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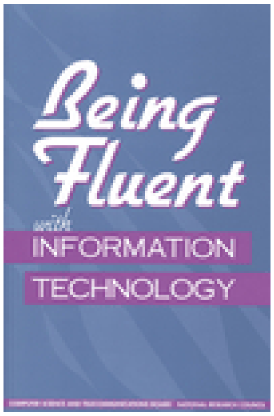

Being Fluent with Information Technology

Committee on Information Technology Literacy, National Research Council

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COMMITTEE ON INFORMATION TECHNOLOGY LITERACY LAWRENCE SNYDER, University of Washington, ChairALFRED V. AHO, Lucent Technologies, Inc.MARCIA LINN, University of California at BerkeleyARNOLD PACKER, Johns Hopkins UniversityALLEN TUCKER, Bowdoin CollegeJEFFREY ULLMAN, Stanford UniversityANDRIES VAN DAM, Brown UniversityStaffHERBERT S. LIN, Senior Scientist and Study DirectorGAIL PRITCHARD, Research AssociateLISA SHUM, Project Assistant (through August 1998)RITA GASKINS, Project Assistant (from August 1998)

Executive Summary

Information technology is playing an increasingly important role in the work and personal lives of citizens. Computers, communications, digital information, software—the constituents of the information age—are everywhere.

Between those who search aggressively for opportunities to learn more about information technology and those who choose not to learn anything at all about information technology, there are many who recognize the potential value of information technology for their everyday lives and who realize that a better understanding of information technology will be helpful to them. This realization is based on several factors:

- Information technology has entered our lives over a relatively brief period of time with little warning and essentially no formal educational preparation for most people.
- Many who currently use information technology have only a limited understanding of the tools they use and a (probably correct) belief that they are underutilizing them.
- Many citizens do not feel confident or in control when confronted by information technology, and they would like to be more certain of themselves.
- There have been impressive claims for the potential benefits of information technology, and many would like to realize those benefits.
- There is concern on the part of some citizens that changes implied by information technology embody potential risks to social values, freedoms or economic interests, etc., obligating them to become informed.

And, naturally, there is simple curiosity about how this powerful and pervasive technology works.

These various motivations to learn more about information technology raise the general question, What should everyone know about information technology in order to use it more effectively now and in the future? Addressing that question is the subject of this report.

The answer to this question is complicated by the fact that information technology is changing rapidly. The electronic computer is just over 50 years old, "PC," as in personal computer, is less than 20 years old, and the World Wide Web has been known to the public for less than 5 years. In the presence of rapid change, it is impossible to give a fixed, once-and-for-all course that will remain current and effective.

Generally, "computer literacy" has acquired a "skills" connotation, implying competency with a few of today's computer applications, such as word processing and e-mail. Literacy is too modest a goal in the presence of rapid change, because it lacks the necessary "staying power." As the technology changes by leaps and bounds, existing skills become antiquated and there is no migration path to new skills. A better solution is for the individual to plan to adapt to changes in the technology. This involves learning sufficient foundational material to enable one to acquire new skills independently after one's formal education is complete.

This requirement of a deeper understanding than is implied by the rudimentary term "computer literacy" motivated the committee to adopt "fluency" as a term connoting a higher level of competency. People fluent with information technology (FIT persons) are able to express themselves creatively, to reformulate knowledge, and to synthesize new information. Fluency with information technology (i.e., what this report calls FITness) entails a process of lifelong learning in which individuals continually apply what they know to adapt to change and acquire more knowledge to be more effective at applying information technology to their work and personal lives.

Fluency with information technology requires three kinds of knowledge: contemporary skills, foundational concepts, and intellectual capabilities. These three kinds of knowledge prepare a person in different ways for FITness.

- Contemporary skills, the ability to use today's computer applications, enable people to apply information technology immediately. In the present labor market, skills are an essential component of job readiness. Most importantly, skills provide a store of practical experience on which to build new competence.
- Foundational concepts, the basic principles and ideas of comput-

ers, networks, and information, underpin the technology. Concepts explain the how and why of information technology, and they give insight into its opportunities and limitations. Concepts are the raw material for understanding new information technology as it evolves.

• Intellectual capabilities, the ability to apply information technology in complex and sustained situations, encapsulate higher-level thinking in the context of information technology. Capabilities empower people to manipulate the medium to their advantage and to handle unintended and unexpected problems when they arise. The intellectual capabilities foster more abstract thinking about information and its manipulation.

For specificity, the report enumerates the ten highest-priority items for each of the three types of knowledge. (Box ES.1 lists these ten items for each type of knowledge.) The skills, linked closely to today's computer usage, will change over time, but the concepts and capabilities are timeless.

Concepts, capabilities, and skills—the three different types of knowledge of FITness—occupy separate dimensions, implying that a particular activity involving information technology will involve elements of each type of knowledge. Learning the skills and concepts and developing the intellectual capabilities can be undertaken without reference to each other, but such an effort will not promote FITness to any significant degree. The three elements of FITness are co-equal, each reinforcing the others, and all are essential to FITness.

