

Tools for Living and Tools for Learning

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Abstract

This paper interweaves the notions of distributed intelligence and scaffolding with fading in discussing the nature of the modes of use of artifacts as tools, particularly computational artifacts. We introduce the notions of *tools for living* and *tools for learning* as parts of a framework for evaluating how artifacts are used and as broad guidelines for the design of artifacts. The tools concept is then studied in the context of the Memory Aiding Prompting System (MAPS) for supporting persons with cognitive disabilities in daily living tasks. Finally, the paper investigates the cultural implications of the use of both kinds of artifacts.

1 Introduction

The CLever (“**C**ognitive **L**ever: Helping People Help Themselves”) (CLever, 2004) research project at the Center for Lifelong Learning and Design (L3D), University of Colorado (supported by the Coleman Institute) develops *socio-technical environments* to support caregivers and persons with cognitive disabilities. CLever’s goal is to create more powerful media, technologies, and supportive communities to support new levels of distributed intelligence (Carmien *et al.*, 2005a). This support is designed to allow people with disabilities to perform tasks that they would not be able to accomplish unaided. The objective is to make people more *independent* by assisting them to live by themselves, use transportation systems, interact with others, and consistently perform normal domestic tasks such as cooking, cleaning, and taking medication.

Our research identified and explored a fundamental distinction in how we think about the empowerment and augmentation of human beings (Engelbart, 1995) and the change of tasks in a tool-rich world by identifying two major design perspectives:

Tools for Living: grounded in a “distributed intelligence” perspective, in which intelligence is mediated by tools for achieving activities that would be error prone, challenging, or impossible to achieve
Tools for Learning: grounded in a “scaffolding with fading” perspective leading to autonomous performance by people without tools

Even though this fundamental distinction is firmly grounded in our work with people with cognitive disabilities, it transcends the work with these communities, *It raises the fundamental question concerning what it means to learn in the 21st century in which powerful tools are available for many intellectual activities—allowing people to have instant access to facts, assisting people in spelling, doing arithmetic, and performing numerous other intellectual activities* (Pea, 2004). Therefore, our research makes fundamental contributions not only to a conceptual framework for designing more effective assistive technologies, but also to the future of education, learning, and the development and use of new media in general (Bransford *et al.*, 2001). The paper discusses the implications of this fundamental distinction and the derived framework guiding the development of socio-technical environments.

2 Distributed Intelligence

In most traditional approaches, *human cognition* has been seen as existing solely “inside” a person’s head, and studies on cognition have often disregarded the physical and social surroundings in which cognition takes place. *Distributed intelligence* (or *distributed cognition*) (Fischer, 2003; Hollan *et al.*, 2001; Salomon, 1993) provides an effective theoretical framework for understanding what humans can achieve and how artifacts, tools, and socio-

technical environments can be designed and evaluated to empower human beings and to change tasks. Applying this framework to people with *cognitive disabilities in design-for-all approaches* (Newell & Gregor, 1997) creates new and unique challenges, and in return it will create a deeper understanding of distributed intelligence.

Minds Are Improvable. Anatomy and cognitive abilities are not destiny (Fischer, 2003)—an important intellectual or philosophical grounding of the vision and mission of our CLever project is provided by Postman (Postman, 1985): “*The invention of eyeglasses in the twelfth century not only made it possible to improve defective vision but suggested the idea that human beings need not accept as final either the endowments of nature nor the ravages of time. Eyeglasses refuted the belief that anatomy is destiny by putting forward the idea that our minds as well as our bodies are improvable!*”

Tools for *learning* support people in learning a new skill or strategy with the objective that they will eventually become independent of the tool. Tools for learning afford an internalization of what was (if it existed previously at all) an external ability/function; tools for learning often serve a scaffolding function (Pea, 2004).

In contrast, tools for *living* are external artifacts that empower human beings to do things that they could not do by themselves. A tool for living supports distributed intelligence; that is, it serves as an artifact that augments a person’s capability within a specific task without requiring the individual to internalize the sub-tasks conducted by the artifact (e.g., a hand calculator). Tools for living can be tailored for specific tasks and for specific persons.

