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AUTHOR	Van Duzer, Eric
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ABSTRACT

A literature review was conducted to define technological literacy and its implications for the role of education in preparing citizens in a participatory democracy, as consumers and family members, for employment, and in the spiritual/philosophical dimensions of life as they relate to our conceptions of technology. A definition of technological literacy is advanced that provides a framework for the analysis. The literature review takes a needs-based approach to describe the nature of each domain (i.e., participatory democracy, daily life, work, dehumanization) and define what skills/knowledge are essential to technological competence in each. The essential knowledge, skills, and dispositions that enable individuals to confront technology, comprehend essential aspects of it, put it into an appropriate/functional context, and control it, are discussed. Each domain is analyzed in detail along these four dimensions (i.e., confront, comprehend, contextualize, control) with a set of summary grids that provide an overview. (Contains 50 references.) (Author/MES)

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Developing a Comprehensive View of General Technological Literacy

Eric Van Duzer

September 29,1998

Position paper II

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Developing a Comprehensive View of General Technological Literacy

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There are dozens of definitions of "Technological Literacy." Many of these definitions focus on a specific goal such as preparing people for employment or citizenship or consumerism (e.g., Yager and Lutz, 1995). Others frame their arguments from specific disciplinary perspectives, where historians see different definitions than economists and they both differ from scientists (Lewis and Cagel, 1992). In addition, many of these definitions do not distinguish between the ultimate reaches of literacy and what could be identified as appropriate for all citizens as a form of general literacy. These advocates expound the virtues of task specific skills with computers or machinery and often involve hands-on competence in design or construction (e.g., Biermann, 1994).

Finally, a number of authors have focused on the semantics, first defining the word "technology" and then "literacy" and then trying to draw conclusions based on that semantic analysis. This approach creates many constraints which often inhibit a full analysis of what technological literacy should encompass. The actual term "Technological Literacy" is not the issue. We could call it technological understanding and facility, or technological competence or many other titles. What is important, is to begin the following analysis with a clear understanding of what is being discussed. Therefore, I offer the following definition. For the purposes of this paper "technology" is defined as; the "tool of human intentions embodied in rational, physical systems". While "literacy", consists of the set of facts, understanding, and skills which will facilitate personal effectiveness in a technological world.

This paper examines the common threads among arguments about the definition of technological literacy across functions, philosophies and disciplines. Ultimately, these common threads will define the components of "general" technological literacy. This is not an argument of how to facilitate technological literacy. That would be putting the cart before the horse. Rather this is an attempt to define the target, to establish what a technologically literate person should know and be able to do.

The ultimate goal of general technological literacy as it is presented here is to prepare citizens in their various roles (at home, work, or in society) to adopt new technology quickly and to adapt it to their specific needs effectively. This definition is purposely limited. For instance, it does not extend to design and construction because not everyone needs those skills. The purpose of narrowing the definition is that the skills associated with "adopting and adapting" are universally required in a technological society. These skills and abilities provide a foundation for individuals who choose to extend them into more specialized areas such as design[1].

In this paper, technological literacy encompasses the broadest range of technologies from hydraulics to lasers to computers. However, the depth is limited to the common core of knowledge and skills which transcend individual technologies and bridge the various goals motivating calls for technological literacy. This common core of skills and knowledge required by all citizens to operate effectively in a technological society define general technological literacy.

Admittedly this set of core competencies is a "fuzzy set" with ill-defined borders and a dynamic nature which makes it difficult to pin down. Given the ubiquitous nature of technology in our society, this is a complicated task requiring research in areas as diverse as business administration, engineering and anthropology. The following framework facilitates this analysis and is useful in organizing the broad range of claims concerning the appropriate nature of technological literacy.

I. The Analytic Framework

A. Basic Goals

According to Dyrenfurth (1991) six goals underlie current debates concerning the development of technological literacy through education. Of those, two are related to how education will be organized to facilitate that literacy. The other four goals have broad implications for the technological competencies required by the general population and are therefore central to general technological literacy.

[1] Design and construction may be appropriate pedagological tools which help students develop skills associated with adopting and adapting such as coming to understand the nature of technological artifacts.

1. Maximize effectiveness in the day-to-day world
2. Create effective citizens for a participatory democracy
3. Prepare a workforce for the 21st century
4. Blunt the dehumanization technology can bring

While it is clear that education can play a key role in the development of technological literacy, the issues associated with how technological literacy is embedded in a curriculum (e.g., requirement vs. elective), how it interacts with other educational goals (e.g., career exploration, guidance), and what effect its introduction in education will have on issues of equity or efficiency will be left to future papers. The sole purpose here is to assess the nature of technological literacy so that future efforts to educate will be focused on the critical aspects of technological literacy required by the general public.

Daily life. We all interact with technology as we go about our daily lives. Automatic teller machines (ATMs), automobiles, telephones, vending machines and so on are a ubiquitous part of American life. Mastering these common interactions increases one's effectiveness in reaching personal goals and optimizes the value of the technology they interact with. Therefore, for the sake of personal effectiveness and social efficiency facilitating the process of mastering new technological interactions can be supported as a legitimate goal of general technological literacy.

Participatory Democracy. Society and technology evolve interactively while constantly shaping and reshaping one another. Currently, globalization and the phenomenal surge in information technologies have accelerated the rate of technological change. This rapid change brings with it a greater number of technological issues which will have to be resolved (Yager and Lutz, 1995). An effective citizenry in a participatory democracy must be able to recognize and understand the social implications of technological options, and make reasoned decisions based on their understanding of those issues (Wraga and Hlebowitsh, 1991).

Employment. While mostly unmeasured, there is general consensus that the pace of technological change required of industry is increasing. This places significant demands on the workforce of the future (Weisbord, 1987; A Nation At Risk, 1983; Marshal and Tucker, 1992). Given that relative productivity is central to economic competitiveness and that technological tools can often improve productivity, one goal for general technological literacy is to provide a common foundation of knowledge and skills to support and inform a broad range of individual choices in terms of productive employment (Stevens, 1991).

Dehumanization. Choices made in the selection and implementation of technology have an effect on the quality of techno/human interaction. For instance, computer technology can reduce human participation to rote, repetitive action, or it can empower human discretion by extending human capacities both physically and cognitively (Zuboff, 1988). Similarly, communications technology can create a global community or isolate and insulate individuals. This final goal for technological literacy involves developing the necessary understanding to select among a range of options in ways which empower humanity.

Given these basic goals, the question becomes what exactly a person should know and be able to do to facilitate them. There are, of course, limits. The core competencies represented in general literacy should support individual efforts to develop skills for task specific situations without having to encompass the specific skills required for the vast number of possible applications.

B. Functional Categories of Literacy Skills

The competencies appropriate to general technological literacy can be organized in a variety of ways (Dyrenfurth, 1991; Hayden, 1989). In the process of reviewing the literature four classes of skills emerge. These four are used here to organize the types of skills and knowledge required by technologically literate citizens. According to this organization, technologically literate citizens must be willing and able to "confront, comprehend, contextualize and control" emerging technology.

Confronting technology. Technology is evolving at an accelerated rate. A society whose fortunes are tied to the social/economic advantages of being on the leading edge must have a citizenry willing to confront an unending stream of technological innovation (Weisbord, 1987). This is primarily a question of motivation and persistence. Ultimately, the saliency of the goals, the difficulty in obtaining them, and the belief in one's ability, controls the degree to which one will confront the complex challenges involved in technological change (Brody, 1983; Elliot and Dweck,1988).

