FOCUS ON GENERIC SKILLS FOR INFORMATION TECHNOLOGY LITERACY

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Introduction

For at least the past four years, the authors of this paper have studied issues related to the possibility of providing "universal" access to electronic mail (and related online access) within the U.S. We have examined both the technical feasibility and the societal implications of such access (Anderson et al, 1995). We are currently studying the costs and benefits of Internet-based interactions between government agencies and their citizen-clients. Our brief comments here are based primarily, but of course not exclusively, on our experiences and findings resulting from this continuing research program.

It is clear that initiatives such as the National Information Infrastructure, digital government, and digital libraries imply that most Americans will have to become Internet literate in the near future just to carry out the day-to-day activities of citizens in a developed society, quite independently of the computer skill demands made on them by their workplace. Our research has focused on those digital literacy requirements for citizen participation, rather than specific workplace skills or the skills required by computer professionals.

A Focus on Generic Knowledge

We believe that generic, rather than application-specific, knowledge and skills should be the focus of computer literacy. Furthermore, we contend that this holds true for individuals in both roles--that is, as everyday citizens in an information society, and as job holders in a highly technologized workplace.

Why not focus on applications? The primary reasons are continuing rapid changes in what becomes available for use, causing rapid obsolescence of application-specific know-how, plus big changes in what extant applications can do when they're integrated with new applications (e.g., intimately combining an operating system like Windows with a web browser, to choose a recent newsworthy example).

Why the generic focus? Generic skills, plus competence in the functions to be performed, will better equip people to carry out their roles as

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citizens (and job holders) under conditions of continuing technological change (see also the discussion in National Research Council, 1997, Chapter 2, pp. 47-48). Here "generic skills" refer, as in general educational literature, to such cognitive abilities as learning-to-learn, analysis and problem solving, innovation, and communication (Stasz et al, 1990; Bikson and Law, 1995; Bikson, 1994). Such generic skills enable new applications to be learned as they become functionally relevant. As Attewell has shown (Attewell, 1994), most new applications needed for doing workplace tasks can be learned with modest effort and training by those familiar with the job functions. Note also that other studies of model-based teaching and learning (e.g., McArthur, Lewis and Bishay, 1995; McArthur, 1987; Curley and Pyburn, 1982) suggest that learning the underlying model is more important than learning highly specific features of a computer application.

What Generic Knowledge Is Valuable?

What, then, are components of the generic knowledge that "information society literate" citizens should have or acquire? There are many possible categorizations; here is one we suggest for discussion.

- *Connectivity.* Perhaps the most fundamental new need for knowledge, with the most profound implications, concerns having a reasonably accurate model of connectivity. When (as a result of my actions, or otherwise) is the device I'm using connected to other sites? When connected, what information is passing over that connection? Is that information protected from eavesdropping? from alteration? Can I know with a degree of certainty which other sites or persons I'm connected with? Can they verify my authenticity?

  - Understanding connectivity includes such constructs as "protected enclaves" and "shared trust," which refer to hierarchies of established trust. The users of modern devices and interfaces should know when they are communicating and computing within such enclaves (and with whom they are sharing trust within the enclaves) and when and how they are reaching out beyond variously defined levels of trust (see also the discussion in National Research Council, 1997, Chapter 2, pp. 58-59).

  - This knowledge becomes all the more important given the next generation of interfaces combining local facilities (documents, folders, applications) with remote ones in a uniform browser-style presentation. One click might be local; a seemingly identical click might download executable code from a remote source; another might send information from the local site to remote ones. Having a clear model of what information transmissions are being initiated by these seemingly similar actions--and placing desired constraints on one's own actions so that they are compatible with the information-sharing policies one holds--are vital for retaining intellectual control

of information-intensive behavior in an environment in which connections are ubiquitous, dynamic, and subtle.

- Is such knowledge of connectivity needed? Is it commonplace among computer users? We believe that, if asked, most users of most interfaces to information today would be hard pressed to answer at all accurately regarding what connections with which sites, both local and remote, and with what protections, they are initiating in the course of their routine interactions with computers. It might be an interesting research project to check the accuracy of this assumption.

- *Logic.* Computers are different from us: they're much more logical (in their operation, not necessarily in their usage). Anyone who needs to understand why they do the kinds of things they do, and don't do other kinds of things, should understand some basic logical and programming concepts that underlie their operations. We're thinking of such constructs as: conditional expressions ("if <this> [is true] then <that> should be done"); repetition (do <this> n times; do <this> until <that> becomes true); simple inferences ("if A then B; A; therefore B"); and the combination of such expressions into simple algorithms (see also the discussion in National Research Council, 1997, Chapter 4, pp. 129-132).