Internal and External Scripts. The differentiation between tools for living and tools for learning is closely related to a similar fundamental issue: the interplay and integration between *internal and external scripts* (Carmien *et al.*, 2005c). *Internal scripts* are chunks of mastered acquired behavior that can be executed without the need for external support. *External scripts* are instructions that afford the accomplishment of more complex tasks by triggering internal scripts to execute the externally cued steps. Tools for living exploit the *interplay and integration between internal and external scripts*. In contrast, the goal of tools for learning is to acquire new internal scripts, thereby becoming independent of external scripts.

3 Tools for Learning

Looking at the relationships between humans and the artifacts they use, tools or systems can be seen as primarily either supporting human adaptation or providing support for humans to effect change in their environments. Thinking about systems and artifacts in this way affords insights into distributed intelligence, the design and use of artifacts, and educational decisions about learning and teaching of skills with and without tool support. Some



Figure 1: Learning to Ride a Bicycle with Training Wheels — An Example of a Tool for Learning

artifacts support people by providing guidance and then gradually removing assistance until the skills become internal scripts, accessible without external assistance. Examples of such *tools for learning* are: (1) bicycles with training wheels (see Figure 1), (2) toddlers' walkers, (3) wizards used in many computational environments, (4) experienced teachers providing help and assistance to learners and (5) caregivers assisting people with disabilities.

4 Tools for Living

Some artifacts enable users to perform tasks that are impossible for them to do unaided. Often, no matter how many times the task is accomplished with the aid of a tool, the user has no greater ability to do the task unaided than she or he did initially. Examples of these tools for living include ladders, eyeglasses, the telephone, screen readers for blind people, visualization tools, and adult tricycles (see Figure 2). No matter how many times people use the phone to talk to friends across town, their native ability to converse over long distances unaided remains the same as before they used the telephone. Tools for living allow people with disabilities to perform tasks that they would not be able to accomplish unaided, and therefore allows these people to live more independently.



Figure 2: Adult Tricycle — An Example of a Tool for Living

5 Memory Aiding Prompting System (MAPS)— A Socio-Technical Environment Supporting People with Cognitive Disabilities

The “minds are improvable” perspective underlying this paper has led to several major system developments in our CLever research project, including: (1) Memory Aiding Prompting System (MAPS) (Carmien, 2004), (2) Lifeline (Gorman, 2005), and (3) Mobility for All (Sullivan, 2005). This paper focuses on MAPS (the other two systems are described in (Carmien et al., 2005a)).

Prompting has long been used as a technique to aid persons with cognitive disabilities to live more independently. With the advent of computationally based prompting systems, the image and verbal prompts that lead a user through task completion can now be highly personalized, and the need to memorize the steps to a task is off-loaded to the computerized prompter (in this case, an HP IPAQ h6315), thus changing the task from memorizing scripts of prompts to accessing the appropriate script and following the prompts as they are presented. Our prompting system consists of the caregivers script editor, which supports the creation and storage of scripts consisting of pairs of images and verbal prompts, and a handheld prompter, which is used by the person with cognitive disabilities and presents the previously made scripts. The prompter also communicates its status to the Lifeline server, which provides an interface to a caregiver as each step of the task is completed, as well as supporting error detection and correction functions. As described, the use of MAPS and Lifeline constitutes a socio-technical environment (Figure 3), comprising humans and their artifacts configured and interacting for the purpose of effecting a goal; in this case,

