Work design. When performing an STS analysis, the following questions can be asked of stakeholders and workers [40]:

- What aspects of the social system do people wish to change or leave behind?
- What aspects of the social system do people wish to retain or strengthen?
- What aspects of the social system should be created which do not currently exist?
- To what extent does the management support the new changes? Is this support adequate?
- What are the norms governing interactions among groups of people in this organisation (supervisor-worker, co-workers, skilled-unskilled workers, etc)
- What does new staff need to know to perform well in the organisation? Is this support and information provided in an appropriate and timely manner?

The STS analysis generally comprises the following set of tasks:

- Identify the Key Performance Indicators[1],
- The layout of the system of how materials pass through the people and processes and the physical/departmental boundaries that currently exist,
- Identify current business units which perform groups of steps separate to each other,
- Collect data on variances which occur in each step of the conversion process,
- Construct a variance matrix displaying interrelationships among variances within and across business units,

[1] Key Performance Indicators (KPI) is financial and non-financial measures or metrics used to help an organization define and evaluate how successful it is.

- Identify key variances that have the greatest impact on success criteria or that cause many other variances to occur,
- Suggest technical changes to achieve better variance control, e.g., technical changes to improve information systems to enhance feedback to employees,
- Suggest social changes to make the work more challenging and meaningful, e.g., allowing staff to be more involved in making the technical process run more smoothly,
- Share analysis and discussions of findings with the rest of the organisation to allow individuals to feel greater autonomy in the process of change.

Frey [19] posits four aspects of STE's (or in his case he calls them socio-technical-systems (STS): 1) STE components are interrelated and interact so that a change in one component often produces changes in the other components and in the system as a whole. 2) STE have different components (i.e. hardware, surroundings, software, groups and roles), which interact with one another.3) Socio-Technical systems embody values, and this embodiment can be identified in specific components in the system and 4) STEs change, and this change, referred to as a trajectory, reveals internal relationships and must be accommodated and perhaps canalized for the system to succeed in all the dimensions of measurement (i.e. efficiency and satisfaction). The developers of 'classical' socio-technical theory created a number of frameworks and tools for analyzing and designing socio-technical systems. Enid Mumford, one of the seminal workers in socio-technical analysis developed an approach to system analysis and design called the ETHICS method [37], ETHICS consists of a series of steps that progressively involve the various stakeholders in the design and adoption of a new system. ETHICS is a 15-step process:

Step 1 - Why change? (The motivation for a new system – what is wrong?)
Step 2 - System boundaries (scope of problem)
Step 3 - Description of existing system

Step 4 - Definition of key objectives

Step 5 - Definition of key tasks

Step 6 - Key information needs

Step 7 - Diagnosis of efficiency needs

Step 8 - Diagnosis of job satisfaction needs

Step 9 - Future Analysis

Step 10 - Specifying and weighting efficiency and job satisfaction needs and objectives.

Step 11 - The organizational design of the new system

Step 12 - Technical options

Step 13 - The preparation of a detailed work design

Step 14 - Implementation

Step 15 – Evaluation

Steps seven and eight nicely bracket the whole of the redesign goal, both technical (efficiency) and social (job satisfaction).

William Frey [19]developed a set of dimensions to analyse socio-technical systems. This grid allows both across system comparison and provides a basis for making system design decisions and roadmaps for change. The elements of his analysis are: hardware, software, physical surroundings, people (groups and roles), procedures, laws, and data and data structures

Of particular use to analysis of large and seemingly amorphous systems is the STE Network Model approach. In this approach the researcher use graph modelling methodology to map out elements and known relations between them, and in the process may find existing implicit connections and missing, but necessary for optimal performance, functional elements and connections [46]

Enid Mumford in her book Redesigning Human Systems [36] presents several personal cases of STE analysis and STE supported design. Following the guideline in the STE approach of understanding current work practices before attempting to re-engineer the system; Mumford closely observed the process getting to know the participants, environment and procedures. Her techniques, in one case of getting a job of a canteen worker in a loading dock area, while not formally using ethnographic protocols, approximated classical ethnographic work. Ethnographic participant observation[3, 4] becomes highly relevant in understanding both the present process and the iterative design and implementation of new processes. Mumford's approach to respecting and learning from the current practitioners of a work practice and environment is echoed in a quote from Mao Tse Tung she presents in her book[36]:

> *Go to the practical people and learn from them: then synthesise their experience into principles and theories; and then return to the practical people and call upon them to put these principles and methods into practice so as to solve their problems and achieve freedom and happiness.*

AT design and use example – MAPS

Introduction

Individuals with cognitive disabilities are often unable to live independently due to their inability to perform activities of daily living, such as cooking, housework, or shopping. By being provided with socio-technical environments [35] to extend their abilities and thereby their independence, these individuals can lead lives less dependent on others. Traditionally, training has provided support for activities of daily living by utilizing prompting and task segmentation techniques. Clients were prompted through specific steps in their tasks in a rehearsal mode and were expected to use the memorized instructions later on in their daily lives.