Comprehending technology. To make effective decisions one must understand the nature and significance of the technology involved.[2] To develop that understanding in a useful way involves the capacity to read and understand technical language, to interpret abstract symbols (Zuboff, 1988), and to reason systematically with an emphasis on the cause and effect nature of the relationships which define technology generally. It also involves developing cognitive models which capture the underlying nature of technology, technological change and the impact that change has on society.

Putting technology into context. Technology is embedded in a hierarchy of functional systems ranging from the mechanical system of the artifact itself to the social, environmental and ideological contexts which shape human life in general. To select, understand or apply technology effectively requires an understanding of the appropriate functional context for the issue at hand (Rumler and Brache, 1988). This means defining the elements of the functional context which affect or are affected by the technology. And, then, defining the strength, direction and implications of those interactions.

Controlling technology. There is a common set of cognitive skills such as problem solving and critical thinking which are central to effective applications of technology (Ost, 1985). Additionally, while task specific skills are beyond the realm of general literacy, there is also a common core

[2] Editorial in Nature (???):335 Scientific Illiteracy and democratic theory.

of tool and process skills (e.g. interpreting abstract symbols, using the generic systems model, etc.) which support efforts in a wide range of applications and are therefore candidates for general literacy.

Next the requirements of each of the four major goals of technological literacy are analyzed in terms of the four competencies associated with adopting and adapting emerging technology.

II. Maximize the Quality of Daily Life by Empowering Citizens to Fully Use Technology.

The following section describes the nature of techno-human interactions in common daily activities and discusses the competencies which facilitate more effective interactions in the pursuit of human intentions.

Confronting Technology in Daily Life

From telephone pagers that talk, to computerized banking, day-to-day opportunities routinely require interactions with technology. However, many Americans are hesitant, some even quite resistant, to adopting new technologies. Some of this reflects individual preferences for low-tech options. However, much of this hesitation has to do with general technophobia. According to research conducted by Dell Computer Corp. and others (e.g. Rosen and Weil, 1995) more than 55 percent of Americans suffer from some degree of technophobia. This can range from a mild reluctance to engage new technology, to physical symptoms such as sweating, nausea and dizziness (Weil,1995)[3]. This is important because as Filipczak (1994) writes, in dealing with new technology "once you have overcome the fear of technology ...you have fought half the battle."

Where it persists, techno-fear reduces a technology's value by inhibiting its adoption, adaptation and application in serving a user's interests (Rosen, 1995). According to a variety of research, many of the inhibitions caused by technophobia are the result of a fear of failure in dealing with technical complexity (Filipczak, 1994; Rosen, 1995, Texas Banking 1993).

Where fear of complexity is the inhibitor, a person's technological self-efficacy is a key to more effective participation (Rosen and Weil, 1995). In a nutshell, self-efficacy is an internal state of mind which acts as a thermostat in regulating effort in the face of challenges. It is strengthened when effort and success are believed to covary and

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[3].Here technophobia is defined from a marketers point of view. technophobics are those who have to overcome existing reservations to engage new technologies.

diminished when success seems disconnected from a person's efforts. Where failure is associated with a lack of natural ability, or some other uncontrollable set of conditions, people will refrain from trying in order to protect their self-esteem from evidence of their inadequacy. On the other hand, if failure is related to a lack of effort, and the goal is valued by the individual, then a person will try harder rather than give up (Mikulincer, 1994). Developing self-efficacy, and therefore a strong sense that one can successfully negotiate technological interactions leads to a greater willingness to confront innovations. This is an important component of general technological literacy for day-to-day life.

Of course there will still be those who prefer human tellers to ATMs, and those who would rather write a letter on stationary than send an e-mail. But technologically literate citizens will choose those options on the basis of their interests rather than because of their fears. Clearly this is a broad view of literacy which encompasses both cognitive competence, attitudes about the environment and one's conception of self. This broad view of technological literacy adopted in this paper encompasses the full range of personal attributes required to operate effectively in an ever changing technological environment.

Comprehending the Technological Interface

What exactly does a person have to comprehend about technology they confront in daily life?

When a customer uses an ATM they need to understand what it can do, and how to interact with it effectively. They do not need to know anything about the internal mechanics, the history of ATMs or their role in modern banking businesses. This is true for most daily technology. While a deeper understanding may be useful, it is generally not a prerequisite for adopting or adapting technology to achieve daily goals. For instance, understanding the mechanics of an automobile can be quite valuable, but millions of Americans get where they are going without a clue of what happens under the hood of their cars. Therefore, in day-to-day interactions, it is the complexity of the technical interaction, not the technology itself, which must be mastered.

Unfortunately, this continues to be a dilemma. For instance, in a study of 1,156 VCR owners more than half had problems using some of the machine's functions.[4] "One-quarter of the adults surveyed (Dell Computer Corp.) had never used a computer, set the timer on their VCRs, or programmed stations on their car radios" (Filipczak, 1994). Interactions as simple as withdrawing money from an ATM continue to intimidate many customers slowing the adoption of new technologies and their value to consumers once they are adopted. There are at least two ways to improve this situation. Either make the interfaces simpler or make the user more sophisticated. Both are valuable, and both are happening.

Graphic interfaces, digital readouts and touch screens (among other technological advances) continue to simplify the human-technology interface. At the same time there is a growing core of technologically literate citizens. Simpler interfaces and more confident consumers will increase the number and range of opportunities available to serve the specific needs of individuals. This changes the relationship of consumer and supplier in relatively profound ways.

As technology becomes easier to understand and use, more is required of the user. "Consumers now accept that more and more of their daily transactions (not just banking but petrol purchases and other products) now require their input" (Marr and Prendergas, 1993). There are many examples of how technology is shifting more responsibility to the user. For instance, banking by computer makes controlling one's accounts more accessible and transparent, but it also requires the customer to do a great deal of work formerly performed by bank tellers with specific training and industry specific knowledge. Direct control improves efficiency but it also eliminates the input of professionals who formerly mediated the transaction. So both the range of, and personal responsibility for, consumer decisions is increased.

More than in the past, to be effective in daily life of the 21st century, consumers must take responsibility for learning what a technology can do and how it can serve their interests. This involves learning about products, understanding the range of functions they offer, comparing benefits and

[4] McKee,1992- cited in Rosen 1995

price, reading and evaluating the appropriate literature and synthesizing the information in relation to their specific needs.

Contextualizing Technological Choices

The fundamental context for all technological interactions including those common to daily life is the goal or task itself. We engage technology in the pursuit of some interest. We may use a telephone because we feel like talking to our friends or drive a car to get to the market. We may buy an air-conditioner to make our home more pleasant in the summer, or use pagers to stay in touch with our children. Technology helps us do something. The task itself provides a context for evaluating the usefulness of one set of options versus another and provides the motivation to discriminate between them.

At this level, the problem or task is the context. To be effective in these situations requires an understanding of the overall task and the ability to anticipate the role of a particular technology in achieving these goals. This involves defining what a new technology can do, how it fits into the broader task and what trade-offs are involved in adopting it. The ability to recognize and analyze the task context as it relates to decisions about technology should be one goal of technological literacy.

The social context of daily technology. Choices involving technology can have a profound effect on an individual's entire social network including the immediate family, friends and regular associates. Determining the likely consequences of choices about technology on this social context is an important consideration. For instance, the popular press often presents articles of how lives are changed through the internet. From, "Thanksgiving in cyberspace: a far-flung, close knit family's computer network" (Washington Post, 1993) to, " Love and lust on the internet (social aspects of marriages that breakup because the man or woman found another love on the internet) (Los Angeles Times, 1996).

