Design Issues, Volume 20, Number 3 (June 01, 2004)

1 Design by Society: Science and Technology Studies and the Social Shaping of Design1

Edward Woodhouse, Jason W. Patton. Design by Society: Science and Technology Studies and the Social Shaping of Design1. *Design Issues*, Volume 20, Number 3 (June 01, 2004), pp. 1-12

13 Alternative Design Scholarship: Working Toward Appropriate Design

Dean Nieusma. Alternative Design Scholarship: Working Toward Appropriate Design. *Design Issues*, Volume 20, Number 3 (June 01, 2004), pp. 13-24

25 Design Style: Changing Dominant Design Practice

Todd Cherkasky. Design Style: Changing Dominant Design Practice. *Design Issues*, Volume 20, Number 3 (June 01, 2004), pp. 25-39

40 Toward Participatory Ecological Design of Technological Systems

Jeff Howard. Toward Participatory Ecological Design of Technological Systems. *Design Issues*, Volume 20, Number 3 (June 01, 2004), pp. 40-53

54 Environmental Information Systems as Appropriate Technology

Kim Fortun. Environmental Information Systems as Appropriate Technology. *Design Issues*, Volume 20, Number 3 (June 01, 2004), pp. 54-65

66 The Challenge of Responsible Design

Jesse S. Tatum. The Challenge of Responsible Design. *Design Issues*, Volume 20, Number 3 (June 01, 2004), pp. 66-80

81 A Reminiscence in Honor of Rob Roy Kelly

Joe Ballay. A Reminiscence in Honor of Rob Roy Kelly. *Design Issues*, Volume 20, Number 3 (June 01, 2004), pp. 81-82

Introduction

Design by Society: Science and Technology Studies and the Social Shaping of Design[1]

Edward Woodhouse and
Jason W. Patton

This *Design Issues* symposium is a continuation of efforts to enrich design studies by selectively reaching out to scholarship in related fields. The contributors to this issue are from the interdisciplinary field of science and technology studies (STS). They include an anthropologist, a political scientist, and an interdisciplinary set of STS graduate students and recent Ph.D.s with backgrounds in engineering and design, as well as in the humanities and social sciences. This volume emerges from a project at Rensselaer Polytechnic Institute to develop "An STS Focus on Design," funded by the National Science Foundation's Science and Technology Studies program. Project participants seek to foster a dialogue with the design studies community on design as a public activity engaging professional designers with many other social actors and institutions.

In this introduction, we provide an overview of how some STS scholars think about the challenges of design, and we briefly summarize the articles in this symposium. However, we begin by discussing the conceptual foundation for the work, distinguishing between what we call "proximate designers" and "design by society."[2] Professional designers most immediately shape design by their decisions at the drawing board, of course, but they work within contexts and incentive structures shaped largely by others. In proposing that design studies pay increased attention to design by society, we are attempting to join with Victor Papanek, Nigel Whiteley, Joan Rothschild, Richard Buchanan, Victor Margolin, William McDonough, and others who think systematically about how design can help shape a commendable civilization.[3]

Proximate Designers and Design by Society

Our starting point is the fact that design involves both professional designers as well as what might be termed "design by society." We refer to the persons often studied in this journal as *proximate* designers, including product, industrial, graphics, and urban designers and architects who exercise direct control over the details of design.[4] Proximate designers work under constraints and incentives established via complex social arrangements involving persons often far removed from the drawing board. This happens partly because

1 This symposium is based on papers originally written for the Design Seminar at Rensselaer Polytechnic Institute, funded by the National Science Foundation under grant B10332 for "An STS Focus on Design." We thank John Schumacher (in memoriam), Linnda Caporael, Judith Gregory, Langdon Winner, and our fellow participants in the Design Seminar for their contributions to this collaboration.

2 Design *by* society is intended as a corollary to Nigel Whiteley's *Design For Society* (London: Reaktion Books, 1992), recalling as well the democratic theme, "Of, by, and for the people."

3 Victor Papanek, *Design for the Real World: Human Ecology and Social Change,* 2nd ed. (Chicago: Academy Chicago, 1985); Joan Rothschild, ed., *Design and Feminism: Re-visioning Space, Places, and Everyday Things* (New Brunswick, NJ: Rutgers University Press, 1999); Richard Buchanan and Victor Margolin, eds., *Discovering Design: Explorations in Design Studies* (Chicago: University of Chicago Press, 1995); and William McDonough and Michael Braungart, *Cradle to Cradle: Remaking the Way We Make Things* (New York: North Point Press, 2002).

4 Of course, we are not trying to legislate usage of the term "design," and some readers may prefer to limit its denotation to the professions traditionally understood to be at the core of design practice.

designers have to earn a living, which usually entails working directly or indirectly for clients; but the overall process of design is far more complex than suggested by the relatively straightforward relationships between proximate designers and clients.

The concept of design by society has three main facets, the first of which is that no simple boundary adequately delineates what counts as design, or who engages in it. To the core design professions as conventionally understood, one might add chemical engineers, computer scientists, nanotechnologists, and other technical specialists who conduct R&D and shape the built world. An even broader collection of people shape design by setting parameters, procedures, and directions within which proximate designers work. For example, managers set corporate policies that establish boundaries for the kinds of projects that can be undertaken. More specific interventions include those of accountants, who shape the financial systems within which design choices occur (e.g., determining whether wastes are to be treated as a cost to be minimized or as someone else's problem). Government officials establish building codes, safety standards, and environmental regulations. Altogether, innumerable persons and organizations participate in the design process with varying degrees of immediacy.

Second, design by society is intended to signify that social norms, values, and assumptions are reproduced—often unintentionally—in the products of design. As we read the design studies literature, it sometimes comes across as if designer (and client) were entirely free to choose how a product or building or artifact will be shaped, and as if their deliberate efforts constitute pretty much the whole story of design. Yet we all really know that cultural assumptions, legal mandates, and other social forces exert considerable influence on technological innovation, often without the participants being aware of all of the background influences. As Wiebe Bijker and John Law put it, "Our technologies mirror our society. They reproduce and embody the complex interplay of professional, technical, economic, and political factors." [5] "(R)elationships of power and authority frequently are expressed in material settings that are deliberately designed and built." [6] For example, product differentiation in consumer durables tends to mirror the prevailing patterns of social differentiation: what it means to be a woman or man, boss or secretary takes on durable form, from the razors we use to the desks we sit at.[7]

One inference from the above is that designs may tend to best serve the needs of those who most resemble the proximate designers.[8] The logic is simple: (1) designers have to proceed in terms of their own understandings of the world; (2) their ideas have been shaped by their individual experiences, disciplinary training, and demographic positioning by race, class, and gender;[9] (3) what "makes sense" will tend to be in accord with designers' tacit assumptions—and possibly *not* in accord with the assumptions of persons

5 Wiebe E. Bijker and John Law, eds., *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), 3.

6 Langdon Winner, "Political Ergonomics" in Buchanan and Margolin, eds., *Discovering Design*, 147.

7 Adrian Forty, *Objects of Desire* (New York: Pantheon, 1986).

8 Donald Norman, *The Design of Everyday Things* (New York: Doubleday, 1988).

9 Donna Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective" in *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991); and Sandra Harding, *Is Science Multicultural? Postcolonialisms, Feminisms, and Epistemologies* (Bloomington, IN: Indiana University Press, 1998).

not engaged in the design process; (4) to the extent that designers' understandings depart in significant ways from those of the unrepresented, unfortunate consequences may ensue. For example, the design of city streets creates obstacles for many people who do not fit the profile of the adept user. Imagine how different city streets would be if urban designers and traffic engineers came disproportionately from the ranks of the visually impaired, elderly, wheelchair-bound, and bicycle commuters.[10]

Third, we intend the concept of design by society to pose the following challenge: how might the great care that now goes into proximate design of particular products be extended to the broader processes of design? As one component of that huge task, what would it take to arrange for the social costs of innovation to be identified, deliberated, and mitigated earlier rather than later? These and related questions arise because the careful attention and skilled performance commonly found in design typically is not applied to technological innovation as a whole. The foundation for this is that designers, to some considerable degree, proceed by serving *clients'* ends, which of course makes good sense insofar as "the primary purpose of design for the market is creating products for sale." [11] One crucial drawback, however, is that "little thought has been given to the structures, methods, and objectives of social design... the foremost intent (of which)... is the satisfaction of human needs." [12] The client-focused, one product-at-a-time marketed approach also means that designers tend to assume that any given design has little effect on other designs, so negative synergisms can be ignored. A corollary assumption is that each new design is politically neutral, so how it is used rather than how it is designed determines whether the effects are for good or for ill. Among other implications, this means that there is no need to design for social equity or for any other public outcome.

We readily acknowledge that it is by no means clear how a lone proximate designer could go about taking these broader issues into account. Even an entire business's or industry's imperatives for timely and cost-effective task performance may fit rather badly with a critical and holistic social perspective. Indeed, hardly anyone in a position of authority in the business sector has a strong and unconflicted interest in paying diligent attention to design by society. An obvious inference is that public concerns about design outcomes might appropriately be taken up in a public way. Rather than throwing responsibility on designers and clients alone, with government officials in the background as intermittent limit setters, how might design move into public debate, systematic inquiry, and institutional practices in unprecedented ways?

Recognizing, then, that a nuanced understanding of design in a complex technological society involves an enormous range of considerations, we suggest design by society as a conceptual approach for (1) considering how myriad persons participate in the

10 How undesignerly persons might be included more influentially is one of the goals of participatory design, discussed in several of the essays.

11 Victor Margolin and Sylvia Margolin, "A Social Model of Design: Issues of Practice and Research," *Design Issues* 18:4 (Autumn, 2002): 24.

12 Ibid., 24–25.

design process; (2) examining how societal norms are built into the world by design; and (3) figuring out how the best spirit of proximate design could be applied to the broader domain of design by society. In other words, this approach locates the work of proximate designers within the larger universe of social institutions and processes that shape the artifacts, symbols, and systems of contemporary life. The cumulative consequences of these rival in importance, scope, and intellectual challenge the domain now considered the field of design. Our goal is to bring the issues of design by society into more frequent and systematic conversation with the traditional concerns of proximate designers and design studies.

STS Perspectives on Design by Society

The field of science and technology studies examines sociotechnical phenomena ranging from laboratory curiosities through seemingly simple artifacts, to complex sociotechnical systems.[13] For example, Kenneth Ames argues that household furniture in Victorian America combined elaborate design with basic functionality to display conspicuous consumption and reinforce social stratification. Ornamental but uncomfortable chairs in the entryways of well-to-do households were appropriate to be seen by owners and guests, while sat upon only by servants and messengers.[14] At a much larger scale, Thomas Hughes explains the construction of electrical power networks as *sociotechnical systems* wrought by system builders with "the ability to construct or force unity from diversity, centralization in the face of pluralism, and coherence from chaos." [15] The analysis of such systems seeks to explain how people and technologies are combined to work as heterogeneous but functional wholes.

To study the social shaping of technologies, STS scholars work in the cognitive space between two commonly held perspectives regarding technology. The position of *technological neutrality* maintains that a given technology has no systematic effects on society: individuals are perceived as ultimately responsible, for better or worse, because technologies are merely tools people use for their own ends. Possibly the most common example of this position is the slogan, "Guns don't kill people; people kill people"—according to which logic the gun is a neutral tool while agency is attributed to the individual pulling the trigger. In contrast, the position of *technological determinism* maintains that technologies are understood as simply and directly causing particular societal outcomes.[16] Thus, a determinist might attribute the decay of U.S. cities to the invention of the automobile, perceiving that the new technology itself undermined the vitality of central cities. Technological neutrality and determinism are folk theories that attempt to understand how people and technologies interact: both explain that interaction in black-and-white terms, attributing agency either entirely to people or entirely to technology.

13 For an introduction to STS, see Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch, eds., *Handbook of Science and Technology Studies* (Thousand Oaks, CA: Sage Publications, 1995); the journal *Science, Technology, and Human Values;* and the annual meetings of the Society for Social Studies of Science. For an introduction to science studies, see David Hess, *Science Studies: An Advanced Introduction* (New York: New York University Press, 1997).

14 Kenneth L. Ames, "Meaning in Artifacts: Hall Furnishings in Victorian Architecture," *Journal of Interdisciplinary History* 9:1 (Summer, 1978): 19–46.

15 Thomas P. Hughes, "The Evolution of Large Technological Systems" in Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987), 52.

16 Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, MA: MIT Press, 1994).

For STS scholars, better explanations require conceptual tools that allow us to think systematically about complex and simultaneous causation as people and technologies interact. One such tool is the concept of *valence,*

> a bias or "charge" analogous to that of atoms that have lost or gained electrons through ionization. A particular technological system, even an individual tool, has a tendency to interact in similar situations in identifiable and predictable ways. In other words, particular tools or technologies tend to be favored in certain situations, tend to perform in a predictable manner in these situations, and tend to bend other interactions to them. Valence tends to seek out or fit in with certain social norms and to ignore or disturb others.[17]

Thus, a gun is neither neutral nor does it cause people to kill each other. Rather, a gun is valenced toward violence. The presence of a gun in the context of a dispute facilitates a course of events in which a person is shot. One can feel the valence of the gun in the tension it adds to the situation. Although a table lamp also can be used to kill, it does not lend itself as readily to the act.

Another way to characterize the complex interplay between agency and determinism is to see technologies as *forms of life.*

> The construction of a technical system that involves human beings as operating parts brings a reconstruction of social roles and relationships. Often this is a result of a new system's operating requirements: it simply will not work unless human behavior changes to suit its form and process .... We do indeed "use" telephones, automobiles, electric lights, and computers in the conventional sense of picking them up and putting them down. But our world soon becomes one in which telephony, automobility, electric lighting, and computing are forms of life in the most powerful sense: life would scarcely be thinkable without them.[18]

Thus, in no simple terms did the automobile cause urban decay. However, automobility as a form of life developed via federally subsidized highways, incentives for single-family home ownership, low-density development patterns with plenty of free parking, and a century-old suburban ideal that previously was only within reach of the upper class.[19] With these enabling conditions in place, automobile ownership became a necessary ingredient for middle-class Americans to flee the city and its strained race relations. The concept of technologies as forms of life expresses how people and technologies shape each other. It is intended as a partial replacement for the conventional notion of a one-way process through which humans design and use technologies as neutral tools.

17 Corlann Gee Bush, "Women and the Assessment of Technology: to Think, to Be, to Unthink, to Free" in Joan Rothschild, ed., *Machina Ex Dea: Feminist Perspectives on Technology* (New York: Pergamon Press, 1983), 155.

18 Langdon Winner, *The Whale and the Reactor: A Search for Limits in an Age of High Technology* (Chicago: University of Chicago Press, 1986), 11.

19 Clay McShane, *Down the Asphalt Path: The Automobile and the American City* (New York: Columbia University Press, 1994); and James J. Flink, *The Car Culture* (Cambridge, MA: MIT Press, 1975).

Impressed by the nuances arising in the design and diffusion of innovations, many STS scholars have investigated the details of how artifacts and sociotechnical systems came to take the shape they did. The social construction of technologies, they say, can be understood as involving a number of relatively predictable steps, including how relevant social groups such as users interact with technologists and businesses to bring "closure" to technical potentials that initially are highly malleable.[20] Perhaps the best known such analysis concerns the evolution of the bicycle.[21] The branch of STS represented in this symposium places less emphasis on the historical and sociological analysis of how things came to be. Instead, it emphasizes where design goes from here, and on what it will take to reconstruct technologies more wisely and fairly.