  - We don't suggest that everyone should become a programmer (although some good ones might be found among those who regard themselves as least likely candidates!). Rather, we argue that it is important to understand the fundamental constructs by which computers "decide" what actions to take, so that users expect neither less nor more of them than they can accomplish.

  - The list of basic logic constructs will need periodic updating. For example, when neural nets and genetic algorithms become more ubiquitous, and computers are tailoring their behavior to their perceived environments, some knowledge of learning, adaptation, and even evolution within programs might be necessary in order to understand--or at least cohabit with--the developing intelligence on the other side of the screen.

- *The structuring of data and information.* Again, we don't recommend creating a generation of programmers. But some understanding of the ways that data can be structured (lists, trees, relational, objects) and stored (volatile memory, nonvolatile storage, archived storage) and an understanding that some data might be migrated at least among storage sites, if not among structure forms, may be critical to users' competence in carrying out day-to-day tasks in a digital world. Is the "smart card" in my wallet that "contains" digital cash a readable and writable nonvolatile storage device? If so, who can read? Who can write? Under what conditions? Is there a backup archive if the card becomes corrupted? And so on.

- *Generic tools.* While our focus is not application specific, a number of tools are common across applications in everyday use; understanding their behavior, then, comprises another component of generic computer literacy. For instance, what can be expected, or not expected, of a "spelling corrector"? A "grammar checker"? A search engine? A filtering system for e-mail or web pages? How can these be tailored to one's specific needs? Can that tailoring be saved for future use? Can it be shared with others? What is the difference (e.g., in a search) between relevant-but-missed information and retrieved-but-irrelevant? How can these forms of error in the course of using generic tools be reduced?

- *Media.* Another key to contemporary computer literacy has to do with understanding that almost all new intellectual creations are becoming digital, and that much of extant knowledge and culture can be digitized as well (see also the discussion in National Academy Press, 1998, pp. 1-2). Whether they are perceived as sound, images, text, numbers, graphics or combinations of these, bits are bits (for purposes of storage, transmission, ...). Future computer literacy means understanding some of the implications of digital media and the accompanying synthesis of communication, computation, video and audio. A "smart card" can in the future store, for example, a song, a video clip, a movie, an encyclopedia. Formerly distinct media domains (e.g., Blockbuster Video; motion pictures on celluloid; songs and telephony over the Internet) will be changing quite rapidly in the future; individuals (and companies) should be preparing for new opportunities and new challenges.

- *Interfaces.* Finally, the user interface represents the means by which people communicate with a particular system and the machines and people connected to it; it is their handle on the functionality of any application. Although usability has improved substantially over the past decades, it is still not easy for most people to make full use of the digital resources to which they--in principle--have access. Despite recurring predictions to the contrary, interface design and performance characteristics are still neither intuitive nor transparent. Until those expectations are realized, we suggest that technical literacy should include learning about the basic ways that interfaces permit users to interactively guide computer programs plus common options for tailoring those interactions.

What are the implications of these new skill needs? We believe that what Toni Carbo (Dean of Library Science at Pittsburgh) has to say about the "new mediacy" is relevant. She says we have to learn to "read," or to interpret and communicate, using a greater variety of information objects than ever before, including multimedia digital objects along with text, graphics and numbers. The "new mediacy" phrase is meant to contrast with earlier notions of literacy by suggesting both the multidimensionality and the interactivity (or immediacy) of the complex digital objects that will constitute the fabric of information and communication in the near future.

Beyond Technical Literacy Skills to Social Values

Earlier discussions of computer literacy often presuppose a view of human-computer interaction as an exchange involving a single individual performing an independent task by using a computer program. This view, perhaps influenced by the "input-process-output" paradigm, gave rise to a substantial body of information about the significance of individual differences in ability and prior experience for ease of use and judged usefulness (or "friendliness") of computer systems (see also National Research Council, 1997, Chapter 4). Now, however, the move to distributed architectures, densely interconnected systems and tools for collaboration means that computers must be viewed as social machines.

Thus perhaps as important as generic computer literacy skills are the social values that accompany them. Two general categories of these values are:

- *Ethics and etiquette.* From simple guidelines on using new forms of communication such as e-mail (e.g., Shapiro and Anderson, 1985) to more fundamental ethical questions of appropriate access to, and treatment and dissemination of, information.

- *Rights and responsibilities.* The broader policy context--now national, soon global--for appropriate handling of information and communication in a networked digital environment. What are a citizen's responsibilities and rights in cyberspace, with respect especially to privacy, anonymity, disclosure, intellectual property and other aspects of its governance?

As a recent National Research Council report points out, these value issues are broadly comprehensive, widely debated, and transcend such area-specific concerns as digital literacy (National Research Council, 1998, p. 40). But because their resolution will affect all aspects of networked computer use, awareness of public deliberation, emerging social norms and eventual legislation should be treated as cornerstones of user literacy.

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