Many decisions, from computer applications to types of entertainment to a choice of cars, have consequences for the family unit. Therefore, to effectively operate in a technological environment one must recognize the importance of analyzing the effects of decisions on the rest of the family and have the tools to do so. This involves an awareness of the embedded nature of decisions, a sensitivity to the needs of others in the family, an ability to adequately predict the possible consequences of particular choices and an ability to synthesize the information in order to make a rational decision.

Controlling Daily Technology

Most people begin their day interacting with a clock. Checking the time is the first in a string of semi-automatic routines we use to handle daily interactions with technology. We switch on the light, open the refrigerator, start the car, jump in the elevator and pick up the phone without consciously analyzing the processes. Most daily interactions with technology are so routine, so common, that we barely think about what they require. However, we also encounter technology which is less familiar. And, with the accelerating rate of technological change the number and variety of novel interactions are increasing.

Coming to understand what these technologies do and how to operate them often requires an ability to read. From mind numbing computer manuals to simple instructions such as "Touch here for deposit", information about what a new technology does and how to use it, is commonly presented in written form. With the rapid changes in technology and the increasing responsibility of the user to evaluate, adopt and adapt it, the ability to read and understand technical material and to accurately follow directions is essential.

The Information Age

To hear Bill Gates (1996) (founder of Microsoft) tell it, the dawning of the information age will have as profound an effect on history as the birth of agriculture, the roads of ancient Rome, and the industrial revolution. While its full impact is not yet known, information technology is clearly changing the nature of the skills required to interact with technology. In her book "In the Age of the Smart Machine" Zuboff (1988) presents case studies such as an automated pulp mill which clearly demonstrate the effects of information technology. As she describes it, pulp mill operators of the past relied on sentient skills. They judged the operation of the pulp plant by listening to the equipment, tapping the gauges, feeling the pulp, smelling, looking and even tasting. All of this perceptual information was synthesized to gain a clear understanding of the state of the process.

Today, workers still have to monitor the pulp making process, but now they do it from an insulated control center. Rather than develop sentient-based skills, these operators interact with the physical plant through the symbolic medium of computer screens and digital readouts.

Information technology, whether at work or in day-to-day life, is separating people from the physical acts they are controlling. In doing so sentient/ perceptual skills are being replaced with abstract/ interpretive skills (Zuboff, 1988).

Conclusion : Empowering Citizens to Fully Use Technology in Daily Life

A technologically literate person overcomes their techno-fear, believes they can succeed in technical interactions, understands what the technology does, takes responsibility for determining the appropriateness of using it, analyzes its potential effectiveness in achieving the task at hand, evaluates the potential effects on them and their family, and develops the necessary cognitive skills to control it according to their interests.

Summary:

	Confront	Comprehend	Contextualize	Control
Day-to-Day	Overcome technophobia. Develop self-efficacy in dealing with technical interfaces	Understanding what a technology can do Read technical material about products Take greater responsibility for analyzing personal needs and determining the suitability of various technical options	Determine the suitability of technical options for accomplishing a given task Evaluate the likely effects of technological choices on one's immediate social group (e.g., family)	Read and follow instructions Frame investigations of new technological interfaces Develop abstract/ interpretive skills

III. Preparing Citizens to Participate Effectively in Democracy as it is Practiced in the United States

There are substantial social, political and economic effects of technological change (Marshal and Tucker 1992; Patrick et al., 1985; White, 1987). Consequently, a number of researchers have argued that a participatory democracy, steeped in technology, requires citizens who can recognize the effects of technology, analyze the relevant issues and make productive choices at a societal or environmental level (Patrick and Remy, 1985; Wraga, 1991; Yager and Lutz, 1995). These arguments are based on the assumptions that citizens who understand technological issues will make better decisions and feel more empowered to participate in the democratic process.

Confronting Technological Decisions In A Participatory Democracy

From irradiated food to smog standards to computers in education, today's social and political issues involve technology to a great degree (Yager and Lutz, 1995). At the same time there is considerable reluctance to engage in the social and political processes of our times. To what degree these two phenomenon are connected is unclear.

According to Harvard political scientist Robert Putnam (Cited in Gans, 1995) "engagement of Americans in collective activity has atrophied in almost every field of voluntary collective endeavor." In 1996, the presidential elections attracted the smallest turnout in 72 years.[5] And Putnam reports that research indicates that people who don't vote tend not to participate in other forms of political, social and civic activity.

From cynicism born of scandals to the overwhelming number of decisions on today's ballots, there are many reasons why citizens do not participate in our collective social or political endeavors. Under these conditions it is difficult to distinguish the role of technophobia and perceived self-efficacy in a citizen's reluctance to engage technological issues through the social and political process.

There is little direct evidence that technical complexity inhibits participation. However, where the complexity does inhibit effective engagement, self-efficacy and motivation will govern involvement. To be willing to engage the issues one must first recognize the importance of making good decisions concerning technology. It is self-interest that motivates most voting decisions (Newman and Bull, 1986). Given this, technological literacy involves recognizing the social/ environmental ramifications of policy options and the personal implications of collective decisions. Furthermore, to be motivated to participate one must believe that their efforts are of some value and can make some difference. As Gans (1995) writes, this is primarily a matter of faith. A faith, the author notes, which is in decline in America.

Comprehending Technological Issues

Many researchers have argued that the current pace of technological change is dramatically increasing the demands on citizens as they try to make informed decisions on techno-political issues.

> It is the burden of contemporary science and technology to produce change at a rate, and of a scale and character, which is genuinely without precedent (Williams, 1989: 458).

[5] Morin and Brossard (1996). Poll: Voters new early, knew enough. Washington Post November 15: A4

...it is not simply the case that complexities and interdependencies have grown; it is also the case that entirely new complexities-technological ones - have emerged, and that we are confronted with a web of hitherto non-existent interdependencies (Satori, 1989: 393).

Emerging technology presents novel challenges which expand the gap between what we know and what is needed to rationally predict the consequences of our decisions. This gap "is historically unique in scale and getting worse" (Barry, 1989: 387). This has led at least one researcher to declare that "we are living above and beyond our intelligence, above our grasp of what we are doing (Satori, 1989: 391).

Given this gap in our understanding, when it comes to deciding complex issues, current research in social (political) cognition suggests that voters are best characterized as "cognitive misers". "Cognitive misers" do not actively seek out all available information in order to make some rational, value-maximizing decisions; instead, they rely on cognitive heuristics and short-cuts based on prior experience to make all varieties of decision" (Lau, Fiske and Smith, 1991: 647). A cognitive miser has a limited attention span and that attention is narrowly focused in a way that minimizes the cognitive demands required to make political decisions (Krosnick, Boninger and Berent, 1994).

Cognitive misers simplify through categorization, fitting complex issues into familiar roles based on superficial characteristics (e.g., Republican or Democrat). What information is attended to, and therefore, how the new experience is categorized, is instrumental in determining the whole veneer of inferred characteristics which are drawn from memory to fill the gaps in our knowledge about the current issue. "(O)nce something has been characterized as fitting into a particular category, people's schema will fill in the blanks with prototypical traits" (Lau and Sears, 1986). By substituting prototypical information for real data about the current situation the issue becomes manageable and familiar.