The research that produced MAPS was driven by three related topics of interest:

- To gain a fundamental understanding of how people with moderate to severe cognitive disabilities perceive and use information in prompting systems for tasks on mobile handheld devices;

- To engage in a theoretically grounded development process of socio-technical environments supporting mobile device customization, personalization, configuration by caregivers (meta-design) and effective use by clients (distributed intelligence); and
- To analyze and assess the process of adoption of MAPS by dyads of clients and caregivers.

MAPS[8] was one of a number of applications and frameworks developed by the Cognitive Lever (CLever) project [11], a research group within the Center for LifeLong Learning and Design [27](L3D) at the University of Colorado, Boulder.

Identifying the Client Community. An individual with cognitive disabilities is defined by the Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV) [2] as a person who is *"significantly limited in at least two of the following areas: self-care, communication, home living social/interpersonal skills, self-direction, use of community resources, functional academic skills, work, leisure, health and safety."* Four different degrees of cognitive disability are defined: mild, moderate, severe, and profound. The target populations for MAPS are individuals with cognitive disability in the mild (IQ 50-55 to 70) and upper range of moderate (IQ 35 to 55) levels.

Independence. Independence emerged as one of the critical concepts in our research. Clients have the desire to live independently without the need for help and supervision by caregivers (similar to the desire expressed by elderly people [38]). This independence from human "coaches" is achieved with the availability of innovative tools supporting a *distributed cognition* approach [13].

Schank and Abelson [44] describe human behaviour in terms of goals and scripts. A script is a description how a goal is attained, scripts can be broken down into sub-scripts and eventually into ‘atomic’ steps. These scripts are typically internal to the person acting on them. However they can be looked at another way. In training and rehabilitation of person with cognitive disabilities professionals often train person with cognitive disabilities to accomplish ADLs by splitting ADL tasks into discrete steps that the client can easily accomplish and then teaching the task as a set of these kinds of tasks sequentially linked together <ref> [43]. The client then memorizes this sequence of steps and then has the ability to do a task that she could not do previous to the training. Such a set of steps is called a script and the individual steps are called prompts. By moving this process out of internal representation into a computationally based system the learning is moved from that to learning the task scripts one by one to learning how to use the script player (implemented on a PDA); such a transfer of necessary skills is part of the process of distributing of cognition [22, 47]. Distributed cognition is also in play in the change from memorizing long texts (Koran, Iliad) to acquiring the ability to read these texts in written form; thus acquiring the distributed cognition skill of reading effectively enables a person to “memorize” as many texts as there are books. In this case the steps are presented, as prompts constituted form an image and a verbal instruction. Tailored exactly to each person with cognitive disabilities some tasks are represented with many more prompts (corresponding to the clients lack of internal sub-task knowledge) or less prompting steps (corresponding to a client having more internal sub tasks) [9]. So the clients’ limited internal scripts are complemented by powerful external scripts [12].

MAPS research has explored independence specifically in the following contexts: (1) to extend the ability to choose and do as many activities of daily living as possible; (2) to be employed, but without the constant or frequent support and supervision of a professional job coach; and (3) to prepare meals and to shop for weekly groceries. Independence is not at odds with socialization; it is the foundation of inclusion and engagement in society.

The MAPS Environment

MAPS [10] consists of two major subsystems that share the same fundamental structure but present different affordances for the two sets of users: (1) MAPS-DE, for caregivers, employs web-based script and template repositories that allow content to be created and shared by caregivers of different abilities and experiences; and (2) MAPS-PR, for clients, provides external scripts that reduce the cognitive demands for the clients by changing the task.