Scholars working in this tradition tend to point to rather basic shortcomings in the processes from which design eventuates. Thus, while proximate design is inherently a deliberate intervention, and a series of thoughtfully selected acts, in the broader realm of design by society, there actually is a widespread predisposition *not* to intervene deliberately. "You can't stop progress" functions as something of a mantra. Thus, the most important institution for design by society—market buying and selling—often does a brilliant job of serving the parties to a transaction; but buyers and sellers are free to ignore third parties who their actions affect. Markets are not structured to steer technological innovation toward social ends because they lack mechanisms to distribute the costs and benefits of innovation equitably, and because they lack mechanisms to deal with serious problems arising synergistically as second-order effects of innovation.[22]

Individuals, organizations, and societies often behave as if sleepwalking, often allowing innovations to move along paths not deliberately chosen by socially sanctioned processes. The concept of *technological somnambulism* names this failure to recognize, debate, and address technological design as a core component in the shaping of everyday life. One manifestation is that means are not crafted and selected to serve carefully chosen ends; instead, "reverse adaptation" makes new technical potentials central—and humans and their organizations adapt.[23] Such deliberate intervention by society as does occur tends to be both late and clumsy. We have largely failed to arrange and conduct the sociopolitical research, design, and training needed to create the repertoire of practices and institutions necessary to intervene effectively. Whereas legislation often receives extensive public hearing and debate, the technological design process usually is limited to a narrow group of people—the proximate designers and their clients—who typically are shielded from scrutiny, partly for reasons of trade secrecy, and partly from habit and public quiescence. It becomes very difficult even to locate responsibility for specific decisions made within complex organizations—from space shuttle disasters, to dumped hazardous wastes, to defectively manufactured passenger vehicles recalled annually by the millions.

20 Bijker, et al., *The Social Construction of Technological Systems*.

21 Wiebe E. Bijker, *Of Bicycles, Bakelite, and Bulbs: Toward a Theory of Sociotechnical Change* (Cambridge, MA: MIT Press, 1995). Questions about the analysis are raised by bicycle historian Nick Clayton, "SCOT: Does It Answer?" *Technology and Culture* 43 (April 2002): 351–360.

22 For a review of market strengths and shortcomings, see Charles E. Lindblom, *The Market System: What It Is, How It Works, and What to Make of It* (New Haven: Yale University Press, 2001).

23 Langdon Winner, *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought* (Cambridge, MA: MIT Press, 1977), 226–236.

One manifestation is a loss of agency, an inability to steer technological development and use in directions responsive to the intentions people would have if they had the opportunity, motivation, and competence to deliberate on the matter. "With the overload of information so monumental, possibilities once crucial to citizenship are neutralized. Active participation is replaced by a haphazard monitoring."[24] Most of us, most of the time, allow the relevant experts and their organizations in each field of basic and applied science, engineering, and medicine to do whatever is technically and financially feasible within their narrow spheres of action. No institution has a mandate to determine whether the many different technological design trajectories fit together wisely and fairly.

Participation, Expertise, and Process

To bring the above insights from STS into somewhat sharper focus for design studies, one step is to reflect on certain foundational questions that integrate proximate design with design by society:

1. Who shall participate in making decisions about new design initiatives (and in revising existing activities)?
2. How shall the benefits of design be distributed?
3. For what range of outcomes will designers assume responsibility—and accountability?

Actually, of course, no one attempts to answer such broad questions, except perhaps in a few utopian studies courses in college. In everyday practice, one takes for granted almost all of the world "as is," and that heuristic move has a certain functionality because getting anything done requires not trying to do too much. Nevertheless, inattention to foundational issues arguably results in significant shortcomings facing design in our era:

1. A tendency for technological innovation to proceed without sufficient contestation and deliberation;
2. Great inequalities in who gets the benefits of designers' energies and skills; and
3. Nontrivial side effects, synergisms, and second-order effects that no one is responsible for foreseeing and preempting.

What would it take to cope better with these and other challenges in technological innovation? Many analysts emphasize some combination of more diverse participation, better deployment of expertise, and improved decision-making strategies and processes.

Echoing the sentiments of those who advocate participatory design, democratic theorist-activist Richard Sclove argues, "Insofar as (1) citizens ought to be empowered to participate in shaping their society's basic circumstances, and (2) technologies profoundly affect and partly constitute those circumstances, it follows that (3) technological design and practice should be democratized."[25] This seemingly radical conclusion arises from a simple analogy: government

25 Richard E. Sclove, *Democracy and Technology* (New York: Guilford Press, 1995), ix.

24 Ibid., 296.

policy making is similar to design in that both determine the allocation and structure of resources that shape people's lives. However, there is no deliberative, public process for design by society equivalent to the legislative process in government, despite the fact that, in many respects, technology *is* legislation that authoritatively reshapes individual and collective life.[26]

Given the complex issues arising in design, *effective* participation obviously requires knowledgeable participation. Just how this can be achieved without the most knowledgeable participants dominating is one of the great, partially unanswered questions of democratic theory and practice. Even though technical experts rarely exercise the sort of authority once feared by critics of technocracy, a substantial fraction of the population lacks the knowledge necessary to participate effectively in many realms of contemporary life.[27] Can those with the requisite knowledge be socialized, selected, and motivated to represent the diversity of affected persons, stimulate a more vigorous competition of ideas, and promote greater political equality? Might "appropriate expertise" actually arrange to champion the concerns of people generally under-represented in, or disenfranchised by, technological decision making?[28] In addition, there may be ways to enhance the contribution of self-trained laypersons, for "bringing such persons into the technological decision-making process should not be seen simply as a democratic necessity; rather it is good sense in terms of using available expertise even when it is found in unexpected places."[29] Lay experts in hazardous waste controversies and other technological disputes sometimes develop sophisticated levels of expertise, and even ordinary people with relevant knowledge of local circumstances can make crucial contributions to public debate.[30]

The issues of participation and expertise intersect with concerns about inadequate institutional processes for governing technological innovation—raising questions, for example, concerning how to reduce, contain, or ameliorate the unanticipated consequences of new technologies. Although technology assessment has been moribund in the U.S. since the demise of the congressional Office of Technology Assessment in 1995, European scholarship and practice continues to push for "constructive technology assessment."[31] Rather than the purely analytic procedure once conceived by technically oriented researchers, it has become clear that assessment of innovations requires social learning; that such learning inevitably has an ideological component; and that it requires pluralistic debates that "expose neglected possibilities, clarify the limitations of accepted analyses, and identify the social values or interests concealed in existing 'objective' trajectories."[32]

But how can learning occur in time, before technological momentum makes it very costly to change course, as in the case of vinyl chloride (PVC) and other twentieth-century innovations? Developed partly to cope with this problem is the decision strategy

26 On technology as legislation, see Winner, *Autonomous Technology*, 317–325.

27 Frank N. Laird, "Technocracy Revisited: Knowledge, Power, and the Crisis in Energy Decision Making, " in *Industrial Crisis Quartterly* 4 (January, 1990): 49–61; and Frank Fischer, *Citizens, Experts, and the Environment: The Politics of Local Knowledge* (Durham, NC: Duke University Press, 2000).

28 Charles E. Lindblom and Edward J. Woodhouse, *The Policy-Making Process,* 3rd ed. (Upper Saddle River, NJ: Prentice Hall, 1993); and E.J. Woodhouse and Dean Nieusma, "Democratic Expertise: Integrating Knowledge, Power, and Participation" in Matthijs Hisschemöller, Rob Hoppe, et al., eds., *Knowledge, Power, and Participation in Environmental Policy Analysis* (New Brunswick, NJ: Transaction, 2001), 73–96.

29 Harry Collins and Trevor Pinch, *The Golem at Large: What You Should Know About Technology* (Cambridge: Cambridge University Press, 1998), 5.

30 Steve Breyman, *Why Movements Matter: The West German Peace Movement and U.S. Arms Control Policy* (Albany, NY: SUNY Press, 2001).

31 Arie Rip, Thomas J. Misa, and Johan Schot, eds., *Managing Technology in Society: The Approach of Constructive Technology Assessment* (London: Pinter Publishers, 1995); and Norman J. Vig and Herbert Paschen, eds., *Parliaments and Technology: The Development of Technology Assessment in Europe* (Albany, NY: Suny Press, 1999).

32 Brian Wynne, "Technology Assessment and Reflexive Social Learning: Observations from the Risk Field" in Rip, et al., *Managing Technology in Society*, 19–20.

of intelligent trial-and-error (ITE), based on an intention of achieving rapid learning from experience at acceptable cost.[33] Derived from analysis of tactics successful in past innovative activities undertaken in the face of high uncertainty, ITE prescribes: (a) early debate involving diverse perspectives; (b) building in flexibility, so that when negative feedback emerges it will be feasible to make appropriate modifications;[34] (c) initial precautions for coping with uncertainty—such as backup systems and the overdesign of components; (d) very gradual scaleup, again to prevent excessive momentum; and (e) deliberately accelerated feedback via a combination of advanced testing and intensive monitoring. At present, of course, these strategies are seldom deployed fully or systematically, but the Premanufacture Notification system for new chemicals and the processes for approving new pharmaceuticals incorporate many of the recommended elements.

In This Issue

This brief overview of STS perspectives on design does not do justice to the diversity of thinking in the field. However, there is a fair amount of agreement that strenghtening the positive potential of design depends on broadening participation in technological decision making, on reevaluating established roles of experts and laypersons, and on developing new institutions and processes by which technologies could be more deliberately designed by society. Accordingly, the articles in this issue attempt to contribute to design studies by analyzing selected aspects of participation, expertise, and strategy/process. We recognize, however, that concerns of this magnitude and breadth do not belong to any small set of persons, nor to any one discipline, and our intention primarily is to nominate research and discussion topics that we think deserve sustained attention by proximate designers, design studies scholars, and everyone else who cares about well-designed innovation.

In "Alternative Design Scholarship: Working Toward Appropriate Design," Dean Nieusma develops a theory of appropriate design using themes from social theory to examine alternative design literature including universal design, participatory design, ecological design, feminist design, and socially responsible design. He uses these literatures as a resource for analyzing how designers have grappled with marginalization and unequal power relations reproduced by mainstream design practice and products. Nieusma argues that the challenge of appropriate design lies in grappling with five themes: accounting for diversity, coping with disagreement, coping with uncertainty, understanding governing mentalities, and thinking through agency. A synthesis of these insights, he shows, would be necessary in a theory of "appropriate design" practice capable of redressing social inequities. Originally trained as an engineer, Nieusma is developing this theory of appropriate design for his Fulbright-funded study of alternative energy practi-

33 Joseph G. Morone and Edward J. Woodhouse, *The Demise of Nuclear Energy?: Lessons for Intelligent Democratic Control of Technology* (New Haven: Yale University Press, 1989).

34 David Collingridge, *The Management of Scale: Big Organizations, Big Decisions, Big Mistakes* (London: Routledge, 1992).

tioners in Sri Lanka who implement renewable energy systems for rural populations.

In "Design Style: Changing Dominant Design Practice," Todd Cherkasky introduces the concept of "design style" to explain how alternative approaches to design may intervene in mainstream practice. Based on his work with labor unions in the baking industry and his experience as an engineer, Cherkasky critically examines factory automation and deskilling by considering technologies as forms of life. He explores the negotiatioins between engineers, managers, workers, and union representatives over automation technologies that shape workplace practices. In contrast to the mainstream "technocentric design," an alternative "skill-based design" incorporates worker knowledge and skills to create an arguably superior form of workplace life. Drawing on Ludwik Fleck and the science studies literature, Cherkasky shows how dominant design styles resist change; but he identifies tactics for reshaping symbolic, social, and material resources to support alternative design styles. Todd Cherkasky is part of the user experience research group at Sapient.

In "Toward Participatory Ecological Design of Technological Systems," Jeff Howard argues that different approaches to environmental reform provide widely varying foundations for ecological design and that this variation deserves attention and scholarly criticism. Deeply influenced by democratic theory and by the participatory design literature, he believes that fundamental improvement in the design of techno-social systems requires empowering laypeople to work conjointly with proximate designers. Howard identifies a spectrum of foundations for ecological design that vary in the strength of their participatory orientation, and he highlights three of these: industrial ecology, community-based social marketing, and the precautionary principle. Howard argues that the approach he calls "strong precaution" provides the most promising foundation for practicing participatory ecological design. A long-time environmental activist, Jeff now is completing dissertation research on the political dimensions of industrial chemistry.

In "Environmental Information Systems as Appropriate Technology," Kim Fortun examines the emerging potential of electronic environmental information systems. Her analysis focuses on "Scorecard," a Web-accessible database maintained by the Environmental Defense Fund that provides local pollution information based on company disclosures of 6,800 chemicals released from plants throughout the U.S. Scorecard's design has been criticized for demanding too much from users, but Fortun argues that dumbing down can be inappropriate for design. She finds Scorecard to be an appropriate technology that empowers and educates environmental activists. Although developed by centralized capital, labor, and expertise, Scorecard enables decentralized action by structuring people's engagement with industry, government, advocacy organizations, and an otherwise overwhelming amount of environmental data. Fortun uses this case to suggest a redefinition of "appropriate technology" so that the concept can apply not just to simple technologies, but also to designs that engage with technical, social, and political complexity. Kim Fortun is an anthropologist who conducted three years of participant/observation in India with grassroots environmental groups responding to the Bhopal disaster.

In "The Challenge of Responsible Design," Jesse Tatum draws on his experience teaching in the Product Design and Innovation Program at Rensselaer, a program that integrates science and technology studies with engineering and architecture in studio courses. Asking "What messages do STS scholars have for designers," Tatum offers seven lessons that operate at the intersection between proximate design and design by society. The first concerns what he calls the "underdetermination" of science and technology: STS studies from physics laboratories to electric power regulation demonstrate that facts are never enough to determine how one understands and designs, that there always are choices to be made, and that these choices inevitably require social judgments. Drawing on his experience with off-the-grid housing and other alternative design, Tatum discusses the vast realm of technological and socio-cultural possibility, together with other lessons from STS that contribute to what he understands as an imperative to teach the next generation about responsible design. Tatum recently has been writing about overconsumption by the affluent, while building an off-the-grid house and offering hands-on design education to at-risk youth in Vermont.

Conclusion

This *Design Issues* symposium may raise more questions than it answers. STS analysis does more problematizing than problem solving, partly because our divergent thinking tends to broaden what counts as matters of consequence. We are debunkers and complicators more than problem solvers, students of the American humorists who perceived that "It ain't so much the things we don't know that gets us into trouble; it's the things we do know that just ain't so."[35] In applying that aphorism to design, one of the first steps might be to question the assumption that the fine-grained activities of graphic artists, architects, and other proximate designers are the main topic worth investigation by design studies—for what we have been labeling design by society arguably is far more problematic.

Whatever improvements may yet be possible in their techniques, team skills, and work styles, proximate designers already bring to their tasks extraordinarily careful attention, which design by society typically lacks. Rather than skilled deliberation, the current state of design by society may be more aptly characterized as somnambulism—sleepwalking. Rather than relative equality such as enjoyed between designer and client, social shaping of design is characterized by marked power inequalities. And rather than the direct and carefully controlled interventions often achieved by proxi-

35 Variously attributed to Mark Twain and others, the phrase probably originated with Artemus Ward, pseudonym of Charles Farrar Browne, *Artemus Ward: His Book* (New York: Carleton, 1862).

mate designers, design by society typically produces unintended consequences such assynergisms and unwanted second-order effects.