The richness of the cognitive resources (schema) stored in memory is related to the number and range of representations of related experiences, the number of links within and between schema, and the body of knowledge concerning the specific category (Lau et al., 1991). The sophistication of a cognitive miser's problem solving process is limited by the identity and richness of available schema. It is also influenced in uncertain ways by a variety of other factors including both affective interactions and environmental conditions (Zajonc, 1984; Granberg and Brown, 1992). A technologically literate citizen will have acquired a substantial range and quality of cognitive models through which a more sophisticated understanding of technical issues can be developed.

<u>The role of information in political participation.</u> The integrity of the decision making process is also constrained by the quality and quantity of information available. Even for the political elite, "(i)t is rarely if ever attained ideal when technical advise is timely, relevant, clear and objective, and allowed a weight in the decision-making process exactly appropriate to its significance" (Williams, 1989). For the voter it is even more difficult, particularly with the overcrowded ballots of modern elections requiring as many as 60 different decisions (Ranney, 1989).

The media is still the primary information source for voters. In times of elections tremendous sums of money are spent on shaping the information voters receive. Everything from (mis)naming initiatives to putting spins on the news to direct advertising, affects the body of information citizens employ in making voting decisions. Clearly a component of general literacy for political participation involves some understanding of how to evaluate information. This will become increasingly important when emerging news sources such as the world wide web begin to proliferate. The greater the volume of raw information the more important it is to distinguish among various degrees of credibility (Krosnic et al., 1994).

Ultimately, the future is unknowable and our ability to predict the consequences of our decisions concerning technology are being diminished in relation to the pace of change. "Probabilistic statements are commonly the only ones which can be made about the future" (Williams, 1989: 468) Therefore, to frame a rational decision concerned with the potential consequences sometime in the future requires a basic understanding of probability -- at least enough to grasp the significance of the claim such as "There is less than a .005 chance that ....".

However, even a complete understanding of the significance of the claims involved in a decision does not ultimately resolve the matter. The values, attitudes and beliefs of citizens ultimately dictate their decisions once they understand the options. What sense should a voter make of a situation where there is a very low probability of a problem, but where the consequences are truly catastrophic (e.g. nuclear power)? Here an understanding of the nature and limitations of technology as well as the social psychology of the times will influence decisions and decision-making at the societal level.

To improve social and political effectiveness one must develop an ability to understand the various arguments, to critically examine the information provided and have a sufficiently rich body of experience to make effective judgments about the likely outcomes of policy choices and their consequences. Where social consequences are the important issue, these schema should be developed around that aspect of technological change (i.e. around historical case studies rather than in-depth explorations of current issues whose effects on society are not yet visible).

Situating Technological Choices In Their Environmental And Social Contexts

Collectively, citizens decide technological issues that have a profound effect on the social and the environmental systems. These systems provide the broader contexts for these policy decisions. Recognizing the relationships between policy decisions, social/environmental consequences and individual interests is fundamental to technological literacy in a participatory democracy (Williams, 1989).

The Social Context. The social consequences of many past choices concerning technology are self-evident. Cars facilitate suburbs which lead to problems in the inner cities, for example. While the effects can be quite significant, they are complex and never fully understood or predictable. Society is constantly shaping and being shaped by technology (Raizen et.al., 1995). This interactive relationship makes the entire process dynamic and uncertain. Yet, it is clear that however uncertain, consideration of the social consequences of technological policies should be central to the policy analysis of technologically literature cognitive misers. Understanding how a technology relates to the system it is embedded in improves decision making, increases productivity and facilitates more effective problem solving (DeVores, 1987).

Having said that, it is difficult to determine the effect of an *a priori* knowledge of social consequences. Would things be different if people in the 1920s knew automobiles would lead to suburbanization? Could people of that era comprehend the consequences of traffic flow as it exists in urban areas in the 1990s? Today we continue to strip the earth of resources at a rate we know is overwhelming the planet. We drive alone to work despite the hour long traffic jams and choking smog. Humans adapt to conditions, but often fail to plan effectively for the future.

<u>The Environmental Context.</u> From ozone depletion, to acid rain, technology can have devastating environmental effects. In a society where citizens set the standards for environmental protection, through direct initiatives or through Congress and the regulatory agencies it oversees (e.g., EPA), it is important to consider the consequences of those standards and their environmental effects on society and the individual.

It is tempting to argue that we must teach future generations to revere the environment because it cannot support the current stream of human activity. However, I will leave that to the biologists and others of their ilk. I do not propose to make a certain set of beliefs or values central to technological literacy. The philosophical debate which shapes values and sets policy priorities according to the "wisdom" of the collective citizenry will rage indefinitely. Jobs or old growth? Houses or wetlands? These are issues to be decided by an informed society not to be dictated by a definition of general technological literacy. The only issue here is one of facilitating effectiveness by empowering people's values through democratic participation. For that, considering the social and environmental contexts and their relationship to the current decision is central to effective participation because it reveals the ways decisions may affect the decision maker.

Controlling Policy Decisions Concerning Technology

Exercising control in a policy environment is essentially the same for technology-related-issues as it is for other policy concerns. The only exception to this is that the degree of complexity of technological issues and society's inability to remain sufficiently educated has transferred decision making to experts out of the direct control of the electorate. Thomas Jefferson's views expressed two centuries ago concerning the importance of adequately preparing citizens to control their own destiny are as relevant today as they were then, if we are to avoid the consequences of a society consisting of "techno-peasants" subjected to the values and interests of a "techno-elite."

While it is essential that citizens be able to participate effectively in the democracy there is nothing unique to that participation in areas of technology which would be defined separately as technological literacy rather than as basic citizenship skills (see Ogens and Koker 1995, or Gans, 1995 for citizenship education).

Conclusion: Preparing Citizens to Participate Effectively in our Democracy

> Concern about effective political and social participation "is ultimately predicated on the assumption that the future contains genuinely different possibilities, on a preference between these, and on the further assumption that a connection exists between discernibly different courses of action now and outcomes at various times in the future" (Williams, 1989: 468).

If we are to shape the future intelligently, then citizens must understand the technological issues, identify the range of concerns (e.g., economic, environmental, social), be able to analyze the likely consequences of their decisions on both the individual and the social context, and understand how to further their interests in our democracy. The more sophisticated and competent the nation's citizens are at these tasks, the better the decisions will be.

The sophistication of a person's decision making process is related to an analysis of various possible interpretations of what a policy will do

(Lau, Fiske and Smith, 1991). While these interpretations are mediated and simplified through the media (Gould, 1989) and then shaped by an individual's prior experiences (Lau and Sears, 1986), situating the problem in terms of competing interpretations results in an analysis of pros and cons which deepens and rationalizes the process. Therefore, improving the quality of participation in our democracy can be accomplished by teaching citizens to frame issues in terms of trade-offs and helping them develop a rich collection of cognitive models with which to interpret emerging issues in the political arena.

Summary:

	Confront	Comprehend	Contextualize	Control
Participatory Democracy	Recognize the personal implications of policy options and develop faith that a social/ political participation can help shape a better future	Develop a range of cognitive models with which to evaluate the socio/ technical interactions that shape the effects of technology on society	Develop an analytic framework that makes the social/ environmental/ ideological contexts central to a cognitive misers basic model of political analysis	Basic citizenship education combined with sufficient understanding of technology to avoid surrendering too much control to the techno-elite

IV. Preparing a Workforce for the 21st Century

In the 21st century the nature of many occupations will be dramatically altered in ways which demand increased cognitive skills. This trend is already well underway.