The MAPS-Design-Environment (MAPS-DE)

The scripts needed to effectively support users are specific for particular tasks, creating the requirement that the people who know about the clients and the tasks (i.e., the local caregivers rather than a technologist far removed from the action) must be able to develop scripts. Caregivers generally have no specific professional technology training nor are they interested in becoming computer programmers. This creates the need for design environments with extensive end-user support to allow caregivers to create, store, and share scripts [18]. Figure 3 shows MAPS-DE for creating complex multimodal prompting sequences. The prototype allows sound, pictures, and video to be assembled by using a film-strip-based scripting metaphor.

Figure 3 The MAPS-Design-Environment for Creating Scripts

MAPS-DE supports a multi-script version that allows caregivers to present the looping and forking behaviour that is critical for numerous task support situations. MAPS-DE (see Figure 3) was implemented on a Microsoft OS (Windows 2000 or XP) platform connecting to and supporting PDAs that run the WIN-Compact Edition (WIN-CE) operating system.

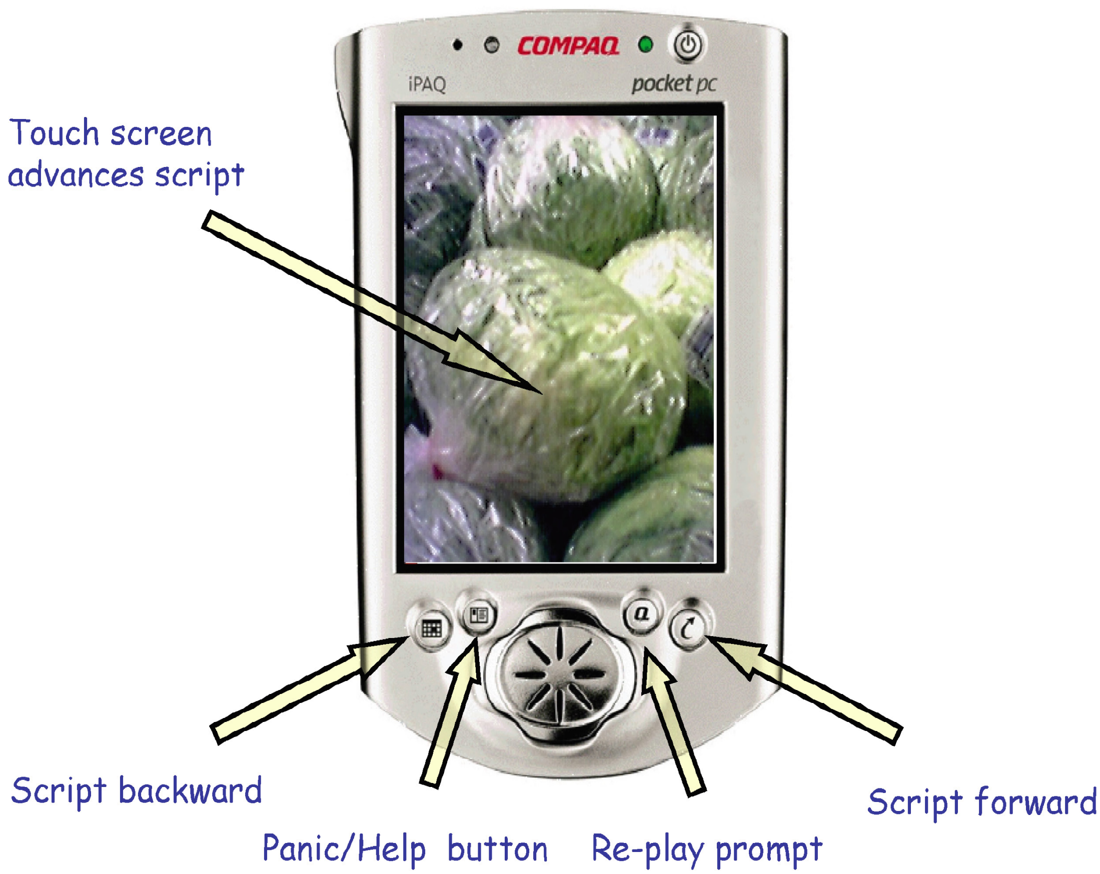

Figure 4 - The MAPS Prompter (MAPS-PR)

The MAPS-Prompter (MAPS-PR)

MAPS-PR presents to clients the multimedia scripts that support the task to be accomplished. Its function is to display the prompt and its accompanying verbal instruction. MAPS-PR has a few simple controls (see Figure 4): (1) the touch screen advances the script forward one prompt; and (2) the four hardware buttons on the bottom, which are mapped to: (i) back up one prompt, (ii) replay the verbal prompt, (iii) advance one prompt, and (iv) activate panic/help status. The mapping of the buttons to functions is configurable to account for the needs of individual users and tasks.