FITness is personal in the sense that individuals fluent with information technology evaluate, distinguish, learn, and use new information technology as appropriate to their own personal and professional activities. What is appropriate for an individual depends on the particular applications, activities, and opportunities for being FIT that are associated with the individual's area of interest or specialization.

FITness is also graduated and dynamic. It is graduated in the sense that FITness is characterized by different levels of sophistication (rather than a single fluent/not fluent judgment). And, it is dynamic in that FITness entails lifelong learning as information technology evolves.

In short, FITness should not be regarded as an end state that is independent of domain, but rather as something that develops over a lifetime in particular domains of interest and that has a different character and tone depending on which domains are involved. Accordingly, the pedagogic goal is to provide students with a sufficiently complete foundation of the three types of knowledge that they can "learn the rest of it" on their own as the need arises throughout life.

Because FITness is fundamentally integrative, calling upon an indi-

Box ES.1
The Components of Fluency with Information Technology

NOTE: Readers are urged to read Chapter 2 for more elaboration of these items.

Intellectual Capabilities

1. Engage in sustained reasoning.
2. Manage complexity.
3. Test a solution.
4. Manage problems in faulty solutions.
5. Organize and navigate information structures and evaluate information.
6. Collaborate.
7. Communicate to other audiences.
8. Expect the unexpected.
9. Anticipate changing technologies.
10. Think about information technology abstractly.

Information Technology Concepts

1. Computers
2. Information systems
3. Networks
4. Digital representation of information
5. Information organization
6. Modeling and abstraction
7. Algorithmic thinking and programming
8. Universality
9. Limitations of information technology
10. Societal impact of information and information technology

Information Technology Skills

1. Setting up a personal computer
2. Using basic operating system features
3. Using a word processor to create a text document
4. Using a graphics and/or artwork package to create illustrations, slides, or other image-based expressions of ideas
5. Connecting a computer to a network
6. Using the Internet to find information and resources
7. Using a computer to communicate with others
8. Using a spreadsheet to model simple processes or financial tables
9. Using a database system to set up and access useful information
10. Using instructional materials to learn how to use new applications or features

vidual to coordinate information and skills with respect to multiple dimensions of a problem and to make overall judgments and decisions taking all such information into account, a project-based approach to developing FITness is most appropriate. Projects of appropriate scale and scope inherently involve multiple iterations, each of which provides an opportunity for an instructional checkpoint or intervention. The domain of a project can be tailored to an individual's interest (e.g., in the department of a student's major), thereby providing motivation for a person to expend the (non-trivial) effort to master the concepts and skills of FITness. In addition, a project of appropriate scope will be sufficiently complex that intellectual integration is necessary to complete it. Note also that much of the infrastructure of existing skills-based computer or information technology literacy efforts (e.g., hardware, software, network connections, support staff) will be important elements of efforts to promote FITness.

Although the essentials of FITness are for the most part not dependent on sophisticated mathematics, and should therefore generally be accessible in some form to every citizen, any program or effort to make individuals more FIT must be customized to the target population. Because the committee was composed of college and university faculty, the committee chose to focus its implementational concerns on the four-year college or university graduate as one important starting point for the development of FITness across the citizenry. Further, the committee believes that successful implementation of FITness instruction will require serious rethinking of the college and university curriculum. It will not be sufficient for individual instructors to revisit their course content or approach. Rather, entire departments must examine the question of the extent to which their students will graduate FIT. Universities need to concern themselves with the FITness of students who cross discipline boundaries and with the extent to which each discipline is meeting the goals of universal FITness.

In summary, FIT individuals, those who know a starter set of information technology skills, who understand the basic concepts on which information technology is founded, and who have engaged in the higher-level thinking embodied in the intellectual capabilities, should use information technology confidently, should come to work ready to learn new business systems quickly and use them effectively, should be able to apply information technology to personally relevant problems, and should be able to adapt to the inevitable change as information technology evolves over their lifetime. To be FIT is to possess knowledge essential to using information technology now and in the future.

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Committee on Information Technology Literacy

Computer Science and Telecommunications Board
Commission on Physical Sciences, Mathematics, and Applications
National Research Council

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

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COMMITTEE ON INFORMATION TECHNOLOGY LITERACY

LAWRENCE SNYDER, University of Washington, *Chair*
ALFRED V. AHO, Lucent Technologies, Inc.
MARCIA LINN, University of California at Berkeley
ARNOLD PACKER, Johns Hopkins University
ALLEN TUCKER, Bowdoin College
JEFFREY ULLMAN, Stanford University
ANDRIES VAN DAM, Brown University

Staff

HERBERT S. LIN, Senior Scientist and Study Director
GAIL PRITCHARD, Research Associate
LISA SHUM, Project Assistant (through August 1998)
RITA GASKINS, Project Assistant (from August 1998)

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Preface

In response to a request from the National Science Foundation, the Computer Science and Telecommunications Board (CSTB) of the National Research Council initiated a study in August 1997 to address the subject of information technology literacy. The rationale for such a study was that the increasing importance and ubiquity of information technology in daily life make it essential to articulate what everyone needs to know and understand about information technology. Such an articulation would be an essential first step toward empowering all citizens to participate in the information age.