We do not accept that such high negatives are inevitable in technological design. We seek to provoke discussion on how the spirit of design practice might be applied to reconstructing technologies as forms of life along wiser, fairer, and otherwise "better" lines. Proximate design, at its best, provides a model for how a careful process of deliberation and negotiation might be applied to technological change in general. The constructive nature of design also provides a model for our own interdisciplinary field by encouraging problem-oriented scholarship that contributes not merely to refined understanding of the past, but to improved practice in the future.[36]

The most fundamental message that STS might bring to design practice and scholarship is that we need to reach beyond what is within the scope of any given designer, design firm, or customer. We need to grasp in a more shared and public way what makes life in a technological civilization worth living. Our primary point is not that proximate designers should behave differently, though perhaps they should in some instances. Nor do we presume that people could ever fully foresee and control all of the consequences of their technological acts. Rather, the challenge is to identify what stands in the way of a thoughtfully designed technological civilization, to establish social institutions more capable of design tasks that are beyond the range of proximate designers, and to work toward forms of life that more equitably serve more people.

36 Edward J. Woodhouse, David Hess, Steve Breyman, and Brian Martin, "Science Studies and Activism: Possibilities and Problems for Reconstructivist Agendas," *Social Studies of Science* 32:2 (2002): 297–319.

Alternative Design Scholarship: Working Toward Appropriate Design

Dean Nieusma

Design scholars from diverse fields have attempted to assist marginalized social groups by redirecting design thinking toward their needs. By offering alternatives to dominant design activities, "alternative design" scholarship seeks to understand how unequal power relations are embodied in, and result from, mainstream design practice and products. Alternative design scholars analyze how technologies and other designed artifacts are implicated in larger social problems, such as rampant consumerism, sexism, ecological abuse, lack of user participation and autonomy, and restricted access to built environments, among others. Through these efforts, alternative design scholarship offers designers an opportunity to think about how their work might be directed as wisely and fairly as possible.

Efforts to redirect technologies toward the needs of marginalized people have a long and varied history. Dating back to the 1960s and before, technology transfer advocates argued for transferring Western technologies to the third world.[1] They hoped to take advantage of the intellectual and financial resources already invested by the West to benefit those who seemed to need technology the most. But it soon became evident that the transferability of technology among contexts is far from straightforward. Limited resource availability (capital, expertise, spare parts, etc.), different perspectives on the nature of the problem/solution, and a lack of familiarity with similar technological systems led to dashed hopes and expensive failures for technology transfers, such as the numerous decentralized power systems fallen into disuse throughout the developing world.[2] Technology scholars came to realize that differences between a technology's developmental context and its use context were significant.

In part as a response to failures of technology transfer approaches, "appropriate technologists" argued that context suitability should be central to identifying technologies relevant to poor people of the Third World and other marginalized social groups.[3] Developing appropriate technologies required accounting for the needs of others by paying careful attention to the use context of that technology, as well as to local perspectives on the problem to be solved. Attention to contextual particularities became one of the guiding approaches to appropriate technology and, hence, unlike technology transfer scholars, appropriate technology thinking took *design* as the point of intervention. Through the 1970s, appropriate

1 Werner J. Feld, "The Transfer of Technology to Third World Countries: Political Problems and International Ramifications" in Mathew J. Betz, et al., eds., *Appropriate Technology: Choice and Development* (Durham, North Carolina: Duke Press Policy Studies, 1984), 49–63.

2 Frances Stewart, *Technology and Underdevelopment* (Boulder, Colorado: Westview Press, 1977).

3 E. F. Schumacher was early to make this observation in *Small Is Beautiful: Economics as if People Mattered* (New York: Harper & Row, 1973). A generation of scholars and practitioners followed.

technology became a strong social movement in both developed and developing countries, with proponents working on projects ranging from shelter to transport, from agriculture to energy. Nevertheless, despite its early successes and widespread recognition, the appropriate technology movement never cemented its place within Western design scholarship.[4]

However, several related alternative design communities arose to take the place of the appropriate technology movement in Western design scholarship: universal design, participatory design, ecological design, feminist design, and socially responsible design have gained various degrees of legitimacy in their efforts to design for marginalized groups. This paper seeks to extend alternative design scholarship by highlighting important themes in that work from the perspective of social theory. I introduce five themes important for analyzing social power in design, using a different body of alternative design scholarship to illustrate each theme. The paper is not a survey of these literature groups.[5] Rather, I identify some of the important conceptual considerations within the literatures in order to highlight key themes in alternative design, namely: diversity, disagreement, uncertainty, governing mentalities, and agency. I conclude by reflecting on how the themes discussed can contribute to a working theory of *appropriate design.* Such a theory would encourage more attention to unequal power relations embodied in design by helping designers understand the many ways social power operates through design thinking and practice.

Accounting for Diversity / Universal Design

Designing for marginalized social groups requires paying attention to the deceptively complex fact that different people have different needs. At a certain level, this fact is obvious to every designer, of course, because imagining needs is fundamental to design, and the needs that designers target frequently are not the ones they experience themselves. Yet beyond the commonplace recognition lies a more complicated problem of effectively accounting for difference. Merely knowing that different needs exist is not the same as knowing what those differences imply. Universal design scholarship illustrates this point by directing our attention to a persistent narrowness in the way designers imagine users' abilities.

Universal design advocates have a simple but important goal: to account for a more diverse range of abilities when designing built environments. Although rooted in the accessibility movement—the advocacy and legal efforts by the disability community in the sixties and seventies to make existing public places physically accessible to people with disabilities—universal design theorists distinguish their work from accessibility design.[6] While the accessibility movement resulted in significant architectural changes in many countries, including ramps, lifts, and larger toilet stalls, universal design theorists push the concept beyond wheelchair access. "[T]he discourse

4 Why this was so is a question asked by many appropriate technology scholars. In part, there was the waning of participation in popular social movements generally and the absorption of many appropriate technology ideas into mainstream consumer culture. Perhaps more important, however, was the failure of the movement to develop a strong, coherent voice within academic communities. See Kelvin Willoughby, *Technology Choice: A Critique of the Appropriate Technology Movement* (Boulder, Colorado: Westview Press, 1990).

5 Hence, I make no effort to account for all the important work in each body of alternative design literature or to review all the main ideas in those works I do cite.

6 Polly Welch, ed., *Strategies for Teaching Universal Design* (Boston: Adaptive Environments, 1995), 1.

on universal design assumes that it is possible to design objects and spaces such that they are usable (and will be used) by a broad range of the population, including but not limited to people with disabilities." [7] Universal design theorists want designers to think systematically about "inclusion" and to broaden their notion of who users are. In addition to the disabled, other groups typically *marginalized by design* include women, the aged, the infirm, and the young. Dominant design practices that for decades centered on 40-year-old, able-bodied males have ignored the needs of these groups and systematically but unnecessarily impeded their mobility and access. Universal design insights have been influential in challenging this narrow approach.

In addition to adopting a more inclusive notion of "users," universal design scholarship encourages designers to broaden their notions of "use." Universal design theorists argue that inclusion applies not only to access, but also to psychosocial aspects of people's interactions with the built world. Early accessibility designers identified the physical abilities/needs of people bound to wheelchairs and walkers, but they failed to account for their psychological needs. Buildings with backdoor entry ramps, for example, may provide access for those in wheelchairs, but they additionally marginalize wheelchair users by separating them from "normal" people who enter through the front. "The principles of universal design are important... in seeking to restore disabled people's self-esteem, dignity, and independence." [8]

Universal design scholarship contributes to analyses of social power in design by identifying entire groups of people whose needs systematically go unmet, and by advocating that the design community begin taking them into account.[9] Universal design scholars have gone further to consider the more complicated question of what "design for others" implies, and the conceptual shift it demands: if designers are to account for diverse users with diverse needs and abilities, they must rethink limited notions of access and independence. Designing for diversity is a crucial contribution and one that should be extended. However, designing for diversity also underscores the importance of accounting for numerous complex design factors. Claims such as, "Universal design is the idea that everyone should have access to everything all of the time" [10] are conceptually problematic, because they imply that trade-offs and compromises need not be made. Working towards greater inclusiveness is not the same as assuming that everyone's needs can be met with any one system.[11] Trade-offs are always required, and redirecting design towards the needs of those marginalized by specific physical conditions means other priorities go unmet. The implication that such trade-offs are not necessary—that singular systems can account for all needs—risks depoliticizing inherently political design questions about whose interests should be accounted for and how. In the case of universal design, depoliticizing the project ends up glossing over

7 Bettye Rose Connell and Jon A. Sanford, "Research Implications of Universal Design" in Edward Steinfeld and G. Scott Danford, eds., *Enabling Environments: Measuring the Impact of Environment on Disability and Rehabilitation* (New York: Kluwer Academic, 1999), 35–57. Quote, 49.

8 Rob Imrie and Peter Hall, *Inclusive Design: Designing and Developing Inclusive Environments* (London: Spon Press, 2001), 16.

9 Additionally, a body of technically oriented work in universal design identifies opportunities for and constraints to the implementation of universal design principles and projects. While a crucial contribution to universal design scholarship, I do not review it here.

10 George A. Covington and Bruce Hannah, *Access by Design* (New York: Van Nostrand Reinhold, 1997), 14.

11 The very language of "universal" design is conceptually problematic for this reason, however the term has become widely used enough that it serves more as a marker for a body of work than a descriptor.

much of the painstaking political work done by accessibility movement activists in the 1960s and 1970s. Many universal design scholars recognize this risk, and accept the challenge of steering around it. They recognize that diversity gives rise to the need for a dynamic assessment of needs, involving trade-offs at every level. Thus, universal design scholarship teaches the importance of embracing ever-greater diversity in design, while being wary of assessments that we can ever arrive at a truly "universal" design.

Coping with Disagreement / Participatory Design

As the universal designers imply through their critiques of differential access to the built world, artifacts embody certain types of power relations.[12] Workplace technologies, for example, can be designed to deskill workers and centralize power in management, or they can be designed to empower workers by capitalizing on their skills (or they can do something in between).[13] Without direct intervention to the contrary, existing power relations usually, but not always, are reinforced by design decision making. When designers choose to counter existing power imbalances, they can work directly on projects representing the interests of marginalized perspectives, as do universal designers, or they can work to mediate conflicts between different perspectives by providing space within mainstream design processes for marginalized groups to voice their concerns. In the latter sense, design is a tool for arbitrating disagreement over which objectives to pursue. Such disagreement may arise merely from different perspectives on a problem or from enduring conflicts of interest.

Participatory design scholars have taken on the challenge of mediating disagreement over desired design objectives. With roots in labor politics, early participatory design scholars saw an opportunity in workplace technology design to empower workers in ways that do not run directly counter to the authority of management.[14] Participatory design theorists engage differential power relations explicitly and directly through recognition of the structural inequalities between workers and management. Participatory designers argue that if designers accounted for workers' perspectives in their design processes—instead of allying wholly and systematically with management—they would arrive at fairer, more satisfying, even more effective design outcomes.[15] Building on these roots, participatory design has developed into a well-articulated, well-justified methodology for user participation in design processes, so that "people destined to use the system play a critical role in designing it." [16] While "[i]magined users, model users, or surrogate users ... stand in for those who will actually work with the technology" in dominant design practices, participatory design has a "central and abiding concern for direct and continuous interaction with those who are the ultimate arbiters of system adequacy; namely, those who will use the technology in their everyday lives and work." [17] As a scholarly force, participatory design has grown stronger and more diverse

12 For a detailed consideration of the potential of artifacts to embody politics, see Langdon Winner, *The Whale and the Reactor: A Search for Limits in an Age of High Technology* (Chicago: University of Chicago Press, 1986).

13 See Todd Cherkasky, this volume.

14 Participatory design has political roots both in the U.S. labor movement and in Scandinavian codetermination laws, which require worker participation in workplace decision making (a prerogative retained exclusively by management in most settings in most countries). As with universal design's roots in the accessibility movement, we see here again the importance of broad contextual factors in shaping particular design agendas.

15 Joan Greenbaum and Morten Kyng, eds., *Design at Work: Cooperative Design of Computer Systems* (Hillsdale, New Jersey: L. Earlbaum Associates, 1991).

16 Douglas Schuler and Aki Namioka, eds., *Participatory Design: Principles and Practices* (Hillsdale, New Jersey: L. Erlbaum Associates, 1993), xi.

17 Lucy Suchman, *Plans and Situated Actions: The Problem of Human-Machine Communication* (Cambridge: Cambridge University Press, 1987), vii.

over the decades. With a background in workplace information technologies, participatory design methodologies and motivations have been extended to architecture, product design, and beyond.

From its inception, participatory design scholarship has sought to cope with differences of perspective and goals in an explicit, productive, and fair way. Instead of ignoring the fact that conflicting interests underlie many important design decisions, participatory designers attempt to leverage such differences to arrive at outcomes suitable to diverse interests. Participatory design scholars call attention to underlying inequalities, and provide two core reasons for working against them: participatory decision making is (1) fairer and (2) more intelligent than nonparticipatory processes. Participatory design is fairer because "[p]eople who are affected by a decision or event should have an opportunity to influence it."[18] Participatory design is more intelligent because broad participation by multiple interests is more likely to result in innovative, widely agreeable solutions to shared problems.[19]

Increasingly, however, participatory design methodologies are used to advance the goals of user-centered design without emphasizing the inclusion of marginalized perspectives in design processes.[20] User-centered design is fine as far as it goes, but, in my view, it should be distinguished from participatory design. Turning designers' attention away from marginalized groups forfeits participatory design theory's greatest contribution: its simultaneous focus on intelligent and fair design decision making. When participatory design is employed narrowly as a tool for improving consumer products—however valuable in that effort—it ignores the more difficult problem of mediating conflicting interests. Reducing participatory design in this way becomes another barrier to focusing attention on questions of fairness surrounding design processes and outcomes. When participatory design focuses the design process on mediating conflicting interests, instead of merely including different perspectives, it offers a solid strategy for coping with disagreement in design decision making.

Coping with Uncertainty / Ecological Design

Beyond appreciating diversity in design and the need for coping with disagreements over desired ends lies a more fundamental difficulty: considerable uncertainty exists when attempting to understand or represent any complicated social-technical problem or design its solution. The designed world is a sometimes explicitly, sometimes implicitly negotiated outcome of complex interactions among institutions, expertise, interests, and environments. Uncertainties arise out of complexities inherent in design problems / solutions, limitations in human analytic capacities, and sheer randomness. No matter how improved, conceptual models used by designers will never result in fully controlled outcomes. To be sure, better design often demands better analyses, but it simultaneously demands recognition of *the*

18 Schuler and Namioka, *Participatory Design*, xii.

19 For a concise introduction to the "potential intelligence" of democratic decision making, see Charles E. Lindblom and Edward J. Woodhouse, *The Policy-Making Process* (Englewood Cliffs, New Jersey: Prentice Hall, 1993), 23–32. While they focus on decision making in the policy arena, their insights apply equally well to design.

20 User-centered design is a "[design] philosophy based on the needs and interests of users, with an emphasis on making products usable and understandable." Donald A. Norman, *The Design of Everyday Things* (New York: Doubleday, 1988), 188. Norman distinguishes market-centered "objects of desire" from user-centered "objects of use," but he still focuses on improving current design (better meeting existing user needs) with limited concern for questions of fairness (who are and are not users and why).

limits of analysis. Since uncertainty can never be completely eliminated, designers need productive strategies aimed at coping with it. In this way, designers can appreciate the complexities inherent in their work without becoming paralyzed by them.