The current platform for the MAPS-PR is an IPAQ 3850. The system was implemented for any machine that runs the WIN-CE operating system. MAPS-PR has been installed on units that have cell phone and GPRS functionality. The prompter software was originally written in embedded Visual Basic, and then ported to the faster and more flexible C# .net environment. The prompter software supports single-task or multi-task support.

Ethnographic design

Because MAPS was intended to be used by a population with abilities and needs very different from the designer and programmer on the project, the initial steps of the design process were to gain understanding of the end-users and their tasks. Various ethnographic approaches were used to support this. Initially spent time was spent with professional caregivers and teachers who specialized in working with young adults with cognitive disabilities. The object was to understand the young adult with cognitive disabilities and their caregivers, both in day-to-day life and in contexts where they might use MAPS. By doing ethnographic participant observation [28] the MAPS designers gained an understanding of the young adult with cognitive disabilities abilities and preferences that informed the prompter design. The observation process also provided example tasks that MAPS could support, as well as provide details about the environment the tasks would be accomplished in. By observing and analyzing the observations of the interactions between the end users and caregivers in daily life the relationship dynamics were exposed in a way the simply gathering formal requirements for a software project could not do [28].

In practice what this meant was spending about 20 contact hours with each dyad, 10-15 hours with just the young adult with cognitive disabilities and a lesser amount with just the caregiver and the balance with the caregiver **and** the young adult with cognitive disabilities. The goal was to learn how each of them interacts with the world and each other. One way this paid off was the discovery that sometimes the verbal prompts should not be recorded by the caregiver, especially so in the dyad consisting of a mother and 16 year old daughter who had typical adolescent power issues; this highlighted the fact that although these end-users were developmentally disabled they would often go through the same changes in realtionsships within their family as their non-developmentally disabled siblings. Spending time with the caregiver gave the designer a better idea of the level of PC expertise that would be available and also helped to give the caregiver realistic expectations for the MAPS system. Most importantly participant observation gave a window into how task accomplishment was currently being supported and provide a reference against which MAPS could be measured.

Having produced a prototype the second part of the MAPS project was to study the initial use, iterative design changes and final adoption of the system in a real world context. With each dyad there was a process of generation and use increasingly challenging set of scripts. The content and environment of the scripts was typically from simplest to most complex:

- Controlled environment (e.g., a housekeeping chore), in which neither the task nor the environment is dynamic and the environment is familiar;
- • Less controlled script (e.g., cooking), in which the task doesn't change and the environment is dynamic but familiar;
- • Least controlled script (e.g., shopping), in which the task and the environment are unfamiliar and the environment changes

The first script was also used to familiarize the caregiver with the script design and composition process and the person with cognitive disabilities with the use of the prompter, its controls, and how to follow a script. The final two were designed to simulate, in a real context, increasingly autonomous use of the system. The three-script process allowed changes to be introduced into the system to make it fit better the needs of the task and user. One example was the addition of multiple scripts that could be chosen by the young adult with cognitive disabilities depending on the state of the tasks. Another dyad changed the script between iterations several times to accommodate learned sub-tasks that were initially cued in detailed prompts and now could be called up with a single prompt.

Intersection between AT & STE

The most obvious connection between the STE approach and successful AT design is the equal focus on the mechanical/technical aspects and the human aspects of the whole system. This section will map some of the more specific topics and schemas from the STE literature and AT design.

Mapping the specific parts of the ETHICS method [37] to the process of designing MAPS shows a congruence that might make for a good framework for AT design in general as well as describing the process of choosing and adopting a new piece of AT. Starting with ETHICS first step, *why change?,* which corresponds to the AT professional determining not whether a change is needed, but what form will the intervention take - the disability itself is the motivator for wanting to change. ETHICS next step, *system boundaries,* corresponds to the caregiver and AT expert determining what the person with cognitive disabilities might be able to do with technological assistance, and what they should not attempt to do. ETHICS Step 3, *description of existing system*, which in the STE process describes the procedure of learning the current system (often from the inside out), corresponds to the AT designer studying the work practices and day-to-day details of the person with cognitive disabilities and dyads life, as well as the occupational therapist or special education professional detailing the end-users existing problem solving personal adaptations. All too often high functioning assistive technology in the form of a cognitive prosthetic fails in functionality and/or adoption because the designers naively felt that they understood the needs of the end users, an insight best gained through personal involvement with the person with cognitive disabilities. Similarly both the AT designer and the OT or AT expert that recommends and guides the end-user in obtaining AT need to perform the *definition of key tasks* which includes both teaching task segmentation and the use of a prompter.