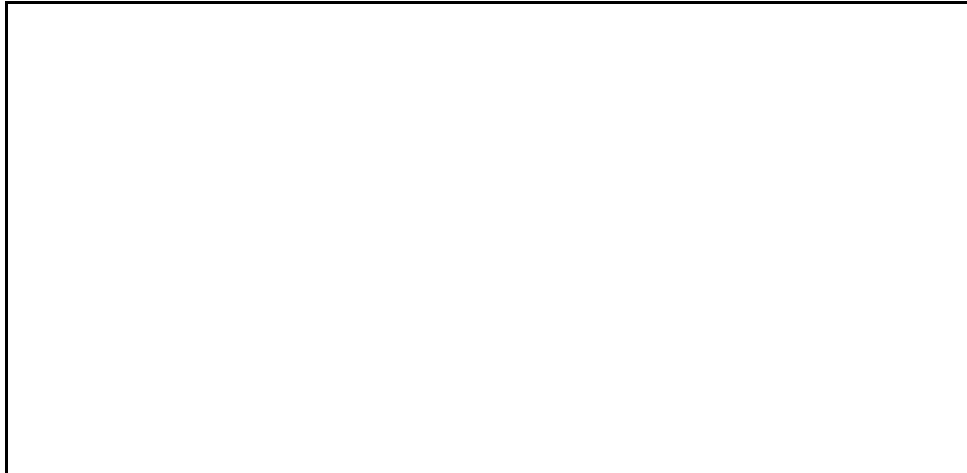


Figure 3: The Architecture of the MAPS Socio-Technical Environment

the goal is living more independently, providing safety and inclusion for both the persons with cognitive disabilities and caregivers. The timeline in Figure 3, from left to right, illustrates the caregiver creating a script with the script editor, downloading it to the prompter, and the completed script being used by the person with cognitive disabilities to complete a task.

These specific developments are grounded in our theoretical framework, and in return these systems have helped to refine and evolve the theoretical framework. To create the most supportive external scripts, we have identified the different internal scripts of our users. With this insight, we are creating “script design environments” for caregivers to design effective external scripts that match the internal scripts, thus allowing people to do more interesting things. Equally important is the determination of the cognitive requirements needed for the interpretation of specific external scripts.

5.1 MAPS as a Tool for Living

MAPS was designed as a tool for living inspired by the Visions System (Baesman & Baesman, 2000), a stationary prompting and scheduling system based on PCs using speakers and stationary touch screens to prompt a user with cognitive disabilities through a complex domestic task such as cooking. The Visions System supplied sets of cards that assisted away-from-the-system tasks such as grocery shopping. Although Visions worked, it had problems with configuration, and was not able to go with the user out of the home in which it was installed (other than the sets of cards). The MAPS user interface is twofold: the actual user and the caregiver. As a tool for living artifact, the initial setup was critical, and special care was paid to functions that aided the caregiver in conforming to the needs and abilities of the prompter user. The initial configuration supports specifying image and verbal prompt styles: image aspect, verbal prompt complexity, and word choice. The configuration wizard also parameterizes the capturing and correction of errors: how to detect that a script was not being followed, how to detect the problem that caused the error, and what to do to correct the error (some users can assist with self-correction, some will need human intervention (e.g., activating the MAPS cell phone connected to a caregiver), and some will require emergency intervention (e.g., calling 911)).

Because the target population has a limited number of possible “operations,” the set of available scripts should not vary greatly, and the same scripts will be used over and over. Moreover, many scripts for outings will be constructed by reusing sub-scripts (e.g., the steps to “get from getting ready to going out to the closest bus stop” will be repeatedly used). What will change is the timing and, to a small degree, the content of the scripts. For example, MAPS is equipped with a GPS and is networked so that when the user gets to the bus stop, the arrival of a specific bus will trigger the prompt to get on the bus (Sullivan, 2005). As a tool for living, MAPS is expected to support a

specific, small set of tasks and, in this mode, not provide support for autonomous generalization of the skills through which the user is being guided.

Training in using MAPS, just as training in using any tool for living, consists of a simple set of instructions in the use of the tool, not extended to any overview or understanding in the principles involved in doing the prompted through task itself. Similar to instructions for the care and use of contact lenses, in which there is no attempt to explain optics, training in using MAPS does not involve anything about the domain of the tool other than pragmatic ATM-style instructions. This is typical for the change in the task that using tools for living involves. The task now is the use of the tool, not the difficult cognitive tasks of figuring out what to do and when to do it. This task re-mapping is a typical result of bringing a tool for living into play. Another example of this is the change in the details for arithmetic calculator users, who are now experts on using the buttons to input and control the calculator rather than memorizing complicated algorithms for calculating square roots.