Ecological—or "green"—design provides an excellent opportunity to examine the role of complexity in design. Most centrally, ecological design scholarship engages complexity by avoiding "command and control" design approaches: those presuming mastery of natural systems is both possible and desirable. Ecological designers recognize the complexity of natural systems and the limits of dominant design models for understanding them. Command-and-control design and brute-force engineering attempt to surmount environmental forces rather than working with them. By over-engineering, for instance, many designers design for worst-case scenarios, such as devising entire building air-conditioning systems so that occupants will not notice the outside temperature even on the hottest day of the year. "Deep [ecological] designers begin with a more inspired assumption: that designs can be made reasonably fail-safe if they incorporate diversity, flexibility, and biological compatibility." [21] Designing "with nature" is one strategy for coping with uncertainties by designing human systems to work in conjunction with natural systems.[22] John Todd's "living machines" is a frequently cited example, in which natural organisms are used to process wastewater in a progressively linked series of human-designed but self-managing micro-ecosystems.[23]

As with universal design, however, it is important for ecological design scholars not to confuse progress with solutions. Respect for complexity should open up, rather than close down, a range of critical questions involving design trade-offs, coping with uncertainties, and the limitations of current analytical approaches. Our design models should ask questions of ecological complexity—such as nonlinear effects over time, cross-scale interactions, and the sheer randomness of outcomes—even if such questions are unaswerable. A disturbing trend in ecological design writing disregards these enduring complexities by intoning that the new "sustainable" design approach provides humanity the long-sought solution to problems of ecological imbalance resulting from human activity. While most ecological design scholarship does not refute the existence of enduring social and ecological uncertainties, a careful observer might question the extent to which it acknowledges them. Thus, there is a disjunction between appreciation for the complexity of natural systems on the one hand, and overlooking the extent to which ecological uncertainty remains on the other. When green designers pay careful attention to the role of complexity and uncertainty in their own models, then the "humans in harmony with nature" rhetoric does not become a sappy substitute for the difficult, critical conceptual work necessary to achieve durable progress on environmental fronts.

21 David Wann, *Deep Design: Pathways to a Livable Future* (Washington, DC: Island Press, 1995), 187.

22 Sim Van der Ryn and Stuart Cowan, *Ecological Design* (Washington, DC: Island Press, 1996).

23 See the chapter on Todd's work in Steve Lerner, *Eco-Pioneers: Practical Visionaries Solving Today's Environmental Problems* (Cambridge, MA: The MIT Press, 1997).

In their search for a shared language, for instance, some ecological design scholarship uses consensus rhetoric that glosses over uncertainties and dilutes difficult questions. The concept of sustainability is a case in point. Everyone supports sustainability; everyone wants to work toward it; and many theorists assume that what sustainability means is self-evident. But because sustainability is so ubiquitous, it is not clear what "it" is anymore. In the rush to implement the next sustainability initiative or to "green-wash" corporate images, critical questions of environmental and economic trade-offs go unasked. Consensus rhetoric masks uncertainties over desirable courses of action and the disagreements that exist. Any approach to ecological design (or environmental theory in general) that *assumes* consensus ultimately ends up undermining the goal of inclusiveness by ignoring the forces that divide, undermine, and separate people or populations in different contexts.[24] Progressive social forces in the environmental movement, in design, and elsewhere would do better to *assume difference* and then work towards consensus in order to create, rather than impose, a shared language. To the extent that ecological design models actively design for non-totality and respect for complexity—ecological and social alike—they serve as exemplars for alternative design thinking.[25] To the extent that they dilute complexity and fail to remind others of the limits of analysis in overcoming uncertainty, they sustain the very forces they seek to eliminate, including command-and-control mentalities, subjugation of nature, and human arrogance.

Understanding Governing Mentalities / Feminist Design

In order to transform entrenched patterns of social understanding and social-material interaction, alternative design needs an understanding of the interlinked, overlapping forces that make status quo relations so durable. *Governing mentalities*—those widely shared values, norms, expectations, and assumptions of how the world operates—are simultaneously the most important and the most difficult to identify: they are pervasive, subtle, distributed patterns of thought that underpin social activity and personal interpretations.[26] Governing mentalities shape how people interpret macro social-cultural phenomena and how they think about their own lives and identities. Coming to terms with the analytic and practical tensions associated with the persistence of such forces is a serious challenge to design thinking. Feminist design scholarship emphasizes the importance of this challenge by showing how governing mentalities impinge on design practice to systematically shape outcomes.

Simply put, feminist design considers the relationship between the built world and the position of women in society.[27] Feminist design theorists criticize dominant design practice for mirroring and thus reinforcing broader sexist cultural forces. They show how gendered power relations become embedded in material objects, and then how social-material relations reinforce and

24 This is especially true when thinking of the tensions between ecological design theory and meeting the needs of the poor. The class bias of mainstream environmentalism has been pointed out by many scholars and environmental justice activists. See, for example, Kim Fortun, *Advocacy after Bhopal: Environmentalism, Disaster, New Global Orders* (Chicago: University of Chicago Press, 2001).

25 See Kim Fortun, this volume.

26 Campbell introduces the concept of "governing mentalities" in her analysis of the discourse surrounding U.S. drug policies. Nancy Campbell, *Using Women: Gender, Drug Policy, and Social Justice* (New York: Routledge, 2000).

27 Note, however, that there is an important and long-standing tradition within feminist theory claiming that all processes of marginalization, not only the marginalization of women, are the subject of feminist analyses.

legitimate sexist practice. For example, in their study of microwave cooking and the design, making, and marketing of microwave ovens, Cockburn and Ormrod show how different assumptions about the skills associated with cooking, and about who exercises those skills, influenced designers' assessments of what the microwave oven is actually intended to achieve. Is it to "zap" food—requiring no skill and minimum intervention—as understood by the primarily male design engineers? Or is it to "cook" food—requiring both skill and regular intervention—as understood by the female home economists that pilot-tested the ovens? Such gendered differences in expectations of the artifact arise out of deeply embedded social roles of men and women around cooking. The design of microwave ovens ends up embodying certain of these expectations, and, by so doing, reinforces them. "Technology is gendered. We collectively gender it, of course; but, in turn, it individually genders us." [28]

Unfortunately, in the face of governing mentalities, the alternative to gendered artifacts is not straightforward. Positing "feminist artifacts" is conceptually problematic if not misleading, because artifacts by themselves are neither neutral nor determinative.[29] Discussing alternative housing experimentation, for instance, Wajcman argues, "The failure of this experiment in architectural solutions to the problems of women's domestic oppression... demonstrates that new, egalitarian architectural forms cannot simply be superimposed on a preexisting social order and be transformative in themselves." [30] Rather than advocating the design of feminist artifacts, most feminist design theorists seek to counter sexist material practices by breaking down social hierarchies that underlie social power inequalities and lead to marginalization in the first place.[31] Dismantling hierarchy through design requires a sophisticated and direct appreciation for the governing mentalities leading to marginalization, including naturalized definitions of "women," how design expertise is legitimated, and how design priorities are determined.[32] Extending Wajcman's line of argument, Weisman notes that, while urgently needed, feminist-inspired housing alternatives are no "solution" to women's marginalization.

> In the long run, they will not gain women their equality or change men's relationship to domestic life, for they largely ignore the underlying values that created the problems in the first place. Genuinely satisfying alternatives to conventional housing and communities will emerge only as we are able to visualize scenarios of the future based on the reconceptualization of work, family life, and gender roles.[33]

According to most feminist scholars, dismantling hierarchy requires understanding the governing mentalities that structure current conceptualizations of social relations. No domain of social life, or of design, is or can be isolated from the influence of gender-based values and assumptions. Reiterating the importance of challenging

28 Cynthia Cockburn and Susan Ormrod, *Gender and Technology in the Making* (London: SAGE, 1993), 159.

29 For greater detail on this point, see Woodhouse and Patton's introductory article in this volume.

30 Judy Wajcman, *Feminism Confronts Technology* (University Park, PA: Pennsylvania State University Press, 1991), 125–126.

31 Amplifying women's voices in design is one way to break down sexist hierarchies. To this end, feminist designers have (1) brought to light the historical contributions women have long made to design, (2) redirected design to women's experienced needs, and (3) designed in ways that allow women to create new, alternative, empowered lifestyles. See Rothschild and Rosner's review essay in Joan Rothschild, ed., *Design and Feminism: Re-visioning Space, Places, and Everyday Things* (New Brunswick, NJ: Rutgers University Press, 1999).

32 Of course, there are diverse interpretations of what such terms as "woman" and "expertise" mean, but these interpretations are built on the very same governing mentalities feminist designers seek to question.

33 Leslie Kanes Weisman, *Discrimination by Design: A Feminist Critique of the Man-made Environment* (Urbana: University of Illinois Press, 1992), 163.

the basic assumptions we live by, Rothschild identifies feminist designers' shared aim "to generate and put into practice projects that work, and so not only change that practice but also transform its supporting concepts and rationale."[34] Thus, addressing marginalization through design requires changes not only to immediate design practices, but also to the governing mentalities that underlie those practices.

Thinking Through Agency / Socially Responsible Design

In addition to the governing mentalities that situate how designers understand their work are macro-level, political-economic forces structuring design practice, especially the market. The market provides strong incentives for designers to participate in economic systems that are arguably beyond any individual's ability to comprehend, no less confront. Yet, consideration of structural forces such as the market is important because it brings into high relief the multifaceted, interconnected constraints to agency for designers who seek to challenge the status quo. "Agency" refers here to the ability of social actors to act independently of larger structural forces. In the context of alternative design, agency refers to designers' ability to work in ways that confront dominant design outcomes and empower marginalized social groups. By squarely addressing constraints to designer agency, especially those deriving from market structures, alternative design scholars are better positioned to identify opportunities for genuinely alternative practice.

Critiques of consumerist design are one way design scholarship has accounted for market forces constraining designer agency. Scholars who seek to counter consumerist design argue that existing market forces focus design resources to an indefensible extent on creating products aimed at satisfying the spurious desires of a narrow group of people.[35] They argue that consumerist market structures provide lucrative incentives for designing the ephemeral, the gimmicky, and the superfluous. By catering to economically powerful groups, market-led design practices create ever more products while leaving many basic human needs unaddressed. According to Whiteley, market structures, together with their consumerist design ideologies, are particularly problematic when they reinforce individualism (not individuality) and work against the possibility of a *social* vision in design.[36] He argues that structural incentives of short-term profitability focus consumer-led design on the (individualized) desires of economically powerful social groups leading to "private affluence" within a broader context of "public squalor."[37] The most apparent instance of this trend is how market incentives for designers overwhelmingly reward consumerist practice in the North, despite the fact that there is a clear (non-market) demand for thoughtful, experienced design in the South. This void is magnified when designers in poor countries are pulled away from their homelands by lucrative salaries in affluent economies. While by no means

34 Rothschild, *Design and Feminism,* 181.

35 Edward J. Woodhouse, "Curbing Overconsumption: Challenge for Ethically Responsible Engineering," *IEEE Technology and Society Magazine* (Fall 2001): 23–30.

36 Consumerist design ideologies are situated in and reinforce structural market forces, so there is a reciprocal relationship between the two. Whiteley argues that designers' very sense of "good design" is tied to consumerism and its emphasis on highly refined aesthetics above all else. Nigel Whiteley, *Design For Society* (London: Reaktion Books, 1993).

37 This claim holds true within nations/markets, but it is especially evident when considering global inequalities.

exclusive to designers, this problem is pervasive within design professions, and significantly shapes what gets designed and how.

Given the pervasiveness of consumerist market structures shaping design, can we reasonably hope for alternative practice that results in anything more than trivial resistance? At issue is the question of how much latitude individual designers have in challenging dominant market and other macro-level structures. Papanek addresses this theme when he argues that designers usually have sufficient latitude to overcome dominant market incentives, at least in their own practice. He says, "The designer often has greater control over his work than he believes he does, that quality, new concepts, and an understanding of the limits of mass production could mean designing for the majority of the world's people" rather than for the few.[38] Papanek calls on designers to take responsibility themselves for moving beyond narrow market considerations, and to design products genuinely needed by humanity.

> The designer's responsibility must go far beyond [marketplace] considerations. His social and moral judgment must be brought into play long before he begins to design, since he has to make a judgment, an a priori judgment at that, as to whether the products he is asked to design or redesign merit his attention at all.[39]

In a similar vein, and building upon Papanek's work, Whiteley discusses various faces of alternative design and the many contradictions in its practice. With regard to the agency of designers, Whiteley explicitly addresses the tension between designing within a corrupted market system on the one hand, and doing the gritty political work to change that system on the other. In a section entitled "'Socially Useful' Design *within* the System," Whiteley identifies a shifting middle ground, but arrives at no clear assessment of where the boundaries of designer agency are.[40] Margolin and Margolin recently renewed the call for a more socially responsible design, using social work as an alternative framework because of its "principle objective... to meet the needs of underserved or marginalized populations."[41] Margolin and Margolin suggest that casting the "market model" and the "social model" as binary opposites "limits the options for a social designer."[42] Instead, they advocate that designers consider collaborating with allied professionals—such as social workers, health workers, and educators—around socially relevant projects, thereby working within established institutional frameworks that are somewhat insulated from market priorities.

Socially responsible design scholars identify some of the most important structural conditions that challenge socially responsible design practice, and they direct our attention to the need for considering designer agency as a key analytic variable. However, considerable work remains to be done for a systematic analysis of the opportunities for and constraints to designer agency. One facet

38 Victor Papanek, *Design for the Real World: Human Ecology and Social Change,* 2nd edition (Chicago: Academy Chicago Publishers, 1984), 234.

39 Ibid., 55.

40 Whiteley, *Design For Society,* 115–118, my italics. This limitation is less a criticism of Whiteley's ambitious, thorough, and sober analysis than a recognition of the difficulty of the task.

41 Victor Margolin and Sylvia Margolin, "A 'Social Model' of Design: Issues of Practice and Research," *Design Issues* 18: 4 (Autumn 2002): 24–30.

42 Ibid., 27.

of that analysis is thinking about design interventions that overcome deeply entrenched structural conditions without relying on heroic acts of self-sacrifice by individual designers. Another facet is exploring the relationship between designers as employees, as professionals, and as citizens in order to more tightly couple daily design practices with the necessary political work identified by Whiteley. By more thoroughly mapping out the terrain of designer agency, design scholarship can assist individual designers to find opportunities within their work to confront structural forces, such as the market, that inordinately shape design outcomes.

Synthesizing Design Alternatives / Toward *Appropriate Design*

This paper has used alternative design literatures to draw out several important themes for thinking about how social power operates in design. While I have relied on one body of literature to develop each theme, all of the literatures, in one way or another, deal with all the themes identified. Building on insights from social theory, I have highlighted both strengths and weaknesses in the current work. But my ultimate goal has been to extend alternative design scholarship by considering what a conceptually robust, integrative alternative design framework would require. Borrowing from the inspiration of the early appropriate technology movement, I use the term *appropriate design* to encompass the best of alternative design scholarship, specifically with regard to thinking about how social power operates in design, and how it should operate to more adequately address the needs of marginalized social groups. To that end, I propose the following four elements of appropriate design:

Appropriate design accounts for diversity and disagreement. Designers should account for as much diversity as possible when conceptualizing users, but they also should recognize that some interests conflict and that trade-offs must be made. Assuming there will be disagreement about desired ends, and then squarely addressing the disagreements, is more likely to empower users than is avoiding potentially contentious areas.

Appropriate design accepts and copes with uncertainty. Designers should avoid command-and-control approaches. While striving for greater robustness in design is a worthy goal, designers should be wary of claims to comprehensiveness. Rather, by anticipating uncertainties and then systematically preparing to cope with them, designers will be better prepared when nasty surprises surface.