> Large investments in technology have led to the need for increasingly literate and math-skilled operators, replacing large numbers of what used to be "unskilled jobs". Management reorganization is putting increasing responsibility on lower level employees. Even jobs that are described in the traditional way require increasing levels of sophistication and education. (Jobs for the Future, 1988)

A Nation At Risk (1983) states that "the demand for highly skilled workers in new fields is accelerating rapidly"(p.10). Both the nature of existing jobs and the types of new jobs being created are increasing the skill requirements for employment. According to the Bureau of Labor Statistics, professional, technical, and managerial jobs account for more than 60 percent of current jobs and will grow faster than any other segment of employment through 2005.

The changing nature of employment could present some problems if citizens in the U.S. are inadequately prepared for the types of jobs being created. In a National Assessment of Educational Progress (NAEP) study (1986), more than half the 17yr olds tested were not prepared to either perform competently in jobs requiring technical skills or to benefit from specialized training (Helgeson, 1992).

As the global economy emerges, the ability of nations to provide a high standard of living will be increasingly based on how well prepared the citizens are to operate in a technological environment using advanced cognitive skills (Reich, 1992). "Today position and power in the global economy are based on the power of ideas, information and productivity,...global market position, i.e. dominance, will go to the nation with the best, most technologically literate industrious workforce" (Barnes et al., 1991).

Confronting Technological Change In Industry

When craft knowledge was passed orally between master and apprentice technical advances originated in relative isolation. Generation after generation used the same tools, techniques and processes. Change, when it did occur, was generated by a small number of craftsmen with limited access to ideas outside their immediate community.

According to Wolf (1935), "a critical turning point in the history of technology was the shift in the way in which technical knowledge was handed down: that is, from an oral to a written tradition." Written records made it possible to build increasingly comprehensive bodies of technical knowledge across space and time. When the written word replaced the oral tradition, and advances in transportation made the populace increasingly mobile, the pace of technological transfer, and therefore change, was accelerated (Rose, 1992).

Still, until the very recent past, the skills and knowledge of a technologist (a person employed in a technical field) could last a lifetime. However, today, the rate of technological change makes many skills obsolete in less than a decade (Bishop, 1992). In his book Productive Workplaces, Weisbord (1987: 253) writes "Now we must come to see learning, not training, as a way of life....unless we keep learning every day, no amount of training will help us stay up with new technology and markets."

Information technology, mass communication and the emerging global economy are vastly expanding the pool of technical knowledge by compiling and incorporating technical advances from all over the world. Adding to these effects is the economic pressure of global competition which creates an imperative for adopting ever more efficient processes, materials and equipment. This information sharing and growing economic pressure combined with the expanding number of people working in technical fields (and other effects of the information age) are dramatically accelerating the rate of technological change that societies have to cope with.

In response to this trend, business leaders, educators and politicians have become increasingly vocal about the need for a better educated workforce. "The people of the United States need to know that individuals who do not possess the level of skill, literacy, and training essential to the new era, will be effectively disenfranchised" (A Nation At Risk, 1983). Clearly, industry's ability to adopt and adapt emerging technology is dependent on the willingness and ability of its employees to actively engage those technologies as they evolve over time.

Research has demonstrated that money (Locke et al., 1980), social norms (Weisbord, 1987) and work organization (Stern, 1995) can influence the rate of learning on the job. However, even where motivation is increased, its effects are mitigated by issues of self-efficacy. In studies of technophobia in computer use on the job a number of findings have emerged which are congruent with findings on self-efficacy in the psychology literature (Vogt, 1996).

The effects of self-efficacy on persistence are predicated on the notion that engaging in some goal directed action represents a risk to one's self-image/esteem (Mikulincer, 1994; Ames, 1992; Elliot and Dweck, 1988; Skinner, 1990; Zimmerman, 1989). Where social and economic factors increase the risks, such as on the job, one could expect that issues of self-efficacy will have a stronger effect on employees' willingness to engage new technology. Therefore, understanding the nature of risks and how risks can be mitigated is a central concern in preparing employees for a world of continuous technological change.

There are three principle dimensions involved in analyzing risk: the identity of what is lost, how important the loss is to the individual and the probability that losses will occur (Yates, 1992).

* The pertinent losses associated with confronting novel challenges involve diminished self-image, confidence and ultimately poorer future performance with some evidence that this cycle can lead to a condition of "learned helplessness" (Mikulincer, 1994; Elliot and Dweck, 1988).

* The significance of these losses, and therefore the severity of their effects, vary among people by the type of attribution made for failure, social consequences and the level of importance the task assumes (Mikulincer, 1994; Yates and Stone, 1992; Ames, 1992).

* The perceived probability of failure, and therefore risk of loss, is related to a variety of internal and external factors both real and imagined (Yates and Stone, 1992).

By minimizing the social consequences and providing a process where employees find success related to their efforts the risk can be mitigated and engagement encouraged. From the perspective of the employee, learning how to approach new technology will reduce the probability of failure and therefore reduce the risk to a person's self-esteem. This involves developing a set of cognitive models which improve a person's ability to initiate an investigation, learn about the benefits and features of the technological innovation, and find an effective way to become proficient in its use.

The process of technological innovation can have a strong influence on the reactions of the workforce. Perhaps the most important determinants of learning rates involve structural issues outside the purview of technological literacy (e.g. compensation, social values, presentation in a non-threatening manner).

However, developing a strong sense of competence in dealing with technological change and building a history of success in non-threatening situations are central to developing the willingness to accommodate emerging technology associated with a technologically literate individual.

Understanding Technology And Technological Processes In Industry

The borderless world of an expanding global economy make it possible for corporations to search the earth for the most profitable combinations of raw materials, labor and markets (Reich, 1992). Therefore, American workers in many industries, particularly in the information economy, will face international competition on the basis of productivity and cost (Marshal and Tucker, 1992). Productivity will increasingly be based on cognitive competencies.

For the first time in history more people work primarily with their minds than with their hands.[6] Ideas, information and productivity are becoming the raw materials of industry in the information age. According to the Governor's (New Jersey) commission on science and technology, the emerging global economy will reward "skill, dexterity and knowledge" with economic growth and power.[7]

To be competitive in this environment employees must be able to adopt and adapt cutting-edge technologies while they still offer an economic advantage. Technical knowledge doubles every two and one-half years. Therefore, ninety percent of the knowledge we will use on the job in just ten years, has not been created yet. This remarkable pace requires employees to learn continuously in order to stay current. As noted above, preparing for the workplace of the future means preparing for continuous change.

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6 (Barnes and Erekson: 96 in Dyrenfurth 1991)

7 Gov's commission on SCI and Tech for the state of NJ cited in: Berkowitz, Marion, Ed. et al. "Technological Literacy and the Science Curriculum. Curriculum Conference (Convent Station, New Jersey, March 27, 1985). Summary Report." New Jersey Science Supervisors Association. 1985: 25p.

The economic pressure forcing employees to learn new technology quickly results from the pace of change and the central role of technology in productivity. In the past, technological advances in standardized high-volume production required months or years of discussions and planning, then implementation, trial runs, system redesign and finally operation. In today's companies, return-on-investment (ROI) periods are becoming increasingly compressed as new technologies race towards obsolescence at an ever increasing pace. Employees must be able to quickly become competent in operating job related technology in order to achieve the nearly immediate productivity demanded by the foreshortened returns-on-investment. Therefore, learning how-to-learn becomes a specific competency required by future industry in its use of technology to support economic growth.