The step *future analysis* corresponds to the AT designer explicitly making the AT re-configurable to support future needs; in some cases providing less support to the end-user – in the case of acquisition of sills; in other cases providing more support for greater levels of disability. This step also corresponds to the notion of an STE system accommodating system change, the *trajectory* in STS terms (see Socio-Technical Systems in Professional Decision Making Module by: William Frey) [19]. This lack of support for co-evolution causes much of the abandonment [39] of assistive technology tools. Caregivers, who have the most intimate knowledge of the client, need to become the "programmer/end-user developer" of the application for that person by creating the needed scripts. Similarly, the other steps in ETHICS can be mapped to stages in AT design or adoption.

Successful AT design and STE analysis are both based on worker (end-user) participation and management (caregiver and AT professionals) support. It is only with a base of both of these that the use of and appropriate AT aid can continue past initial use. Suchman [48] describes the actual trajectory of attaining a goal as being heavily dependent on *situated action*- on accommodating changes in the context and requirements to attain a given goal. Therefore both STE systems and successful AT must be able to accommodate change in use, what Frey and others [19, 21] refer to as *trajectory*. For a STE to continue to be relevant and appropriate it must adapt to coordinated sets of changes within the socio-technical system. This coordinated series of changes in an STS is called a trajectory. Trajectory must fit situational needs if STN's can support/withstand change. It is also a quality of successful AT for persons with cognitive disabilities such that it must reflect change as the system does not need to fit into 'artificially' created (and thus stable) work practices but into the world as it is, which is constantly changing. In the case of MAPS, the ability of the caregiver to edit the MAPS scripts, enlarging them if there is greater need, compressing them in the case where sub-tasks become learned.

Decomposing AT into STE grid

Frey [19]uses a schema to analyze socio-technical systems that divides the system into seven components. These parts: hardware, software, physical surroundings, people (groups or roles), procedures, laws, data (and data structures) give a good staring point for comparing different STEs and also for clarification of the interaction between the technical and social dimensions of an STE. Following is the decomposition of the MAPS system:

Hardware: MAPS uses a PC for its MAPS-DE script-designing tool, feeding the script composition are recorded voice prompts and images collected by a digital recorder and camera, respectively. MAPS scripts are played on by the MAPS-PR on a PDA or smart phone that runs one of the mobile versions of the windows operating system.

Software: The MAPS system software consists of the MAPS-PR script player and the MAPS-DE script editor. Optionally, in addition to these (and in support of them) are an image editor for the pictures illustrating the prompt and an audio editor for the verbal prompts. Behind these are the windows desktop and small device operating systems. Because one of the functions not disabled in the PDA was the MP3 player (to motivate retention of the PDA), the MP3 player application was also sometimes used. Additionally some caregivers used a text editor (like MS Word) for preliminary script design. The scripts themselves were stored in a Sybase database on the PC and PDA, as well in as in a MAPS script template server that held pre-outlined typical scripts accessible in the Internet.

Physical surroundings: MAPS was used in two kinds of environments. The MAPS-RP was used wherever the end-user was performing tasks with the aid of the scripts prompting. In the initial trials of MAPS these ranged from the end-users home to a school to employment (i.e. in a used clothing store). As well as the MAPS-PR being used in these spaces, the caregiver would photograph prompt visuals in them for script creation. The prompts were most often recoded in the home, or in the case of the job coach, the office of the caregiver. In the case where the MAPS-PR PDA was being used as a MP3 player, the location varied with the path of the end-user through the day.

People: The list of people includes not just individuals (roles) but also groups of people (groups). These include the designers of the MAPS system and the end-user co-designers. Central to the socio-technical system are the end-user (also referred to as the MAPS-PR-users, a person with cognitive disabilities, and the client) and the day-to-day caregiver, who may be a family member or a professional caregiver paid for by insurance, the family, or the state. Influencing the system at a remove are AT experts, special-ed experts and teachers (in the case of a young adult with cognitive disabilities), insurance personnel and state funding staff. At a further remove, but still very much affecting the system are school administrators and employers. Finally intimate influencers of the system are the end-users immediate family and friends, as well as their peer groups (either in school or employment).