Appropriate design recognizes the importance of governing mentalities. Designers should understand that the forces shaping dominant design norms run deep. The governing mentalities that shape what is "good," "right," and "true" are the most difficult to identify and the most important to challenge. While governing mentalities cannot be rejected outright, they can and should be continuously challenged in design practice.

Appropriate design theorizes agency-structure tensions. Design practices are constrained both by design ideologies and by macro-structural conditions, especially market forces. Within constrained spaces, however, lie opportunities for creative acts. Designers should recognize both the extent and the limitations of these constraints: some constraints can be avoided; others can be turned into productive stimuli. The trajectory of design careers, like that of designed artifacts, is neither fully free nor predetermined.

The barriers to social change through design are dispersed, pervasive, and resilient. They overlap and interact to "over-determine" the status quo. They work at the level of dominant design models, dominant social assumptions, dominant economic incentives, and even dominant political structures. Because status-quo forces are so difficult to counter, highlighting them often leaves designers feeling paralyzed rather than directed to act. This dilemma brings to light the dual character of incrementalistic approaches to social change: in the face of status quo-preserving forces, incremental change is simultaneously insufficient and imperative.[43] Any single design effort, no matter how intensely motivated, is inadequate relative to the enormity of the problem. Incremental efforts necessarily lack the punch needed for broad social change, since existing conditions are over-constrained and barriers must be addressed simultaneously at multiple nodes. Yet designers (as with other social actors) have no avenue for change outside of specific (narrow) projects in specific (narrow) contexts. In the end, designers are faced with a double bind, which requires humility and diligence, more than anything else, to negotiate.

Appropriate design squarely acknowledges the power of status quo-preserving forces in order to pragmatically address the enormity of the task facing those who would work for social change through design practice. As advocates of social change, alternative design scholars should celebrate the progress that has been made in identifying and addressing uneven social power relations through design. Yet as social critics, we also should recognize the dangers of feeling satisfied that alternative design scholarship has found the correct path: that it has arrived. Like democracy, appropriate design is an ongoing activity that can never be fully or finally achieved.[44]

43 Charles E. Lindblom, *The Science of "Muddling Through"* (New York: Irvington Publishers, 1993 [1959]).

44 I would like to express my appreciation to Todd Cherkasky, Kim Fortun, David Levinger, Jason Patton, and Edward Woodhouse for their critical reviews of this paper over numerous revisions.

Design Style: Changing Dominant Design Practice

Todd Cherkasky

Thirteen years ago in a rural Michigan town just south of a major university, I joined a group of revolutionaries. We were well-trained and generously funded. We were organized and had strong allies in major political parties. We used sophisticated tools and techniques that changed relationships of power and control throughout the United States. We did not organize marginalized social groups through solidarity, or catalyze emerging institutional crises, or lash out at figureheads who represented power imbalances. Instead, we designed industrial automation technologies. As a computer engineer on the front lines of workplace change, I helped develop control systems in various industries from California to Maryland that polished semiconductors, painted automobiles, processed and packaged food, and injected plastic molds.

To describe the engineers that I joined as revolutionaries is not entirely accurate. We were not, for example, at risk ourselves. Our design work significantly reinforced relationships of power and control in the workplace rather than disrupted them. And yet, the term "revolutionary" is at least partly accurate. We often changed everyday work life for people we never met. Our design decisions were decisions about who did what work, and how that work was done. I use the term "revolutionary" not to exaggerate the importance of my work as an engineer, but to reinforce the idea that the design of common tools, machines, and artifacts is a political act.

These technologies are not simply used and set aside, discarded, or forgotten. Their instrumentality is conjoined with patterns of social activity. Design processes and products are situated within social relationships, structures, and meanings, which can be resources for marginalized social groups or their representatives to improve their condition. If these resources play an important social role, then how does it come to pass that they enable particular forms of life over others? [1] In other words, if artifacts, tools, techniques, and machines provide texture for the fabric of everyday social activity—and if design is the process whereby they are configured—then the study of design is likely to reveal opportunities for creating better forms of life.

In my own work as an application engineer of machine control products, I did not recognize these opportunities. Perhaps I did not look for them. Or, perhaps I did not imagine how the artifacts, tools, and machines I helped to design could be config-

1 Langdon Winner provides an alternative to thinking about artifacts in functional terms. He sees technologies as "forms of life" and asks, "When we make things work, what kind of world are we making?" Langdon Winner, *Autonomous Technology* (Cambridge, MA: MIT Press, 1977) and Langdon Winner, "Technologies as Forms of Life" in Langdon Winner, *The Whale and the Reactor: A Search for Limits in an Age of High Technology* (Chicago: The University of Chicago Press, 1986), 3–18.

ured in radically different ways, enabling different forms of life at work. My analysis of design might have been limited because the design context in which I was embedded offered little opportunity to discuss the social implications of industrial automation projects.[2] Engineers' time was consumed by detailed analysis of technical problems. Managers carried out "product segmentation" to identify market niches for their computer and control systems. Engineers—frequently expected to be in control of technological development—often thought that technologies were out of their control. They seemed to believe that they could only react to innovations. They acted as though they were either technicians responding to managerial directives, or were subject to larger economic constraints. Front-line workers who used the control systems were not included as part of the design arena; they had no role in the development and distribution of emerging workplace technologies.[3]

The Social Life of a Mundane Artifact

Ultimately, frustration with the gap between design and use led me to study workplace design and to work with managers, engineers, and labor union representatives to improve the forms of life emerging from the design of control systems. Fieldwork over the past decade has taken me to industrial automation suppliers, national research laboratories, car and truck manufacturers, shipping and distribution facilities, consumer electronics research campuses, and oil processing facilities. For several years, I studied technological change in large-scale bakeries in the United States. Baking is a useful subject for discussing forms of life because it surfaces in most of our everyday lives while also residing below our critical awareness.

Imagine a loaf of bread made by hand from a family recipe. And consider another one pulled off the shelf at your local supermarket. Each loaf affords and emerges from different patterns of civic life, economic production, social organization, and meanings. Making bread by hand takes a lot of time. It can be quite good if you have a lot of experience. Consider the process of making a braided challah for the Jewish Sabbath. It provides an opportunity for religious reflection. The following piece of advice is commonly associated with making a challah: "Each time one strand of challah is passed over another, say a prayer or read a line of a favorite psalm of praise." The outcome—a braided loaf of egg bread—is of course important, but the process itself highlights meaningful social practice.

"Wonderbread," however, brings to mind something else entirely. It emerges from and is situated in a very different set of social institutions. The person who will eat it seems to find the most value in the outcome—a loaf of consistent, white, sugary bread. The process of creating the loaf is relatively invisible, appearing only in the final stage, when a consumer selects the loaf from a grocery shelf. The resources required to manufacture and distribute this

2 Louis Bucciarelli introduces the term "object world" to explain how traditional engineering education and practice ensure a narrow problem focus. Louis L. Bucciarelli, *Designing Engineers* (Cambridge, MA: MIT Press, 1994).

3 In a tradition of technology-as-politics, Thomas outlines a "power-process" theory of design that embraces historical and cultural contexts of the organization. Detailed case studies stress that workers, especially those who are overlooked in the production process by management, can contribute constructively to the design process. Machines are too highly esteemed; workers too often neglected as a productive contributor. Robert J. Thomas, *What Machines Can't Do: Politics and Technology in the Industrial Enterprise* (Berkeley: University of California Press, 1994).

loaf are enormous: the factory from which it emerged may cover as much as one-hundred acres, require one million feet of floor space, consume over three-million pounds of flour each week, and employ a thousand people.

To maximize throughput, many factories have modeled themselves on the production methods of chemical processing. Instead of breads derived from a traditional "sponge" that takes several hours to rise, these factories use a liquid sponge, which is processed in a large vat called a continuous mixer. Chemicals and air are forced into the flour enabling continuous fermentation. The advantage of this process as seen by operating engineers is that, once the system is set up and properly maintained, human intervention can be kept to a minimum.

In continuous-mix systems, touching the dough is not possible because pipes route the dough from one automation cell to another. By contrast, in artisan production, the method for determining if the dough is ready is called "squeezing the dough." Human mixers physically test the dough by squeezing it. While artisan bread comes in many shapes and flours, the output of continuous mix systems traditionally has been limited to varieties of white breads and buns.

A loaf of bread emerges from a loosely connected set of social institutions including production systems, labor and industrial relations, baking science, city planning, religious and secular meanings, and domestic customs. These institutions shape the bread through expectations of consumers and assumptions of bakers, scientists, and other bread "designers"—among which are plant engineers, vendor field engineers, product line managers, front-line operators, and others who plan, install, configure, and maintain the industrial baking enterprise. For example, bakery managers perceive a consumer demand for bread that stays fresh longer. In response, baking scientists from J. R. Short Milling Company designed "Mor-Life"—an "exciting, enzyme-based product that gives 7 to 10 days of freshness 'you can feel' after baking.... You'll get longer shelf-life, experience fewer-store deliveries, and enjoy larger distribution areas." Agricultural scientists, controls engineers, and managers of large industrial bakeries work to improve yields and the "end-use functionality of wheat" not only through new enzymes designed into breads, but also by using anti-staling agents, low-calorie and no-calorie fats, and genetically engineered ingredients. Each of these ingredients represents a network of "technoscientific" and economic institutions considered by baking professionals as essential for the design and manufacture of a modern loaf of bread.

The bread from your supermarket is one outcome that emerges from complex interactions involving multinational corporations, machine vendors, labor unions, and national research and development agencies. It is shaped in part by decisions and assumptions of industrial automation engineers, consumer education and demand, and baking science. It exists as a result of the investment and configuration of production equipment, the demand for biotechnology, and the construction of enormous factories. A loaf of bread—whether a challah or Wonderbread—is surrounded by social worlds constituted by people with diverse skills and situated throughout diverse institutions. These people work together directly and indirectly to support a complex network of technologies, tools, and techniques to produce not only a loaf of bread, but "forms of life."

Industrial Baking, Work Organization, and Technology Design

Throughout the 1990s, the dominant management strategy in industrial bakeries was to replace aging capital equipment with increasingly integrated manufacturing control systems. In the early part of the decade, several prominent baking companies spent millions of dollars to implement fully computerized production facilities. When they lost their expected savings to degraded quality, high levels of waste, and increasing costs, they went bankrupt or were acquired by competitors. After these failures, corporate strategists backed off from attempts to create entirely automated, essentially workerless production systems. While many managers still pursued the dream of a robotic bakery, others started to consider alternatives to these work systems.[4]

I visited one small bakery in New England with the research director of the Bakery, Confectionery, Tobacco, and Grain Millers International Union (BCT). Intent on "modernizing" their bakery, management decided to build a new facility. The union research director and I presented a manufacturing approach that recognized not only the value of engineering expertise, but relied on the discretion and judgment of all of the two-hundred employees' skills—from mixing, to baking, to packaging, to maintenance. I had been on trips like this before with union representatives when we spent a full day presenting the merits of this alternative to technocentric design. We argued that "automating Taylorism" is a road to failure—to pumping out poor quality products, faster, with more waste.[5] When we arrived at this bakery, however, management already had decided to pursue what they called a "high performance work system."[6] They brought in an engineer who was trained in Denmark, and was familiar with "skill-based" design.[7] With pressure from the union, they already had developed a joint labor-management steering committee, and they were committed to participatory design of the new production system.[8]

The labor union pushed for the high performance, skill-based design alternative because, in such systems, the knowledge and skills of front-line workers become critical resources for ensuring quality products and dependable, high-throughput production runs.[9] Preventive maintenance replaces crisis management. Engineers consult regularly with plant floor workers instead of running from

4 Key institutional models of manufacturing are documented in Eileen Appelbaum and Rosemary Batt, *The New American Workplace: Transforming Work Systems in the United States* (Ithaca, NY: ILR Press, 1994). See also Franz Lehner, "Anthropocentric Production Systems: The European Response to Advanced Manufacturing and Globalization" (Luxembourg: Commission of the European Communities, 1992) and Dietrich Brandt, *Advanced Experiences: European Case Studies on Anthropocentric Production Systems,* 2nd ed. (Gelsenkirchen, Germany: FAST [Forecasting and Assessment in Science and Technology], 1990).

5 Frederick Taylor is credited with being the father of "scientific management, " which held that "one best way" can be found for any task and workers should be held to it. Frederick Winslow Taylor, *Scientific Management* (New York: Haper and Brothers, 1911).

6 The term "high performance" is derived from economist Ray Marshall, who was Secretary of Labor under President Carter. Marshall stresses the instrumental, productive, and intrinsic, democratic benefits of increasing worker participation in the design of their work. Ray Marshall, "The Eight Key Elements of High Performance Work Systems" (Conference Proceedings: High Performance Work and Learning Systems, Washington, DC, September 26–27, 1991), 3–14 and Ray Marshall, "Work Organization, Unions, and Economic Performance" in *Unions and Economic Competitiveness,* Lawrence Mishel and Paula Voos, eds. (Armonk, NY: M.E. Sharpe, 1992), 287–315.

7 Scandinavian design theorists and software developers have significantly challenged traditional Taylorist design. Pelle Ehn, *Work-oriented Design of Computer Artifacts* (Stockholm: Arbetslivscentrum, 1988); Gro Bjerknes and Tone Bratteteig, "User Participation and Democracy: A Discussion of Scandinavian Research on System Development," *Scandinavian Journal of Information Systems* 7:1 (1995): 73–98; and Christian Berggren, *Alternatives to Lean Production: Work Organization in the Swedish Auto Industry* (Ithaca, NY: ILR Press, 1992).

remote offices in response to alarms set off by "intelligent" sensors embedded in automated controllers. Knowledge, distributed throughout the organization, ensures short feedback loops. In this bakery, front-line workers, as well as engineers, were considered to have legitimate design knowledge. Engineering knowledge and front-line experience with mixing machines and recipes informed the setup of production lines and management information systems.

Like the small, New England bakery, a Nabisco plant that I visited had a well-developed, highly interactive, skill-based production facility. Throughout the one-million square-feet of floor space, factory workers could monitor production and modify ingredients and other process variables through operator terminals that displayed process-operating guidelines. In many factories throughout the United States, this information is reserved for supervisors and engineers who know the passwords to access recipes, histogram data gathered from machines, and date-stamps of hours worked by particular operators. Often, these display terminals are housed in locked rooms with glass walls. To get around locks in various plants, workers wedge open the doors of these control rooms, with the implicit consent of supervisors who would otherwise be obligated continually to modify process changes noted by operators. Even in facilities that apply skill-based design principles, technocentric engineering practice persists.

In the Nabisco plant, an operator of the "Chips Ahoy!" production line continually manipulated a large metal spatula over the six-foot wide conveyor to pick off individual cookies for testing. He monitored the shape and color of the cookies by directly examining them. He also monitored other process variables by checking the computer display. If he needed to change the recipe in the computer, he would put down his spatula at his workstation and type in the changes on a keyboard. One day, he arrived at work to find a brand new, stainless steel workstation with state-of-the-art electronic access to process operating guidelines, and real-time control over the Chips Ahoy production line. Unlike his previous, obsolete workstation, however, he had nowhere to put down his metal spatula while he was modifying recipes on the operator display panel, making typing difficult.