Concerns about the robustness of the tool, and concerns about the target population (e.g., what if the user loses it, what if it breaks while the user is in a bad part of town at night?) are part of our research agenda. Any design that allows and encourages a somewhat fragile population into a situation that may be somewhat of a threat in the case of breakdown has a moral responsibility to ensure an elegant decay/failure in such cases. LifeLine (Gorman, 2005) aims to address these concerns by monitoring the use of MAPS and involving a caregiver if necessary (Carmien *et al.*, 2005b).

Creating Tools for Living. A crucial part of MAPS is the script design environment used by caregivers to design effective external scripts that trigger the internal scripts to allow persons with cognitive disabilities to live more independently. Critical to successful design of a tool for living is the initial fit of the device; examples include visits to an optometrist for eyeglass fitting or to a clinic for prosthesis fitting—devices that require precise alignment to the user to operate. In the case of the MAPS system, the handheld user needs images that have the right affordances (Norman, 1993) to allow the correct selection of the desired object. Similarly, the verbal prompts need to have the right level of words and grammar to fit the needs and abilities of the person with cognitive disabilities who is using

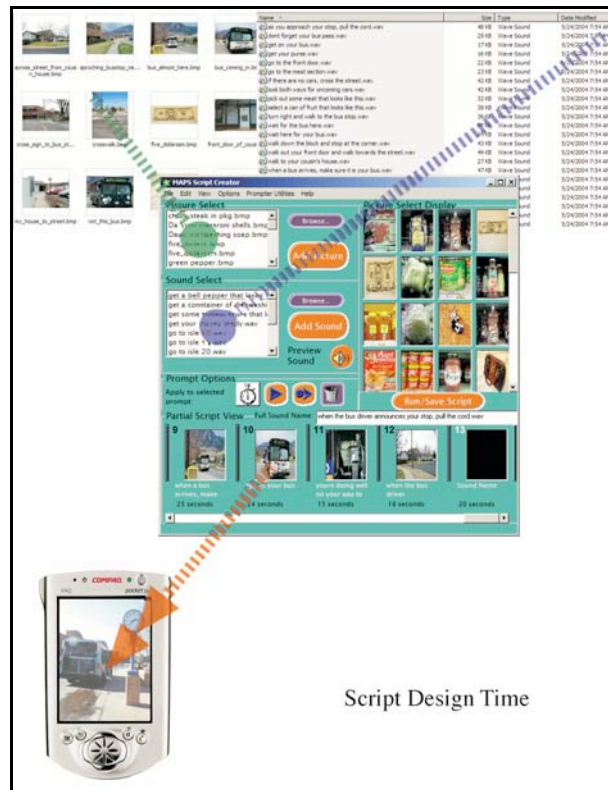


Figure 4: The MAPS Script Editor

the prompter. Generic icons and computer-generated verbal prompts will typically not be as effective as ones tailored to the user specifically (Snell, 1987). Figure 4 shows the caregivers script editor in use: the caregiver builds prompts by selecting from sets of pictures and recorded prompts, and creates scripts from sequential prompts. The finished script can then be loaded into the prompter for use by the person with cognitive disabilities in accomplishing the desired task (see Figure 5). Because this initial fit is so critical to the use of the tool for living, generic script templates, which have been previously used successfully, are provided for caregivers to use as models in producing specific scripts.

Learning to Use Tools for Living. Tools for living will be of no help if people are unable to use them. In the context of MAPS, we are exploring the interpretation of specific external scripts. In designing and using tools for living, two key elements are the initial fit and the correct leverage of existing skills. In the case of MAPS, the caregiver and assistive technologist need to understand what would be the best modality and style for the effective delivery of scripts. Perhaps the user is able to map standard icons to articles in the real world for a shopping script; this would make the creation of scripts much easier than those for the person with cognitive disabilities who needs specific pictures of the exactly the target item. Similarly, some users would respond best to prompts from a familiar authority figure (i.e., mom), whereas for others this might be totally wrong, due to typical teenage power struggles (the user's own voice doing the prompting might be best). Having determined the appropriate modality for the tool, the caregiver needs to assess and fit the prompting structure of the script for the internal scripts that the user may have. For instance, one user may need only an overarching prompt of *"Go to your bus stop"* whereas another may need to have this segmented into three steps: *"Walk down the street to the corner,"* *"Cross the street,"* and *"Turn left and walk to the bus stop in the middle of the block,"* each one of these steps corresponding to an internal script possessed by the user that may be successfully triggered by an external script in the prompting sequence.