Teamwork. The complexity of modern technology combined with the speed with which change is occurring requires cooperation and teamwork to maintain a competitive pace of adoption and adaptation within organizations. For instance, in developing new products the need to bring them to market quickly requires concurrent engineering practices which transform the traditional linear process into a parallel one where engineering, marketing, and manufacturing are working simultaneously and in concert (Chambers, 1996). This is particularly true where profits are related to organizational flexibility and the exploitation of niche markets. The introduction, modification and continuous improvement of technological artifacts and processes require team efforts. This is why industry, politicians and educators have all emphasized the need to develop teamwork skills (SCANS, 1991; Synthesis Coalition, 1995; Gummer, 1995).

The sheer volume of new information required to effectively adopt and adapt technology requires teamwork. The required interpersonal skills are facilitated through understanding the dynamics of small groups in goal directed action as well as a set of social skills. Therefore, this understanding is a natural part of technological literacy when the goal is 21st century employment.

High-performance work organizations. Increased teamwork is one aspect of the move towards new forms of work organization variously referred to as high-performance, Japanese management, world-class manufacturing, etc. These have proven their merits in a variety of organizational settings since being introduced to the U.S.. Perhaps the best known example of the power of this management approach is the NUMMI automobile plant in California which demonstrated in the early 1980's how a shift to high performance management could rehabilitate one of America's worst automobile plants, transforming it into an international model in less than a decade. These forms of work organization capitalize on the knowledge, skill and experience of employees within the organization. A central feature of these high performance organizations is the transferring of real autonomy, decision making and responsibility, to those immediately involved in production (Jobs for the Future, 1988).

According to the Secretary's Commission of Achieving Necessary Skills (SCANS, 1990), who in cooperation with the US Department of Labor, analyzed the demands of modern workplaces, there are three goals directly related to technology and technological change (Department of Labor, 1995: 2) appropriate for employees working in 21st century companies:

Select technology: Judges which sets of procedures, tools, or machines, including computers and their programs, will produce the desired results.

Apply technology to task: Understands the overall intents and the proper procedures for setting up and operating machines, including computers and their programming systems.

Maintain and trouble shoot technology: Prevents, identifies, or solves problems in machines, computers and other technologies.

Selecting the appropriate technology for a specific job, applying it and maintaining it, requires task specific knowledge and competencies tailored to the immediate situation (e.g., What a person needs to know in selecting the proper lathe for a machining operation is entirely different than deciding on which spreadsheet program to buy for the needs of an insurance office). Today, specific job related knowledge such as that defined by SCANS rapidly becomes obsolete (Bishop, 1992). This presents a challenge in including the three basic technology goals identified in SCANS as a part of general technological literacy. Clearly if general literacy extended to the specific levels sufficient to fully achieve the SCANS goals in all types of industries, it would have to include a significant number of skills and large body of knowledge about an impossible number of technologies, including their operational variations, relative capacity, merits and limitations.

Therefore, the competencies associated with general literacy must enable individuals to achieve these situation specific goals without encompassing them. The question becomes what level of understanding will enable employees to compare technological options, control technology in pursuing productive goals and keep technological systems operating effectively in a wide, but unknown, variety of specific situations in the future?

"Understanding" as it is discussed in the psychology literature is defined as the assimilation of basic rules concerning the nature and relationships of elements in a given system (Mayer, 1989). In coming to understand a new technology, the underlying "substrate of stable knowledge" about the nature of technology is extended through association with relevant information related directly to the current situation (Pierce et al., 1993). This makes it essential that we identify the general rules which comprise this "stable substrate" concerning technology and attempt to impart them in the process of creating technologically literate citizens. Where there are stable characteristics among classes of technology, understanding these will provide a basis for later decision making in the widest variety of situations. Essentially this involves defining "the nature of technology".

The effects of information technologies. Information technology is transforming markets, industries, firms and jobs. According to Bill Gates (1996), founder of Microsoft, the information age may be as significant as the industrial revolution in transforming the nature of work. Whether or not this proves to be true, there is little doubt that information technology is fundamentally changing the skills required by many jobs. Computers, with their potential to inform and automate are becoming commonplace in industry. Most employees will have to interact with them during their working lives. This is requiring changes in the nature of skills, cognitive demands and social conditions at work.

As discussed earlier, information technology is having a profound effect on the cognitive meaning-making skills required to work effectively. Increasingly, employees interpret their work through symbolic information presented on computer screens. This requires the ability to accurately interpret symbolic communication in developing an understanding of the physical reality they represent. Furthermore, computers are encouraging an explosion of information. To be effective in an information age one must be able to sort, find, understand, use and generate useful information. Information management skills will become increasingly important as the World Wide Web (and what follows) turns the current wave of information into an ocean.

Information technologies have also created a new form of equipment which, in turn, is transforming the nature of work in many industries. Programmable equipment (e.g., computer controlled milling machines) provide the unique power to change product and process in small batches while maintaining the automated features of computer controlled processes. The balance between automation and continual change results in the need for continuous problem-solving as new challenges pop-up associated with the multiple applications using the same technology.

Continuous change whether driven by technology or market conditions demands employees who can effectively deal with novel challenges. Accordingly, general problem solving skills are routinely cited as valued by modern industry (SCANS, 1991). The ability to identify, define, evaluate and solve problems becomes increasingly important in an environment of rapid change and is central to organizations where real authority is transferred to line-level employees.

<u>Putting Technology Into A Systems Context At Work</u>

Technological literacy in modern industry will require employees who can understand how micro-level operations fit into macro-level processes (Raizen et al., 1995). Just like many of the issues mentioned earlier, this becomes increasingly important as new work practices emerge, flattening the organizational hierarchy and shifting decision making to line-level employees. This "fitting in" with the macro-processes of an organization requires an ability to see the larger context, determine its relationship with the current options and make decisions which allow the micro-processes to support the macro-level operations.

The "universal systems model" is one way to analyze the relationships within a larger system. It consists of a causal chain of inputs, processes and outputs with a feedback loop to inform and improve the system's operation (Raizen et al., 1995). The demands of modern industry include understanding how "social, organizational and technological systems work, and (the ability to) operate effectively with them" (SCANS, 1991). In this situation mastering the thinking process embodied in the universal systems model is an important skill.

The systems approach has been advocated as a part of technological literacy for several decades. It has been as much a way of thinking about technology as it is about understanding the organizational context. The "Man Made World" curriculum of the 1960s and early 70s defines the purpose of this approach as "a way of looking at complex problems" (David et al., 1971).

While the systems model is a valuable tool, its limitations in practice are quickly revealed in industry. The value of a systems perspective is most clearly demonstrated where the inputs (e.g., people, capital, energy), processes (e.g., action, practices) and outputs (products, services) are clearly definable. The complex nature of the contextual systems in industry makes this difficult. The social, organizational and technical systems of industry are interactive, shaping one another in an unending stream of complex influences. These systems affect the way technical problems are framed, what options are considered and ultimately how the technology is implemented (Thomas, 1994). Analyzing how these organizational contexts frame technical decisions and considering how technological change will affect the systems or be affected by them is important for working effectively in a technological environment (even though one may not fully understand the interactions within the complex systems). This approach may turn out to be as much a matter of awareness and inclusion in the cognitive processes used to analyze technical issues as it is a specific body of knowledge or skills. Some people develop the sensitivity and perceptual acuity to recognize the social and political contexts. Clearly people are trained to be more sensitive to these contexts (e.g., sociologists and political scientists). However, further research will be required to determine how feasible it is to teach the population in general to be more perceptive of the social and political contexts affecting and effected by technological change.