A technocentric bias in work redesign—whether in the form of "lights out" workerless production, or in the lack of workers' participation in the design of their workspaces—undercuts front-line expertise in favor of supervisory and engineering knowledge. Supervisors are expected to know and report to senior management on the current status and historical trends of mixing systems, the bakeshop, distribution, and inventory. Front-line workers carry out highly specified directives in response to visual "alarms" on their "graphical operator interfaces." Construction, application, design, and process engineers decide the ostensibly "optimum" configura-

8 Participation with management is a highly contested strategy within labor communities. See Andy Banks and Jack Metzgar, eds., *Participating in Management: Union Organizing on a New Terrain, Labor Research Review* (Chicago, IL: Midwest Center for Labor Research, 1989); Ray Scannell, "Adversary Participation in the Brave New Workplace: Technological Change and the Bakery, Confectionery, and Tobacco Workers' Union" in Glenn Adler and Doris Suarez, eds., *Union Voices: Labor's Responses to Crisis* (Albany, NY: SUNY Press, 1993), 79–123; and Michelle Kaminski, et al., *Making Change Happen: Six Cases of Unions and Companies Transforming Their Workplaces* (Washington, DC: Work and Technology Institute, 1996).

9 Harold Salzman provides several articulate comparisons between skill-based and technocentric design. Harold Salzman, "Participative Design and Engineering Practices for High-Performance Work Organizations" (paper presented at the Annual Meetings of the American Association for the Advancement of Science, Baltimore, Maryland, February 8–13, 1996).

tion of plant layout, operator interfaces, and information flow for the factory.

This technocentric bias dominates design practice in the industrial bakeries and baking exhibitions I visited, undermining front-line workers' expertise and constructive contributions to making bread in large factories. While the dominant approach to mechanized bread production seems to resist efforts to change design practice, there may be opportunities to overcome the tenacity of traditional industrial baking. Within the worlds of industrial baking, the resistance of design arises through complex institutional connections among prevailing modes of engineering pedagogy, economic incentives, advertising campaigns, and technological understanding. By examining how these prevailing modes of thought are sustained, we may learn how they can be disrupted.

Overcoming the Tenacity of Technocentric Design

My general approach to thinking about design has been to borrow from key figures in science studies to inform the study of artifacts and technologies. The field of science studies has demonstrated the work required to generate and sustain legitimate knowledge of the world.[10] This knowledge stabilizes through jointly entrenched ideas, conventions, and assumptions developed within social networks. Social groups outside of these networks, and marginalized by dominant systems of knowledge, must find ways to overcome the tenacity of prevailing modes of thought.

In his book *Genesis and Development of a Scientific Fact*, Ludwik Fleck used the concepts of thought style and thought collective to describe how a belief becomes legitimated as a fact.[11] Since I am interested in how alternatives to dominant design practice might emerge, I draw on Fleck's concept of thought style to introduce the concept of design style. Borrowing from Fleck's "thought style" helps to make two central points for encouraging alternatives to dominant design practice. First, Fleck uses the term *denskil,* which connotes "worldview"—not only rational cognition, but also other dimensions of experience (emotional, behavioral, cultural, etc.) that an individual uses to make sense of the world. By borrowing this aspect of *denskil,* I import an institutional dimension to what otherwise risks treatment as an overly rational, individualistic endeavor. Second, borrowing from the translation of *denskil* to "thought style" usefully flags a shift from style-as-aesthetics to style-as-a form of life.

A design style is a legitimated institutionalized pattern for how an artifact or technological system is created and sustained. This pattern includes prevailing design methods, practices, conventions, assumptions, principles, and objectives. While Fleck asked, how does one thought style emerge over another, I am interested in how one design style becomes dominant over others, and how a dominant design style might be disrupted, providing openings for change.

10 Barry Barnes, *Scientific Knowledge and Sociological Theory* (London: Routledge and Kegan Paul, 1974); David Bloor, *Knowledge and Social Imagery,* 2nd ed. (Chicago: University of Chicago Press, 1991); Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, MA: Harvard University Press, 1987); Karin D. Knorr-Cetina and Michael Mulkay, eds., *Science Observed: Perspectives on the Social Study of Science* (Beverly Hills, CA: Sage, 1983); David Hess, *Science Studies* (New York: New York University Press, 1997); and Ludwik Fleck, *Genesis and Development of a Scientific Fact,* trans. Fred Bradley and Thaddues J. Trenn (Chicago: University of Chicago Press, 1979 [1935]).

11 Fleck, *Genesis and Development of a Scientific Fact.*

Table 1
Technocentric versus skill-based, high performance design styles

Technocentric Design	Skill-based, High Performance Design
Focus on efficiency and cutting costs	Focus on overall organizational performance and quality
Work redesign focuses on narrow tasks	Work redesign encourages functional interdependence and broad work responsibilities
Top-level hierarchial control	Reliance on workers' discretion and judgment. Managers and engineers provide support and resources.
Information concentrated in centralized management and engineering staff	Information freely dispersed throughout the organization
Design decisions made exclusively by engineers and managers	Workers participate in all phases of design
Human activity adjusts to capabilities of technology	Technology is used to take advantage of knowledge and skills of workers
Output is standardized through centralization of process settings and modification	Output is standardized by short feedback/adjustment loop, which requires decision-making at the lowest possible level
Technologies compensate for human error (Automation requires human intervention limited to monitoring)	Workers ensure smooth operation of complex technological systems (Direct labor is used for machine supervision and analysis)

The bakery workers, for example, have worked to understand how the dominant technocentric design style in their industry is sustained, and how they might intervene in design to replace it with a "skill-based" or "high performance" design style. (Table 1) In other words, they have been trying to encourage a skill-based design style—which depends on using workers' knowledge and judgment, and demonstrates that they are important organizational assets.[12] Their approach reflects a concern for the quality of their members' jobs and an interest in producing high-quality, hearth breads—which they know will require more skilled labor. The bakery workers argue that skill-based design is better not only for them, but for others. They argue that skill-based design will "build a strong company and a strong union to provide greater security to its people and provide for the greater benefit of its employees, the community we live in, the customers we serve, and those who have invested in the success of the enterprise."

To disrupt the technocentric design style and replace it with skill-based design, the bakery workers have developed a variety of tactics for intervening in design. I characterize these tactics in terms of three key elements of design: symbolic, social, and material resources. (Table 2) In practice, the bakery workers have used these three elements of design to address how design problems are framed, what social institutions sustain design activity, and how material resources are configured to achieve design goals. The new

12 P. Brodner, ed., *Skill-based Automated Manufacturing: Proceedings of the International Federation of Automatic Control Workshop, Karlsruhe, Federal Republic of Germany, September 3–5, 1986* (Oxford: Pergamon Press, 1987); and Hans D. Pruijt, *Job Design and Technology: Taylorism vs. Anti-Taylorism, Routledge Advances in Management and Business Studies* (London: Routledge, 1997).

workstation on the Chips Ahoy line is one example of how material resources in industrial bakeries can be configured to support or undermine an operator's work. Similarly, the bakery workers understand that decisions about what types of mixers, packaging systems, ovens, and other machines and tools in the factory are decisions about control over work. They know that, if the engineers choose a 3,000-pound mixer for their production line, they will be producing a very limited variety of breads. A 3,000-pound mixer must have at least 1,500 pounds of dough in it to operate. The high capital cost of these large mixers requires continuous throughput and machine utilization, which limits the types of bread that can be produced. Artisan and hearth breads are out—breads that require more labor-intensive, craft production. McDonald's buns and Wonderbread-type breads are in—breads which can be highly automated through continuous mix and intense chemical processing.

Table 2
Design Elements

Element	**Description**	**Examples**
Symbolic resources	• Representations of design • Framing of design • Problems and goals	• Advertisements in the trade press • Engineering narratives
Social resources	• Social institutions and organizational structures sustaining design activity	• Labor-management committees • Co-determination laws
Material resources	• Content and connections of artifacts, tools, machines, elements of physical environment	• Configuration of operator displays, computers, and plant-floor sensors

In addition to attending to how material resources are configured, bakery union workers and leaders have worked to shape representations of design and create organizational structures that support participatory design. To help me illustrate how engaging these two design elements—symbolic and social resources—help bakery workers shift from a technocentric design style to skill-based design, I will draw on Ludwik Fleck's five-stage outline of the tenacity of a dominant thought style.

The method I apply here is to try to understand how a dominant way of thinking, or—in this case, designing—resists viable alternatives. By understanding the tenacity of a design style to resist alternatives such as skill-based design, interested social groups including the bakery workers can develop tactics for intervening in design. According to Fleck, the tenacity of a thought-style emerges at first when "a contradiction to the dominant system appears unthinkable. Second, what does not fit into the system remains unseen. Alternatively, if it is noticed, either—third—it is kept secret, or—fourth—laborious efforts are made to explain an exception in terms that do not contradict the system. Fifth, despite the legitimate claims of contradictory views, one tends to see, describe, or even illustrate those circumstances that corroborate current views and give them substance." [13]

Early in his work, the labor union research director had a hard time convincing the regional technology representatives, much more shop stewards and front-line workers, that alternatives to the dominant trends in baking could be developed.[14] This is Fleck's first stage, where a contradiction to the dominant system appears unthinkable. Most believed that machines would gradually, but inevitably, replace union members. Why would a factory not want to implement labor-saving devices? The prevailing representations in trade magazines and subsequent automation of packaging, tray handling, and other baking processes reinforce this view.

Consider the representation of human actors in baking advanced by Bill Davis, president of Pulver Systems, Inc., a manufacturer of laser-guided vehicles for bread basket, pan handling, and trailer loading. At the 1998 Baking Exposition and Show, I attended a talk by Davis during which he announced that, "We've pushed employees out of the bakery to the shipping dock... it's the final frontier...The factory of the future will have only a man and a dog. The man feeds the dog; the dog keeps the man from touching the controls." [15] Reinforcing this view, a Peerless Machinery Corporation advertisement in the trade press promises to "help you dim some lights in your bakery...There's a lot of talk about future technology making "lights out" bakeries a reality. Peerless already is there. Peerless technology. We're making your bakery a lot easier to manage." The union representatives easily identify what does not fit into these technocentric representations but, at this point—stage one of Fleck's outline—they believe there is little they can do to counter them.

The second stage—where what does not fit into the system remains unseen—reinforces this debilitating view. The dominant representations of baking design deny the quality contributions of skilled mixers, bakers, and maintenance workers. At best, they ignore these contributions. At worst, they represent human intervention as error-ridden. Contributions of skilled workers largely remain unseen by baking engineers, system integrators, and managers. For example, consider a new technology called the "Eagle Eye vision system." The "eagle eye" is a small camera mounted on a set of headphones that is connected to a remote engineering staff via the Internet. According to the manufacturer of Eagle Eye, with their "highly-advanced remote engineering system, you'll be able to slash soaring maintenance costs...By utilizing [their] exclusive technology, real-time video images, and full streaming, audio can be sent ...anywhere in the world, making the dream of remote engineering a practical reality." Preventive maintenance is replaced by reactive engineering diagnosis. What does not fit into this technocentric system is the alterna-

13 Ibid., 27.

14 Ashford presents possible points of intervention to increase labor unions' engagement with technology. Nicholas A. Ashford, "The Role of Labour in Choosing and Implementing Information-based Technologies" (paper presented at the International Symposium on Work in the Information Age, Helsinki, Finland, May 1996); and Nicholas A. Ashford and Christine Ayers, "Changes and Opportunities in the Environment for Technology Bargaining," *Notre Dame Law Review* 62:5 (1987): 810–858.

15 Davis made these comments while describing new technology trends at the 1998 Bakery Exposition and Show in Las Vegas, Nevada.

tive design approach that values training programs and long-term, highly skilled maintenance workers over advanced technologies and low-paid, contingent workers.

In the third stage, even those things that are recognized as valuable—or at least useful—are hidden if they do not conform to the dominant design style. At the International Bakery Exposition in Las Vegas, the BCT technology representatives were intrigued by one vendor's booth. We noticed that the mixing system of what the vendors called a "completely automated baking line" was walled-off by temporary cubicle partitions. Behind these partitions, a human mixer using an artisan-style machine was making the dough. The dough was physically picked up and carried to the dough stand, which initiated the automated part of the process. The lesson seemed to be: Human involvement should be kept secret from the beauty of a completely workerless system.

In stage four, extraordinary effort is made to accommodate an exception along the lines of the dominant design style. This process can be seen as the baking industry tries to respond to new design constraints resulting from the dramatic increase in demand for artisan breads. Compared to baking white breads, buns, and other staples of the baking industry, artisan breads require much shorter runs, higher product variety, and fewer industrial additives. While the best artisan breads are made in traditional, labor-intensive craft style, the challenge, as identified by the American Institute of Baking and as reflected in vendors' booths at the Baking Expo, is to scale-up production of these breads without increasing labor. The design constraints explicitly considered by baking engineers and managers remain the same, even when an opportunity for radically disrupting them arises. The dominant design style will accommodate the trend towards artisan breads by replacing labor through automation, and by manufacturing partially baked goods which can be baked off at corner bakeries to provide the appropriate hard crust and "fresh baked" appearance. While this will result in lower quality artisan breads, the product quality still will be higher than that of traditional breads. The point is that, even though artisan bread production contradicts many conventions of technocentric design, the dominant design style finds a way to incorporate these contradictions on its own terms with prevailing design methods. And how can it do otherwise?

The baking industry is constrained by the underlying assumptions, objectives, and methods of its technocentric design style. Without a disruption to this design style—the way the design problem is framed, the limits that are explicitly considered, and the means of distributing baking solutions—the baking industry can only react to the artisan bread opportunity in these terms. This is the final stage of Fleck's outline. Despite the valid claims of those who advocate high-skill, high-wage work, managers, engineers, and other influential designers of bakeries understand the bakery as an object for machine manipulation of food ingredients. The trade show was called the "baking expo," but it actually was a machine and tool exposition for the baking industry. The "baking expo" might have been conceived as a political-social-economic enterprise that draws on training, apprenticeship programs with local community colleges, and other regional economic planning initiatives, as well as current trends in industrial automation. Representations of design, however, told the story of baking-as-machines, not baking-as-social relations.

Table 3

Five stages in the tenacity of a dominant design style

	Stage	Example
1	A contradiction to the system appears unthinkable	Prevailing technological determinism within the baking industry limits perception of high-performance alternatives
2	What does not fit into the system remains unseen	Preventitive maintenance by front-line workers is superceded by reactive engineering diagnosis
3	If a contradiction is noticed, it is kept secret, or	Manual elements of "completely automated baking lines" are hidden by cubicle partitions
4	Laborious efforts are made to explain an exception in terms that do not contradict the system	Increased demand for artisan breads is met by manufacturing "fresh-baked" appearance and par-baked goods
5	Despite legitimate claims of contradictory views, one tends to see, describe, or illustrate circumstances that corroborate current views	Continual treatment of baking as manipulation of food ingredients versus techno-social enterprise

To disrupt the tenacity of the dominant design style, the bakery workers challenged the prevailing representations of design, created alternative institutions of design, and intervened in dominant ones. They worked with engineers, managers, and supervisors within these structures to explicitly consider how design problems might be framed in alternative ways. A first step for the union was to recognize the fact that representations such as those of Pulver and Eagle Eye do not depict inevitable technology trends. To help disrupt these common representations, the BCT research director needed staff members throughout the country that could tell alternative stories about how new technologies could be used. He was able to create the position of technology representative within the union's organizational structure—a position many other U.S. unions do not have.

A second organizational step for the union was to create institutions that consider the union's design criteria, as well as the prevailing criteria of the dominant design style. In several bakeries, they have initiated joint labor-management partnerships, joint design steering committees, and work groups that have the authority to broaden engineering design criteria to embrace skill-based design. Using these organizational resources, the union has investigated the distribution channel of new technologies. They have analyzed what producers of industrial automation equipment say about how their technologies could be used. They have visited system integrators and trade shows, and read trade magazines. Their enhanced understanding has helped them to participate actively in design meetings at their members' bakeries. This understanding depended on identifying how mundane workplace tools—computers, operator displays, and other plant-floor artifacts—were configured and how they might be arranged to support or undermine front-line workers' skills.