Information technology as a topic for literacy has multiple constituencies. For example, the library science community has developed a conceptual underpinning for skills that are important for finding, evaluating, and using information, all of which are important aspects of any definition of information technology literacy. Because they spend their professional lives as creators of information technology, computer scientists have their own perspectives, as do practitioners in disciplines that have traditionally relied on computational tools, such as science and engineering. Disciplines in the arts and humanities are just beginning to tap the potential of information technology and will become (indeed, some would argue are now) important stakeholders. More generally, the broad category "knowledge worker" encompasses many professions in the workplace, and virtually all knowledge workers make use in greater and lesser degrees (increasingly greater) of information technology. Traditionally "blue-collar" workers such as auto mechanics and heating/air-conditioning technicians must also cope with a proliferation of embedded computing devices. And as government begins to provide more services to the public using information technology, the citizenry itself becomes an interested constituent.

THE COMMITTEE'S APPROACH

In addressing its charge, the committee chose a broad definition of information technology. Information technology was defined to include the more traditional components of information technology (such as general-purpose computational devices, associated peripherals, operating environments, applications software, and information), as well as embedded computing devices, communications, and the science underlying the technology.

As for the knowledge and understanding component of its charge, the committee decided to use the term "fluency." Professor Yasmin Kafai, who briefed the committee, noted that fluency connotes the ability to reformulate knowledge, to express oneself creatively and appropriately, and to produce and generate information (rather than simply to comprehend it). This report uses the term "fluency with information technology," or FITness, and it characterizes as fluent with information technology (FIT) those who use, understand, and know about information technology in the ways described in Chapter 2. Chapter 1 contrasts fluency with the more common term "literacy."

All of the committee believed in the social desirability of the broadest possible dissemination of a set of fundamental concepts, skills, and capabilities. Good arguments were made to and by the committee for defining "everyone" in terms of all junior high school graduates, all high school graduates, all non-college-bound individuals, all college-bound individuals, and all adult citizens (as lifelong learners). But in the end, rather than argue that FITness was required of everyone in some demographic category of the population, the committee instead chose to make its case for the education of individuals who want to be able to use information technology effectively. Furthermore, issues of committee expertise and budget imposed some practical constraints on the committee's work, and the committee decided that it was best qualified to focus, as a first step toward fuller implementation, on the group of learners with which it was most familiar—the four-year college or university graduate. This first step toward implementation is discussed in Chapter 4.

The intent of this report is to lay an intellectual framework for fluency with information technology that is useful for others in developing discipline-specific and/or grade-appropriate efforts to promote FITness. However, this report is not a FITness textbook, a curriculum for FITness, or even a description of standards for FITness.

METHODOLOGY

The committee sought input in three ways: through briefings on the topic from individuals who have worked in the field (Appendix C), from electronic input in response to a set of questions about FITness that the committee broadcast widely over the Internet, and from perspectives provided at an invitation-only workshop in Irvine, California, held to explore the subject, for which participants were sought from a broad range of backgrounds and interests (Appendix D). The committee, itself composed of individuals representing varied backgrounds and expertise (Appendix E), used this broad range of input in an integrative manner to inform its own deliberations on the appropriate scope and nature of FITness.

ACKNOWLEDGMENTS

The committee appreciates the sponsorship of the Cross-Disciplinary Activities of the Directorate for Computer and Information Science and Engineering of the National Science Foundation for this project, and especially the support of John Cherniavsky.

The committee benefited from input from a broad range of sources. A list of workshop participants is contained in Appendix D; a list of briefers is provided in Appendix C. Douglas Brown of Bellevue Community College and Mary Lindquist of Columbus State University provided useful comments on Chapter 2. Comments of reviewers (listed immediately following this preface) helped the committee to tighten its presentation and to determine the appropriate emphasis on the various topics contained in the report.

Acknowledgment of Reviewers

This report was reviewed by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the authors and the NRC in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The contents of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report:

George Bugliarello, Polytechnic University,
Robert Patterson Cook, University of Mississippi,
Ronald Danielson, Santa Clara University,
Scot Drysdale, Dartmouth College,
John Hennessy, Stanford University,
Leah Jamison, Purdue University,
Joan Lippincott, Coalition for Networked Information,
Arthur Melmed, George Mason University,
Susan L. Perry, Mount Holyoke College,
Jane Prey, University of Virginia,
Harold Salzman, University of Massachusetts – Lowell, and
Kendall N. Starkweather, International Technology Education Association.

Although the individuals listed above provided many constructive comments and suggestions, responsibility for the final content of this report rests solely with the study committee and the NRC.

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