Controlling Technology On The Job

Being able to control technology (i.e., to use it effectively in achieving organizational goals), involves the standard array of cognitive skills which have become almost cliche'. General cognitive skills such as problem solving, critical thinking and the ability to read and understand technical material are well recognized skills required to participate effectively in a high tech environment.

Meanwhile, specific skills such as programming computers, analyzing circuits or operating a robotics assembly line are clearly beyond the scope of general literacy. However, there are some central skills which fall between generic thinking practices and technology specific skills which should be included in a definition of technological literacy.

Many of the skills appropriate to general literacy involve the application of information technology. As information becomes more central to both processes and products the ability to collect, organize and evaluate information becomes increasingly important. Furthermore, the "symbolic analyst" skills described earlier are clearly central to operating effectively in an "infomated" environment (Zuboff, 1988). More and more, we operate on the world through the symbolic medium of computer screens and digital readouts.

Furthermore, technology is a rational affair. While its design, selection and implementation are inextricably tied to social processes, its nature is strictly rational. The systems model described in the previous section is an important tool because it allows a logical process of analysis in which the operation of technology can be followed sequentially from cause to effect in search of problems or simply as a way to continuously improve the technical system itself. This is an example of a general skill which directly supports the SCANS competencies for the full range of employers.

Finally, computers and their associated processes are mathematically based. From operating automated machining cells to using statistics in quality control, math skills are increasingly a part of modern industry. While some authors (e.g., Ost, 1987) have advocated deep mathematical components including programming, modeling and other advanced skills as a part of technological literacy, the level required to adopt and adapt most technology on the job falls somewhat below this level. Indeed, many jobs will require minimal math skills. However, since technology can be modeled mathematically and information technology often requires substantial mathematics ability, basic mathematics skills are an important component of general technological literacy which will support specialization in the future.

Conclusion: Workforce for the 21st Century

According to Majchrzak (1988) emerging technologies require new manual skills, perceptual skills, conceptual problem solving skills and interpersonal skills. With the prominence of computer technology employees also need abstract "sense-making" skills that allow them to interpret the state of a process through abstract symbols presented on a computer screen. Most manual skills, (beyond perhaps keyboarding) are situation specific and therefore not necessarily good candidates for general technological literacy. However, to the extent that they can be taught, perceptual, problem solving and interpersonal skills are central competencies that extend across technological domains in the workplace of the 21st century.

Summary:

	Confront	Comprehend	Contextualize	Control
Work	Prepare for continuous learning Develop effective processes for approaching novel technology	Learning how to learn Dynamics of small groups in goal directed action Define the nature of technology as a tool of human intentions embodied in rational systems Develop symbolic/ meaning making skills Use information effectively Develop problem solving skills	Universal systems model Understand how organizational contexts frame problems and restrict the range of options considered Develop a perceptual acuity for the political environment Analyze the likely effects of technology on the organization	Ability to collect, analyze, and generate useful information Apply the systems model to complex problems Develop mathematics competence

V. Shaping the Future to Blunt the Dehumanizing Effects of Technology

Existentialists and idealists have concerned themselves with questions of how choices we make influence the consequences of new technology on the human race (Dyrenfurth, 1991).

In his book Time Wars, Rifkin (1987) describes the influence of clocks in limiting the level of personal autonomy among citizens. Today the clock ticks 5:00 PM and millions of workers become anxious for the liberation that moment provides. The clock controls, it liberates, it constrains human discretion. Of course its power is given, not predestined, but once given its power is considerable. Depending how they are developed and used, many technologies can demand the surrender of human discretion as the price for enjoying the benefits they offer.

Clearly there are many possible definitions of dehumanization such as, reduced interpersonal contact, increased disparity of wealth within society, devaluing of human life, etc. However for the purposes of this paper those value judgments will be left to the collective wisdom of a technologically literate society. Here the only overarching value which validates this definition of literacy is the primacy of facilitating the ability of individuals to act in their own interests according to their values and beliefs. Dehumanization as it is used here, is the constraint of this ability.

It is clear technology can and often does increase demands which limit human agency and discretion and therefore, according to this definition, have a dehumanizing effect. There is a hope that technological literacy can help people make decisions which empower humankind, surrendering as little human discretion and freedom as possible in pursuit of the benefits available with technological advances. These are decisions about the nature of life. Zuboff (1988) writes "These choices for the future cannot be deduced from economic data or abstract measures of organizational functioning. They are embedded in the living detail of daily life at work as ordinary people."

In her book In the Age of the Smart Machine, Zuboff (1988) counterpoises the dehumanization of an automated system with the human empowerment of what she calls an 'infomated' approach. She describes how choices concerning the application of information technology have profound effects on the working lives of those involved. According to this definition, making decisions which enhance discretion while limiting the demands of technology is the goal of technological literacy in blunting its dehumanizing effects.

Confronting Misconceptions Of Determinism

Today, little or none of the predictability common to past generations remain. We make choices moment to moment which combine to define our existence without any certainty about the consequences of our actions. However, while the future is ultimately unknowable, it is clearly influenced by our decisions. We have an effect even if we cannot predict precisely what that effect will be. In such an environment we must ultimately act on faith guided by our beliefs and our values.

If we accept the argument that technological literacy should include the beliefs and attitudes which can limit the dehumanization effects of technological advances, then we need to confront the misunderstandings and detrimental beliefs which inhibit participation in shaping technological change. Central to these detrimental beliefs is the idea that the effects of technology are inevitable and deterministic.

Comprehending The Human Role In Shaping The Effects Of Technology

In his article "Do Artifacts Have Politics" Langdon Winner (1985) states that artifacts embody specific forms of power and authority, arguing that one must "pay attention to the characteristics of the objects themselves and the ramifications of those characteristics." As he puts it, "the issue has to do with ways in which choices about technology have important consequences for the form and quality of human associations."

In support of this argument Winner offers two types of examples. One set involves examples such as the highway overpasses in New York which were designed so low that they prevented busses from reaching the recreational beaches. This resulted in a *de facto* enforcement of segregation between the primarily white automobile owners and minorities who often relied on busses for transportation. This set of examples demonstrate the obvious, that artifacts can be designed to support the interests of one group over another.

In contrast to these examples were those in which the social/political effects arising from technological change are byproducts of the technology itself. Here the "tyranny of the steam" in turn-of-the-century production plants is the epitome of how changes driven by economic or market goals have embedded in them certain dehumanizing effects through the social constraints required by the employment of that technology. On the face of it these examples seem to support a deterministic view in that the very nature of the technology has social and political consequences.

While there are clearly social/political consequences of technological change, the question of whether or not technology's effects are deterministic or socially constructed cannot be answered without examining the ideological context in which those developments occur.

The Ideological Context Defining The Effects Of Technological Change

In arguing that the nature of certain technologies dictate their social/political effects, one question which needs to be addressed is to what degree the effects of the technology are controlled by the ideological context they exists in. The McCormick Reaper provides a useful example with which to examine this question.

Invented in the 1840s, the McCormick reaper automated the most labor intensive activity in agriculture, the reaping of wheat. Clearly the reaper reduced costs, increased productivity and replaced labor with equipment making production more predictable. In our society, the consequences of those features were to displace nearly half the country's agricultural workforce sending them streaming off the farms and into the urban areas in search of work.

Was there something embedded in the nature of the reaper which determined its effect on agricultural work? Obviously it offered economic benefits to the farm owners. However, the effects were as much the result of the ideological context of an America which prized efficiency and economic growth over tradition, as it was the technology itself. If the ideological context were different, reflecting other values, values besides efficiency and profit (e.g., socialism), the effects of the technology might well have been different. Therefore, it is insufficient to argue that there are specific social ramifications from technological change without acknowledging that those effects are context dependent.