The union faces many barriers and often is successful only where their membership is strong. Many other obstacles exist. Often, corporate engineering staff dictates how new technology will be used at individual plants. In these cases, the union must have a national partnership agreement to have any chance at influencing design decisions. In addition, the efforts of individuals to shift design styles need to be supported by structural changes. For example, federal research and development agencies could make grants more readily available to labor unions by recognizing them as viable industrial partners with nonprofit organizations. Or, a shift in design style could be facilitated by companies that are mandated to pay the salaries of application engineers who work within state labor councils. Another possibility involves engineering professional societies that could lower entrance fees for workshops on new tools and machines, so that labor representatives and workers could attend.

In the face of these considerations, some BCT labor union members recognize that design can encourage social change or entrench existing relationships of control and authority. They have worked to understand how design problems are framed, how design activity is structured, and how artifacts and other material resources are configured—three key elements that help to constitute design practice. In the process, their members work in several bakeries where skill-based design has displaced the technocentric approach.

Intervening in Design

The concept of design style characterizes the tenacity of dominant design practice and entails a set of tactics for reshaping social, symbolic, and material resources to support alternative design processes and outcomes. The approach outlined here can be taken up in other design areas. Nigel Whiteley and others who share his critique of consumerist design are working to disrupt its dominance.[16] A first step for helping mobilize this critique is to articulate an alternative design style. In Whiteley's analysis, green design is one such alternative. See table 4 for a brief comparison of consumerist and green design styles.

16 Nigel Whiteley, *Design For Society* (London: Reaktion Books, 1993).

Table 4

Consumerist versus green design styles

Consumerist Design	**Green Design**
Focus on continuous innovation of distinctively styled products	Focus on innovation to solve social and environmental problems
Use marketing and advertising to create desire/demand	Use marketing analysis to identify existing social and environmental needs
Redesign of products increasingly frequent	Redesign only when the need demands it
Product materials are used to support styling, which encourages planned obsolescence, or "creative waste"	Product materials are used to minimize waste and maximize safety
Product designer has an obligation to quickly satisfy clients' desires	Product designer has an obligation to challenge clients' assumptions, e.g., using expertise to encourage efficient use of well-suited materials
High consumption and obsolescence viewed as democratic: they are seen to promote economic growth; over time products diffuse from high to low economic class	The idea that "less is more" is democratic; more resources are available for more people for longer; materialistic competition is reduced

Social, symbolic, and material design elements may be used to catalyze green design initiatives and undermine the dominance of the consumerist design style. For example, images from anti-consumerism campaigns sponsored by organizations such as the Canadian nonprofit Media Foundation (which produces *AdBusters* magazine) encourage alternative representations of product design that specify more sustainable design processes and outcomes. Design journals and magazines can disseminate design ideas consistent with green design. Institutions such as professional design societies and their codes of conduct, as well as progressive design organizations, also can help shift design styles. Organizations such as the Design Forum in Finland and the Ergonomi Design Gruppen in Sweden influence product designers to focus less on high-fashion extravagance than on fundamental human and ecological needs. In terms of material resources applied to product design, a shift in design style would require that both the materials used in design and the designed products minimize waste and maximize safety.[17] By working through these three design elements, product designers can fruitfully synthesize lessons in green design already developed by others.

In architecture, as in product design and in work design, the concept of design style can be used to describe attempts to shift from a dominant design approach to an alternative that is more agreeable to an interested social group. The concept of design style also can be used to help catalyze such a shift by helping participants jointly interrogate symbolic, social, and material resources in the design context. For example, building livable and likable affordable housing seems to be a persistent challenge for dominant architectural design practitioners. According to several architects committed to

17 Victor Papanek catalogs many inventive applications of common materials that meet the design goals of green design. Victor Papanek, *Design for the Real World* (London: Thames and Hudson, 1981).

low-rent, creative, community design, "Media portrayals of the nation's primary low-rent housing program—public housing projects—focus on the obvious failures: Chicago's Cabrini Green and Robert Taylor Homes, St. Louis's Pruitt Igoe, and Boston's Columbia Point.... There is a clear need to put forth convincing examples where low-rent housing works. And that, in large part, is a question of design." [18] Working to meet this need, their approach to design can be characterized as an alternative to the dominant design style in affordable housing, which typically involves private developers creating standard, unimaginative buildings with no cultural connection to local communities.

These architects have worked to shift the dominant design style to an alternative that involves the participation and cooperation of developers, neighbors, potential residents, local officials, and architects—all of whom work towards "a design solution that resolves the physical, social, and cost issues, and produces a building that the entire community can be proud of for generations." [19] In addition, the marginal design style works to limit the role of the automobile, combine land uses, and experiment with health-conscious and environmentally sound building materials and methods. These architects have represented the design problem with a larger set of constraints than the dominant design style in affordable housing, which seems to battle with the few constraints of fitting the needy into a limited space, with exceedingly fewer financial resources. They have created alternative organizational structures to support their marginal design style, including strategies for funding and creating participatory workshops on housing design and site planning. Participatory inquiry is enabled by exercises in which potential residents use models to arrange desired relationships between cars and dwellings. They are encouraged to disrupt conventional assumptions about neighborhood design. In addition, the marginal design style is fostered by close attention to material configurations in design. Not only do product participants work with safe, efficient materials, they also use materials to support community development. For example, in the Hismen Hin-nu Terrace project in Oakland, California, the town homes and apartments were designed to take advantage of the community's cultural diversity by employing four local artists to interpret their respective traditions and express them in frieze panels that then were installed throughout the development.[20] In other projects, birdhouses encouraged civic participation. And exhaust pipes disguised as fireplace chimneys seemed to discourage neighboring homeowners from organizing against the affordable housing project. Material amenities such as birdhouses and "chimneys" perform cultural work that the dominant design style does not recognize or appreciate. Set in the terms of design style, this quick review of affordable housing projects suggests how critical analysis of design might be extended for analyzing and fostering change in architectural design practice.

18 Tom Jones, William Pettus, and Michael Pyatok, *Good Neighbors: Affordable Family Housing*, (New York: McGraw-Hill, 1997), 8.

19 Ibid., 47.

20 Ibid., 100.

As the bakery workers found in their efforts to put into place "high performance" work systems, imagination and effort are required to disrupt a dominant design style, and to displace it with an alternative. Yet heroic efforts are not required—only systematic mobilization of material, social, and symbolic resources. The bakery workers did not need to start from scratch. The contradictions in the dominant design style already existed: efforts to optimize factories through total automation resulted in more rigid, less efficient operation. Bakery workers fought against the tenacity of the dominant technocentric design style by catalyzing emerging alternatives to totally automated baking systems. Taking advantage of existing social resources, they drew on labor-management committees to create participatory design work teams. The union mobilized and trained members as technology specialists who could educate others on design options. To create alternative representations of industrial baking, they challenged engineering narratives at trade shows and actively participated in design meetings within their home firms. To change how technologies were being implemented on the factory floor, they learned options in configuring existing operator displays, computers, and plant-floor sensors.

Artifacts and technologies are not traditionally recognized as politically relevant. Unlike issues that are recognizably political, few readily available venues exist for contesting scientific and technological innovations. Overcoming the technological somnambulism that lulls people into passively accepting their conventionally defined roles demands a change in design style.[21] A change in design style requires, in part, an interrogative method that fosters inquiry into the way that artifacts, tools, and machines are configured. If they are interested in catalyzing an alternative design style, designers—whether they work under the label of engineer, shop steward, supervisor, packaging technician, operator, product designer, or architect—will need to complicate their understanding of design. They will need to understand their work as a process of creating not only products and machines, but also forms of life and patterns of authority and control. The tactics identified here for intervening in design, and the general approach I have encouraged to inspect design styles, are attempts to link the worlds in which artifacts, tools, techniques, and machines are developed with the worlds in which they circulate. This type of analysis can encourage participatory inquiry into the social practices and customs that surround technologies, as well as the institutional resources required for it to exist. By raising questions about how design problems are framed, who participates in design, and how material resources are configured, people can encourage shifts in design styles, making it possible to find revolutionary potential in mundane places.

21 Absently accepting and unreflectively circulating within the forms of life generated by technologies—what Langdon Winner has called technological somnambulism—limits opportunities for improving design outcomes. Langdon Winner, "Technologies as Forms of Life," in Langdon Winner, *The Whale and the Reactor: A Search for Limits in an Age of High Technology* (Chicago: The University of Chicago Press, 1986), 3–18.

Toward Participatory Ecological Design of Technological Systems

Jeff Howard

Introduction

Environmental controversy is controversy about what kinds of technology designs work, what kinds don't work, and what it means ecologically, economically, and politically for a particular design to "work." So although ecological debate historically has not been framed as debate about design, proposals for *ecological reform* should be understood, in part, as proposals for *green* or *ecological design* of technological systems.[1] And the wide range of contemporary frameworks for ecological reform[2] should be recognized to provide diverse, even competing, foundations for ecodesign. It is reasonable to expect, for example, that ecodesign based on a libertarian "wise use" philosophy would look quite different from ecodesign based on ecocentric "deep ecology."

In light of the deeply social character of all design,[3] a crucial component of ecodesign criticism as it matures[4] will be assessment of these frameworks' relative fitness as foundations for effectively engaging ecodesign as a social process. Significantly, some reform frameworks appear to largely ignore the social dimensions of technological change or envision them as residing "outside" of the design process, while others regard them as central. What are the implications for ecodesign, given that we must define it as the design of techno*social* systems for compatibility with ecological systems?

As ecodesign criticism struggles with this question, one issue deserving special attention will be the relationship between experts and laypeople, which, in design and many other contexts, embodies deep assumptions about the relationship between the technical and the social. A major theme in recent democratic theory has been that the line between experts and laypeople often has been conceptualized and enacted in ways that are socially harmful—and urgently needs to be renegotiated.[5] This is a theme that science and technology scholars have elaborated in analyses of decision making about technology;[6] and some scholars have pointed out that depletion of the stratospheric ozone layer and other major technological impacts on the environment have begun prompting just such a renegotiation.[7] Indeed, struggles over the expert/lay divide have been prominent in many environmental controversies, such as in cases of "popular epidemiology." In such controversies, laypeople contest scientists' and engineers' values and assumptions, their theories and meth-

1 See Kate T. Fletcher and Phillip A. Goggin, "The Dominant Stances on Ecodesign: A Critique," *Design Issues* 17: 3 (2001): 15–25.

2 See John S. Dryzek and David Schlosberg, eds., *Debating the Earth: The Environmental Politics Reader* (Oxford: Oxford University, 1998).

3 E. J. Woodhouse and Jason W. Patton, "Design by Society: Science and Technology Studies and the Social Shaping of Design," *Design Issues,* this issue.

4 See Pauline Madge, "Ecological Design: A New Critique," *Design Issues* 13:2 (1997): 44–54.

5 Benjamin Barber, *Strong Democracy* (Berkeley: University of California, 1984) and Charles Lindblom, *Inquiry and Change: The Troubled Attempt to Understand and Shape Society* (New Haven, CT: Yale, 1990).

6 Frank Fischer, *Technocracy and the Politics of Expertise* (Newbury Park, CA: Sage, 1990); Richard E. Sclove, *Democracy and Technology* (New York: Guilford, 1995); and E. J. Woodhouse and Dean Nieusma, "When Expert Advice Works, and When It Does Not," *IEEE Technology and Society Magazine* 16:1 (1997): 23–29.

7 E.g., Silvio O. Funtowicz and Jerome R. Ravetz, "Science for the Post-Normal Age," *Futures* [Butterworth-Heinemann Ltd.] 25:7(1993): 739–55; and Jane Lubchenco, "Entering the Century of the Environment: A New Social Contract for Science," *Science* 279 (1998): 491–7.

odologies, their models and data, their interpretations and designs, and their substantial de facto power in political processes that shape the technological landscape. The political economy of ecodesign will be signaled in large part by whether it promotes this renegotiation, ignores it, or impedes it.

In probing ecodesign's potential for facilitating this renegotiation, it will be helpful to apply a theoretical framework from a subdiscipline familiar to many design studies scholars: participatory design (PD). Emerging from the broader ferment of conflict over the expert/lay divide in technological affairs, and conceiving design as a process that fuses material and social practice, the PD movement seeks to actively engage laypeople in the design of technosocial artifacts and systems.[8] Although we cannot expect the PD literature to provide a template for ecological design, we can look to it for precedents, principles, and models. To what extent can and should the design of consumer packaging, shopping malls, and municipal sewer systems involve laypeople—and how? In this paper, extending scholarship that emphasizes the need for vigorous lay participation in technology decision making, I use the main themes of PD as lenses to examine three of the numerous potential political foundations for ecodesign, concentrating on one—strong precaution—that appears to closely parallel PD. The objective of the article is to identify aspects of the three frameworks that are in line with the sensibilities and emphases of PD and aspects that are not, and to suggest opportunities for promoting strategies within these paradigms that are more effectively participatory.

Participatory Design

Participatory design encompasses a variety of strategies to give the people who will use a particular technology or technological system a direct role in decision making about its development. It has been undertaken in a broad range of settings, from information technology systems and computer-based newspaper typography to public housing development, management of Third World health services, and the development of micro-scale power systems.[9] Wherever it is practiced, PD focuses on "empowerment, participation, and a bottom-up approach" and aims to achieve not only instrumentally improved designs but "greater user satisfaction, social well-being, and empowerment, as well as a greater sense of and commitment to community."[10] These aims and this participatory sensibility align PD with public-participation initiatives in technology contexts even more diverse, from AIDS treatment to genetic engineering and food irradiation, and with prescriptions for vigorously participatory decision making in technological affairs as a whole.[11] These prescriptions are themselves variations on the theme that society needs to move toward "strong democratic"—that is actively participatory—decision making in all arenas.[12] Therefore, PD may be understood as an emerging body of theory and experience concerning the exercise

8 Douglas Schuler and Aki Namioka, eds., *Participatory Design: Principles and Practices* (Hillsdale, NJ: Erlbaum, 1993).

9 Jorn Braa, "Community-Based Participatory Design in the Third World" in J. Blomberg, F. Kensing, and E. Dykstra-Erickson, eds., *PDC '96: Proceedings of Participatory Design Conference* (Palo Alto, CA: Computer Professionals for Social Responsibility, 1996), 15–24; Andrew Clement and Peter Van den Besselaar, "A Retrospective Look at PD Projects," *Communications of the ACM* 36:6 (1993): 29–37; P. Ehn and M. Kyng, "Cardboard Computers: Mocking-it-up or Hands-on the Future" in J. Greenbaum and M. Kyng, eds., *Design at Work: Cooperative Design of Computer Systems* (Hillsdale, NJ: Erlbaum, 1991); Roberta M. Feldman, "Participatory Design at the Grass Roots" in Joan Rothschild, ed., *Design and Feminism* (New Brunswick, NJ: Rutgers University, 1999), 135–48; and Jesse Tatum, "The Challenge of Home Power: Toward a More Democratic Shaping of Technology" in Tatum, *Muted Voices: The Recovery of Democracy in the Shaping of Technology* (Bethlehem, PA: Lehigh University, 2000), 152–69. These works, selected as representative of PD in diverse settings, serve as the primary referents for PD in the discussion that follows.

10 Braa, "Community-Based Participatory Design," 15; and Feldman, "Participatory Design at the Grass Roots," 135.

11 Sclove, *Democracy and Technology*, and Daniel Lee Kleinman, ed., *Science, Technology, and Democracy* (Albany: State University of New York, 2000).