Procedures: There are several kinds of procedures in MAPS, in setting up the system and in using it to guide task performance. Included in the tasks required to setup the system are task segmentation (i.e. breaking the task down into sections that are of the correct cognitive level), task rehearsal (i.e. performing the task your self to ensure no implicit steps are left out), and script building. The construction of scripts (after the outlining has been done) requires collecting photographs of the task with a digital camera and recoding the verbal prompts with a computer and mike. The caregiver must master the art of using the MAPS-DE using the provided tutorial. Script assembly requires using the MAPS-DE editor and the operating system to identify and insert script steps into the script database.

Next the caregiver has to transfer the script to the MAPS-PR from the caregivers PC. The end-user has to initially learn how to use the prompter by working with the caregiver and perhaps the MAPS designer- support personnel. The young adult with cognitive disabilities is then ready to use the script on the MAPS-PR to accomplish the task, which is embedded in the larger set of ADL and IADL tasks that she can do without external support.

Finally the caregiver has to review the script log to see if the script needs to have certain steps collapsed into a trigger step (collapsing scaffolding) or expended into several additional steps because the end-user found performing them too difficult (expanding scaffolding).

Laws, statutes, and regulations: The MAPS system is not impacted by laws and regulations except inasmuch as it’s purchase can aided by state funding.

Data and data structures: MAPS stores external wave files (for the recording prompts) and jpg files (for the prompt images) in the caregivers PC. Completed scripts are stored in a Sybase database on the caregivers PC and scripts on the MAPS-PR are stored on a mobile lightweight version of the Sybase database. Additionally a Sybase database of template scripts is stored on a networked server, accessible through the Internet. Design documents used in creating scripts (i.e. task segmentation notes) may be stored in text documents. MAPS-PR stores a log produced of the use of a given script in a text file for later analysis.

Table 1 - Comparing Industry and AT as STE

	Hardware	Software	Physical surroundings	People (Groups and roles)	Procedures	Laws	Data and data structures
AT example (MAPS)	PC and PDA prompter	MAPS-DE and MAPS-PR	Caregivers home, end-users world	Client Caregiver Maps developer AT special ed experts	Creating and editing a script Using prompter to do a task Segmenting a task	Privacy and copyright laws	Scripts database Folder of images Folder of recorded prompts
Industry example – Volvo from [36]	Assembly tools	Worker protocols	Automobile factory	Workers, management, line supervisors, workers families, researchers	Assembling automobiles, updating work practices, updating team practices	Worker rights, economic realities, contracts	Assembly an bills of materials, lean production artifacts

One difference between the two domains is in motivation to participate in a new STE system. In industrial implementations of a new STE the employee's critical element of motivation to work within the new system is an economic incentive: in order to continue holding employment the employee must embrace the STE; this can be called 'the compulsion motivation'. In contrast the adoption of AT like MAPS is driven by a desire of independence and extended ability to participate in ones own life. Failure of the system results in abandonment, so on one side there is a degree of economic compulsion and on the other the motivator of adoption.

Finally in our comparison between AT design and adoption and traditional STE analysis there is in both a concern of studying work-practices or in the case of AT, the activities of ADL and IADL, as they are. Therefore both disciplines use varying forms of ethnography and base their theoretical analysis on both foreground (worker/person with cognitive disabilities) and background (environments, rules, and technologies).

Conclusion

Good AT design is then best approached from the STE perspective. The creation of AT for persons with cognitive disabilities is particularly a STE issue due to the complexities of relationship and invasiveness of the technology. Following on this is the question of how best the STE approach can be formalized in AT design. Frameworks such as the ETHICS method [37] and the decomposition into facets as presented by Frey [19] would be good places to start, most useful is the emphasis on ethnographic study forming the basis for understanding the potential and requirements of the situation. An explicit drawing out of stakeholders' roles and investments in the whole system is illustrated in the several ethnographic studies in Mumfords works. Illustrating a similar approach is MAPS inclusion of the caregiver's role and interface design which naturally flows out of approaching the problem from a STE perspective, a concern that is often missing in other high functioning but low adoption systems.

Developing an explicit checklist set of heuristics to incorporate STE perspective in AT design is another approach that may roll back the tremendous problem of abandonment; this chapter is an attempt to do just that. Finally STE's systemic approach of acknowledging the dynamic interaction between user, artifact, environment and tasks is critical for good AT design.

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