Winner (1985) argues that the very nature of atomic bombs demand a tightly controlled hierarchical structure which by definition empowers some people at the expense of others. However, in the former Soviet Union there are many nuclear weapons which despite their awesome capacity for destruction are no longer enmeshed in a strict hierarchical system of authority (Blair, 1966; Mytsykov, 1995). We can rationalize that such a system would be beneficial but it is clear that the social structure is not determined by the technology, but rather by the ideological context and its implications for social action.

Controlling The Dehumanizing Effects Of Technological Change

Once we recognize that choices are available which can limit the dehumanization of technological change it becomes a question of values, access and control. Dyrenfurth (1991:3) writes "A healthy understanding of technology and its nature might well empower humankind to resist such easy fallacies as blaming the machine by forcing acknowledgment of reality, i.e., that it is people who make decisions ultimately." Those decisions can limit or promote access to the benefits of technology just as they can determine how it will be used and to some degree what dehumanizing effects it will have.

Dehumanization at work. Currently the issue of embedded social ramifications of technological change is being explored by the work of people such as Thomas, (1994) and Zuboff, (1988). They raise interesting questions of how skills in an infomated environment are changing and how decisions about employing technology can effect the daily lives of workers.

What is particularly interesting is the way in which empowering human discretion in certain situations can result in greater productivity while reducing managerial authority. This trade-off and its political implications are central to questions of dehumanization in the workplace. It seems likely that in those industries where automation is more productive than infomation and human discretion, then working life will become automated and dehumanized. On the other hand it seems equally obvious that the degree to which automation is more productive than infomation is related to the skills, motivation and natural ability of the workforce.

There will always be those who think Taylorism did them a favor by limiting the cognitive demands of their jobs, and those who resent any interference with their personal autonomy in dealing with the demands of life. A technologically literate person will therefore, be one who recognizes the range of options and employs technology in ways which reflect their interests. Limiting the dehumanization of technological change becomes a reflection of an individual's interests as long as it is not constrained by a false sense of helplessness or the lack of skills required to make technology their servant in pursuing their interests.

Summary:

	Confront	Comprehend	Contextualize	Control
Dehumin-ization	Overcome the belief that the effects of technological innovation are deterministic	Understand that there are socio/ political ramifications of technological choices	Recognize that the consequences of technological choices are socially constructed through the ideological context they are embedded in	Recognize the range of options and learn to act in ways which shape the effects to empower human discretion

VI. Conclusion

In examining the requirements of preparing people for daily life, effective citizenship, employment and as advocates of a more humane future their are several trends which inform our efforts to define general literacy. There are clearly different facts, technology and consequences for each of these areas of concern. However, what defines general literacy are those commonalties which cut across goals and specific technologies. These commonalties can then form the basis for policy decisions concerning the support of specific programs to the degree that those programs reinforce the skills identified herein.

Several common attributes have emerged, such as a willingness to engage unknown technology, to take responsibility for learning about it, and developing a set of meta-schema which define the nature of technology as a referent for analyzing claims about technology. Furthermore, several literacy skills associated with information technology are common to most (but not all) of the goals such as, using information technology effectively, understanding its implications and the nature of the opportunities associated with it. There are also general cognitive abilities which cut across the various goals for technological literacy. Rational analysis, contextualization using a systems model, open-ended problem solving inherent in continuous change, and an ability to read and follow technical material are all a part of the skills required by general technological literacy.

Among the interesting distinctions which arise from the discussions in this paper is the difference between those skills required by the technology itself and those demanded by the pace of technological change. The need to interpret physical reality through abstract symbolism is demanded by the nature of information technologies, while the need for increased teamwork is primarily the result of the pace of change required to maintain a competitive position in a world where technological advances are ongoing at a furious pace.

The nature of technology and technological processes in the current age define several aspects of technological literacy. The value of accurately assessing the social/political context's effect on technological decisions and the consequences of those decisions on the context are common to all four goals for technological literacy. For educators the question then becomes how to improve a persons ability to accurately perceive this context and improve their ability to predict the interactions between specific technological choices and the social context it is embedded in.

Many of the issues raised in this paper involve an understanding of the nature of technology. A country whose citizens understand that technology is rational, constructed by people to serve their interests, constrained by the laws of nature, dynamic in the ongoing struggle to achieve the aims of people yet stable in the characteristics common to specific classes of technology, will be a country in which decisions about technology will be more rational and effective.

Information technology is having a substantial effect on all areas of life. Accompanying these technologies are requirements for skills in collecting, sorting, evaluating and applying information. There is also increased demand for producing new information as the raw material for future efforts. Finally, the nature of the information is changed from sentient perception to symbolic interpretation in which the understanding of reality must be reconstructed from a symbolic medium such as a computer screen or digital readout.

In addition to the skills associated with specific technologies, there are a host of demands created by the pace of technological change. The ability to continuously confront novel interfaces, come to understand technologies capacity and develop the skills required to control it results in what Weisbord (1987) describes as the need for continuous learning.

Teamwork, learning how to learn, and continuous problem solving are all closely associated with change. The need for concurrent engineering and the value of shared knowledge as a hedge against obsolescence are cases in point. Problem solving, is associated with the need to deal with a continuous flow of novel challenges as well as the need for continuous improvement in industry in general. The transformation of many industries from static, standardized production to more nimble forms of product development and production results in these ongoing challenges and the need for skills in problem solving.

Finally, perhaps the most significant requirement of modern technology on the individual is the increased personal responsibility accompanying the more direct control of the effort to achieve one's interests. Inherent in this control is the need to accept the responsibility for identifying individual needs, understanding the capacity of technical options to serve those needs and then acting on those decisions in their pursuit.

Summary:

	Confront	Comprehend	Contextualize	Control
Day-to-Day	Overcome technophobia. Develop self-efficacy in dealing with technical interfaces	Understanding what a technology can do Read technical material about products Take greater responsibility for analyzing personal needs and determining the suitability of various technical options	Determine the suitability of technical options for accomplishing a given task Evaluate the likely effects of technological choices on one's immediate social group (e.g., family)	Read and follow instructions Frame investigations of new technological interfaces Develop abstract/ interpretive skills

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Participatory Democracy	Recognize the personal implications of policy options and develop faith that a social/ political participation can help shape a better future	Develop a range of cognitive models with which to evaluate the socio/ technical interactions that shape the effects of technology on society	Develop an analytic framework that makes the social/ environmental/ ideological contexts central to a cognitive misers basic model of political analysis	Basic citizenship education combined with sufficient understanding of technology to avoid surrendering too much control to the techno-elite
Work	Prepare for continuous learning Develop effective processes for approaching novel technology	Learning how to learn Dynamics of small groups in goal directed action Define the nature of technology as a tool of human intentions embodied in rational systems Develop symbolic/ meaning making skills Use information effectively Develop problem solving skills	Universal systems model Understand how organizational contexts frame problems and restrict the range of options considered Develop a perceptual acuity for the political environment Analyze the likely effects of technology on the organization	Ability to collect, analyze, and generate useful information Apply the systems model to complex problems Develop mathematics competence
Dehumin-ization	Overcome the belief that the effects of technological innovation are deterministic	Understand that there are socio/ political ramifications of technological choices	Recognize that the consequences of technological choices are socially constructed through the ideological context they are embedded in	Recognize the range of options and learn to act in ways which shape the effects to empower human discretion

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