Figure 5: MAPS Handheld Prompter and Caregivers Monitor in Use

Another perspective on using tools for living is that once the task that was too difficult to do is remapped to a task that is within the domain of existing skills, there still remains the need to acquire those skills that are needed for the remapped task. An example in the case of MAPS would be replacing the whole task of performing a janitorial job at a restaurant, requiring a series of executive (when to do the subtask) and mnemonic (the specifics of the subtask) actions that constitute the job, with the task of using the controls on the prompter to sequentially trigger the existing internal scripts that would then constitute the whole job. An example from another domain might be replacing the task of memorizing the Qur'an with reading the Qur'an. In both examples there is the need to learn the use of the tool for living, and this learning with the same external support constitutes a tool for learning. In the case of learning the use of the MAPS prompter, in our studies we have observed young adults with cognitive disabilities taking about a half hour; in the case of learning reading, this would take perhaps many thousands of hours.

5.2 MAPS as a Tools for Learning

MAPS is also designed to be used as a tool for learning; even when used in the tools-for-living mode, it will afford some tools for learning functionality. MAPS is designed to accommodate several types of scaffolding fading. The first and most crude form of fading is based on a review of the logs of user behavior that MAPS keeps (with awareness of the privacy issues involved): the caregiver can consequently manually edit a given script, folding several prompting steps into one “reminder” prompt. Next, MAPS could evaluate usage and autonomously, in an algorithmic fashion, compress a script based on logs in a batch mode. Finally, MAPS could dynamically expand or contract the steps required to perform a given task based on past behavior, user input, and immediate history. MAPS is designed to provide scaffolding to augment memory and cognition; as a memory prompt tool, it may just need to “nudge” the user in the correct direction upon determining that an error condition is about to happen (a probabilistic guess, but no harm done if the guess is wrong).

One specific use for MAPS in this context is as a tool for learning to use the public transportation system. A sister project to MAPS is the “Mobility for All” project (Sullivan, 2005), which aims at aiding in the training of less affected persons in learning bus routes and simple employment tasks. As the user repeats the prompted sequence for a typical bus trip over and over, the Mobility for All designers expect that the need for MAPS prompting may fade completely for *that* trip. As the users rapidly scan through prompt sequences, demonstrating that they know the sequence well enough for the start of the sequence to be the only trigger for the whole set of prompted behaviors, the script could be dynamically compressed to remove the now-redundant cues. The mechanism for this compression, embedded in the script editor, could flag to the caregiver that a sequence is ready to be compressed and represented as a single prompt; all of this is triggered by logs of the user’s behavior that the prompter retains and passes through to the script editor.

6 Implications and Future Work

The conceptual framework presented in this paper that differentiates between tools for living and tools for learning provides insight and understanding on several current and historical controversial issues, including the focus on rejection of distributed intelligence in learning and education and the resulting design of socio-technical environments. The basic concern is a very old one: Socrates already expressed apprehension that learning to read would cripple the ability to memorize.

Trade-Off Analysis. As with any category scheme, there are overlaps and differences of interest and use (Table 1 summarizes some of those). The categorization of devices depends only to a small extent on the intentions and viewpoints of designers and developers, but their use is much more profoundly determined by the cultural values of the use situations and the societal organizations that determine them. The inappropriate use of some tools for living has been identified as causing a sort of “learned helplessness” in that the ease and accessibility of using some of these tools inclines the user to not expend the energy and time to acquire these skills internally. Examples of this learned helplessness are the use of hand calculators and spell checkers as tools for living, thus blocking the acquisition by the users of arithmetic and spelling skills, not unlike the above-mentioned example of complaints about reading ruining native human abilities. Much has been written and debated about the use of calculators, spell checkers, and other cognitive tools in education and whether they should be used as tools for living or tools for

learning and how these decisions may be different in the case of children who suffer from permanent disabilities such as dyslexia.

Table 1: Overview of Tools for Living and Tools for Learning

	Tools for Living	Tools for Learning
Definition	Do task with tools	Do tasks without tools
Examples	Eye glasses, phone, radar, cockpits, scuba diving gear	Spelling correctors, hand-held calculators, tricycles, wizards,
Strengths	Extends reach beyond natural ability	Extends unaided reach
Weaknesses	Learned helplessness	Long training time (reading can take thousands of hours to learn)
People with disabilities	Optical character recognition page readers, specialized mice and keyboards, assistive communication devices, adult tricycles.	Learning Braille, learning how to use prompts and prompter, learning a specific bus route
Prompting systems (maps)	For people with memory problems (disabilities, elderly)	For people without memory problems (but: people use calendars on paper, reminding systems)
Distributed intelligence perspective	Resource rich (professional life)	Independent of external resources (school), memorization

Over-reliance on Tools for Living. Does an over-reliance on tools for living lead to learned helplessness and deskilling, ruining the users’ native abilities by making them dependent on the tool? The cautionary point of *The Time Machine* (Wells, 1905) was that the Eloi had lost any power in their world by having too much done for them. It is this fear that leads to a moral judgment about the use of such tools. Asimov (Asimov, 1959) tells the thought-provoking story "The Feeling of Power," in which a scientist who is actually capable of doing simple math problems on paper without the aid of a computer is identified by the military of that distant century and how the military tries to make use of his “newfound skills.” Perhaps the resistance to them is also tied to the 19th century belief that mental deficits were illnesses that reflected moral vices or immoral lifestyles. The logic goes something like this: a calculator is a “crutch” that allows a person to forgo the effort associated with true learning (displaying the moral vice of laziness). There is little doubt that the *inappropriate* use of these devices can lead to “learned helplessness” (e.g., providing screen readers to children with dyslexia has in some cases prevented them learning techniques that may have largely ameliorated the effects of their developmental disability (Olsen, personal communication, 2000)). However, accepting that as a genuine concern does not necessarily lead us to the conclusion that all such technology is bad for humans. The daily life of all of us is filled with an almost infinite number of tools for living.

Future Work: Gaining Experience with Real Users. Currently we don’t have much empirical evidence on MAPS as a tool for living in a real environment; in the coming year, however, we will be performing trials of the system in authentic and realistic environments. Sets of MAPS tools will be provided to pairs of caregivers and persons with cognitive disabilities. We will then follow and document their use in creating and using script support to perform appropriate activities of daily living over several weeks. From these trials, we expect to understand better how people learn to use tools for living, and how, if at all, tools for living exhibit the scaffolding fading characteristic of tools for learning. MAPS is also designed to be a platform for testing another important research concern—the adaptive collapsing of scripts. We will be capturing the timing and state information on the use of well-constructed scripts. Based on the results, we will design algorithmic models of how scaffolding fading and automatic extension could be managed. This phase will help us to empirically assess the relevance of the distinction between tools for living and tools for learning and will also help us to further refine the framework for designing more effectively.

7 Conclusion

We believe that this research on gaining a deeper understanding of distributed intelligence will make fundamental contributions not only to a conceptual framework for designing more effective assistive technologies, but also to the future of education, learning, and the development and use of new media in general. Pea (Pea, 2004) supports our view that this is an important problem to consider by saying: “*I believe that clearly delineating the boundaries*

between scaffolding with fading and more general distributed intelligence without fading is a central problem for the learning sciences and for education, and the argument structures and warrants used in marking these boundaries will be informative — as well as contentious.”

We need new ways of thinking and new approaches about tools for living and tools for learning in which we address the basic question associated with distributed intelligence and the design of socio-technical systems: what tasks or components of tasks are or should be reserved for educated human minds, and which can and should be taken over or aided by cognitive artifacts (Landauer, 1988; Norman, 1993)? Our research efforts are directed to exploit the power of omnipotent and omniscient technology based on reliable and ubiquitous computing environments and an increasing level of technological fluency (supported by socio-technical environments such as the MAPS script editor (see Figure 4) for caregivers) to help people with disabilities in our society to lead a more rewarding and enjoyable life. Our research efforts are directed at using this understanding and the resulting socio-technical environments to the benefit of all people.

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