12 Barber, *Strong Democracy;* and Lindblom, *Inquiry and Change.*

13 Clement and Van den Besselaar, "A Retrospective Look at PD Projects"; and Feldman, "Participatory Design at the Grass Roots."

14 Feldman, "Participatory Design at the Grass Roots," 136, 146.

15 Tatum, "The Challenge of Home Power, quoted at 156. Rather than de-localizing design practice, the home power network functions much like the extensive literature and personal connections linking other far-flung PD practitioners: it provides ideas and experience that can be transported across geographic

of strong democracy in technology decision making. It has three principal themes:

Importance of the local—Although PD techniques are drawn from and applicable in a wide variety of settings, advocates emphasize that PD is rooted in place—in particular confluences of people, institutions, culture, and economics.[13] Whether a PD project takes place in a First World workplace or a Third World village, it taps into and builds on indigenous community structures.[14] Even when it involves a broad network of individuals on several continents, as in the "home power" movement, PD "begins ... from the lives of ordinary citizens" bound to local particularities such as water flow, wind patterns, and solar flux.[15]

Importance of lay empowerment—The essence of PD is deep lay engagement in shaping technology. Given the domination of contemporary technology design by engineers and professional designers, such participation requires a significant effort to provide laypeople with the means to play a central role in envisioning, prototyping, testing, and refining it.[16] This is accomplished not by ousting professional designers, of course, but by altering institutional arrangements to allow laypeople to *share* responsibilities and prerogatives conventionally reserved exclusively to professionals.

Professional designers may be expected to provide technical knowledge or analytic or managerial skills; but specific professional and lay roles may be negotiated as part of the PD process itself.[17] The professional's role shifts toward what Woodhouse and Nieusma describe as "democratic expertise," in which the expert becomes an openly partisan "participant in democratic problem solving," alongside and in the service of laypeople.[18] Correspondingly, laypeople provide local knowledge: an intimate knowledge of the organizations, communities, and social contexts in which the design is to be deployed.[19] Crucially, this knowledge may include awareness of "apparently viable technological alternatives that are expressive of values distinct from those incorporated in more conventional patterns of technology."[20] Ideally, PD applies local knowledge at the most fundamental level of design: in the conceptual formulation of the problems to be addressed.[21] Overall, then, PD may be said to empower laypeople by giving them the opportunity to participate in technology decision making processes that will deeply affect their lives, building in a set of understandings and sensibilities rooted in their own experience and values.

Importance of organization—PD requires organizational support in the form of funding, space, personnel, equipment, and altered work routines.[22] But organizational context also *shapes* PD projects. For example, PD projects for information systems have been significantly influenced by the ideologies and structures of the labor unions that initiated them.[23] Furthermore, as Clement and Van den Besselaar argue, even a PD project that initially is quite successful cannot be sustained unless it becomes thoroughly embedded in its host orga-

Footnote 15 continued
boundaries but that ultimately must be rooted in local conditions.

16 Braa, "Community-Based Participatory Design in the Third World," 15; Clement and Van den Besselaar, "A Retrospective Look at PD Projects," 29; Feldman, "Participatory Design at the Grass Roots," 139, 144-6; and Tatum, "The Challenge of Home Power."

17 Ehn and Kyng, "Cardboard Computers: Mocking-it-up or Hands-on the Future," 181.

18 E. J. Woodhouse and Dean Nieusma, "Democratic Expertise: Integrating Knowledge, Power, and Participation" in Matthijs Hisschemöller, Rob Hoppe, et al., eds., *Knowledge, Power, and Participation in Environmental Policy Analysis* (New Brunswick, NJ: Transaction, 2001), 73–96, quoted at 92; see also Fischer, *Technocracy,* 344–51.

19 Ehn and Kyng, "Cardboard Computers," 179-81; Clement and Van den Besselaar, "A Retrospective Look at PD Projects," 34; Braa, "Community-Based Participatory Design," 22; and Feldman, "Participatory Design at the Grass Roots," 140. The lay designer's role assumes characteristics that we might call "lay expertise"; see, e.g., Sclove, *Democracy and Technology,* 177; and Richard E. Sclove and Madeleine L. Scammell, "Practicing the Principle" in Carolyn Raffensperger and Joel Tickner, eds., *Protecting Public Health and the Environment: Implementing the Precautionary Principle* (Washington, DC: Island, 1999), 252–65, at 254.

20 Tatum, "The Challenge of Home Power," 152.

21 Ibid., 159.

22 Clement and Van den Besselaar, "A Retrospective Look at PD Projects," 32; Braa, "Community-Based Participatory Design," 15; and Feldman, "Participatory Design at the Grass Roots."

23 Clement and Van den Besselaar, "A Retrospective Look at PD Projects".

nization and unless the organization can accommodate a significant level of ongoing participation.[24] So important is favorable organizational context, these authors conclude, that organizational reform must be one of the principal goals of PD projects, for "without organizational reform in the direction of greater democratization at all levels, the knowledge and commitment that PD can stimulate in users will ultimately reinforce patterns that limit the growth of their capabilities and thus undermine further initiative ...Only by giving participation the meaning of full engagement in vital organizational affairs is the process likely to flourish."[25]

Diverse Foundations for Ecological Design

Each of the numerous political frameworks for ecological reform—from wise use to deep ecology, and from market liberalism to environmental justice—can be expected to provide a characteristic foundation for ecodesign. Such a foundation will include factors such as political-economic orientation, conception of technological "progress," assumptions about the severity of environmental degradation—and, crucially, assumptions about the relationship between technology (as well as science) and society and, at the same time, about the relationship between experts and laypeople. Given that the heart of PD is its commitment to lay empowerment, it will be helpful to examine foundations for ecodesign that differ significantly from PD in this dimension, as well as an approach that does not. Using variation in this dimension as the basis for a typology of approaches to ecodesign, this article considers how commitment to lay empowerment manifests or fails to manifest in each approach. At the same time, it considers whether and how each shares PD's emphasis on the local and on democratic organization.

Foundations for ecodesign range from those that, by most standards, are quite technocratic, or expert-centered, to those that we can call strong-democratic, that is, egalitarian and participatory.[26] At the technocratic end of the scale, activities and decision making ordinarily assumed to be "technical" or "scientific" remain largely the province of engineers and scientists. Here the experts dominate the power structure; and direct lay engagement, if it occurs at all, is focused primarily on "nontechnical" (e.g., ethical) considerations. In contrast, at the strong-democratic end of the continuum, lay citizens intrude, often quite deeply, into territory long dominated by scientists and engineers. Here the traditional power structure is disrupted, with laypeople exercising significant influence. And the line between "technical" and "nontechnical" considerations is fuzzy, with citizens both claiming a substantial role in the former and, at the same time, actively demonstrating that scientists' and engineers' activities rest on a (usually covert) foundation of the latter.[27]

Toward the technocratic end of this continuum, I suggest, are quantitative risk assessment and cost-benefit analysis, industrial ecology, and adaptive management.[28] Toward the strong-democratic

24 Ibid., 35–36.

25 Ibid., 36. Here again, PD takes its place as part of the larger struggle for strong-democratic reform and points to the often crucial role of technology decision making in such reform (Sclove, *Democracy and Technology;* and Tatum, "The Challenge of Home Power").

26 On technocracy, see Fischer, *Technocracy.* On strong democracy, see Barber, *Strong Democracy;* and Sclove, *Democracy and Technology.*

27 The continuum described here is based, in part, on Kleinman's description of several dimensions in which citizen involvement in technoscience can be seen to vary. See Daniel Lee Kleinman, "Democratizations of Science and Technology" in Kleinman, *Science, Technology, and Democracy,* 139–65, at 140–1.

28 Adam M. Finkel and Dominic Golding, eds., *Worst Things First? The Debate over Risk-Based National Environmental Priorities* (Washington, DC: Resources for the Future, 1994); Per-Olov Johansson, *Cost-Benefit Analysis of Environmental Change* (Cambridge: Cambridge University, 1993); T. E. Graedel and B. R. Allenby, *Industrial Ecology* (Englewood Cliffs, NJ: Prentice Hall, 1995); and Kai N. Lee, *Compass and Gyroscope: Integrating Science and Politics for the Environment* (Washington, DC: Island, 1993).

end are grassroots environmentalism, consensus conferences and other deliberative-democratic environmental initiatives, and some forms of ecological precaution.[29] Other approaches are arguably ambivalent, perhaps amenable to strong democracy in some ways but in other ways technocratic. Here we find ecological economics, ecological modernization, post-normal science, and community-based social marketing.[30]

Considering an example of a reform program in each region of the continuum will help to illuminate the social dimensions of the ecodesign foundations that we may expect to encounter there. Industrial ecology and community-based social marketing are reviewed here briefly; and strong precaution, at the strong-democratic end of the continuum, is reviewed in greater detail.

Spectrum of Approaches to Ecological Reform

Technocratic	Ambivalent	Strong Democratic
Industrial Ecology	Community-Based Social Marketing	Strong Precaution

I will describe each approach, consider its location on the continuum, examine its relation to PD's three primary emphases, and consider prospects for it to incorporate PD strategies.

Industrial Ecology

Industrial ecology (IE), an increasingly prominent interdisciplinary approach for reducing the "cradle to grave" environmental impacts of industrial processes and products, provides a distinctly technocratic foundation for ecodesign. In design contexts ranging from detergent formulations to lighting systems to consumer packaging, its principal objective is reducing impacts to levels that, from a risk assessment-based perspective, are ecologically sustainable and, implicitly, doing so without directly addressing prevailing levels of consumption or the institutional structure of technology decision making.[31] IE draws on the natural sciences to assess a particular natural system's ability to withstand a particular industrial stressor, such as emissions of mercury or lead. And its backbone is engineering: conducting materials and process "audits"; assessing product impacts over their entire life-cycle; analyzing energy consumption; designing products for ready recyclability; and so forth.[32] Although IE's leading theorists regard these activities as *constrained by social forces*,[33] in the final analysis, they do not treat them as inherently social.[34] One leading proponent acknowledges that IE involves deep values, but he argues it must be vigorously portrayed as strictly objective if it is to be credible in academic, regulatory, and industrial

29 Sherry Cable and Charles Cable, *Environmental Problems, Grassroots Solutions: The Politics of Grassroots Environmental Conflict* (New York: St. Martin's, 1995); Richard E. Sclove, "Town Meetings on Technology: Consensus Conferences as Democratic Participation" in Kleinman, *Science, Technology, and Democracy*, 33–8; and Raffensperger and Tickner, *Protecting Public Health and the Environment*. Here I also would place environmental justice as well as ecology-oriented architectural and municipal design. See Richard Hofrichter, ed., *Toxic Struggles: The Theory and Practice of Environmental Justice* (Philadelphia: New Society, 1993); Sim Van der Ryn and Stuart Cowan, *Ecological Design* (Washington, DC: Island, 1996); David Wann and Center for Resource Management, *Deep Design: Pathways to a Livable Future* (Washington, DC: Island, 1996); and Mark Roseland, Maureen Cureton, and Heather Wornell, *Toward Sustainable Communities: Resources for Citizens and Their Governments* (Gabriola Island, BC: New Society, 1998).

30 Robert Costanza, John Cumberland, et al., *An Introduction to Ecological Economics* (Boca Raton, FL: St. Lucie; International Society for Ecological Economics, 1997); Paul Hawken, Amory Lovins, and L. Hunter Lovins, *Natural Capitalism: Creating the Next Industrial Revolution* (Boston: Little, Brown, 1999); Funtowicz and Ravetz, "Science for the Post-Normal Age"; and Doug McKenzie-Mohr and William Smith, *Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing* (Gabriola Island, BC: New Society, 1999).

31 Graedel and Allenby, *Industrial Ecology*, esp. 5–8.

32 Ibid.

33 Ibid., 7–8.

circles.[35] Many IE proponents do not see the lay public as having a principal or even, apparently, a direct consultative role: they regard it primarily as the source of "external" market and political pressure for improved environmental performance.

Little in this picture resembles PD. There is no effort to empower ordinary citizens—even those living within a stone's throw of a client's manufacturing facility—to participate in IE-based design decisions. To the extent that such a consideration enters the mainstream IE vision at all, it is through a usually subtle implication that IE-oriented engineers and scientists represent an (expert) embodiment of citizen support for sustainability. And while IE emphasizes organizational context, the context to which it is tailored—the industrial corporation—is one that typically eschews participatory initiatives, and that IE's leading proponents seem to passively accept rather than actively challenge.

Still, if IE theorists and practitioners were intent on adopting a more participatory approach—perhaps recognizing an ethical obligation to do so[36]—how might they proceed? Some possibilities: To broaden the number and diversity of individuals and groups engaged in IE-style analysis and design of, say, a manufacturer's new line of electronic audio equipment, IE proponents could consult with environmental justice advocates, other grassroots activists, and labor unions; place IE technical experts at the disposal of such groups; and take steps to make IE and its corporate clients more accountable to the community, perhaps by publishing analyses and recommendations on a Web page for public review and comment. More broadly, IE proponents also could invite union members, social scientists, activist organizations, elected representatives, and members of the general public to systematically critique the manner in which IE theory and practice have disguised values choices as technical choices and have marginalized the voices of nonengineers and nonscientists.[37]

Measures such as these are unlikely to render mainstream IE a major force for participatory technology decision making, but they would give it a significant participatory dimension. If environmental justice activists and residents living in the shadow of the factory were commissioned to act as design consultants, IE-based "Design for Environment" would be able to more fully grasp "life-cycle" impacts and would be able to consider a broader range of design alternatives. While IE will be strongly inclined to remain in thrall to corporate culture, creative efforts to open it to participatory engagement would begin reorienting its political-economic foundations.

Community-Based Social Marketing

McKenzie-Mohr and Smith argue that governmental agencies and nonprofit groups seeking to improve community environmental behavior often find the standard tools of environmental reform—regulation and education—to be largely ineffective.[38] In community-

34 Social scientists writing in the IE literature emphasize the field's social dimensions, of course; e.g., Frank Boons and Nigel Roome, "Industrial Ecology as a Cultural Phenomenon: On Objectivity as a Normative Position," *Journal of Industrial Ecology* 4:2 (2001): 49–54. So far, however, social scientists play a limited role in the field: mainstream IE practitioners consult them primarily for guidance on how the technical vision of IE-oriented engineers can be implemented politically and economically.

35 John R. Ehrenfeld, "Industrial Ecology — An Idea Whose Time Has Come?" (Paper presented at the 4th Norwegian Academy of Technological Sciences [NTVA] Seminar and Workshop on Industrial Ecology, Trondheim, Norway, June 14–15, 2001).

36 Patrick Feng, "Rethinking Technology, Revitalizing Ethics: Overcoming Barriers to Ethical Design," *Science and Engineering Ethics* 6:2 (2000): 207–20.

37 E.g., the International Society for Industrial Ecology could commission leading critics of risk assessment to formally assess the implications of IE's reliance on risk methodologies.

38 McKenzie-Mohr and Smith, *Fostering Sustainable Behavior.*

based social marketing (CBSM), these are replaced or supplemented with social science-based efforts to systematically identify benefits that would accrue to individuals who engage in desired behaviors, identify barriers that inhibit those behaviors, and identify means of reducing the barriers and enhancing the benefits. If the objective is altering the public's relationship with municipal energy infrastructure by reducing residential energy consumption, for example, one of the desired behaviors may be residents purchasing energy-efficient homes; a benefit may be reduced residential energy costs; an obstacle may be a cultural assumption that a house's purchase price is more important than the long-term cost of operating the house; and interventions could include requiring real estate developers to disclose long-term costs. Thus, CBSM is a framework for designing the integration of technical systems and social systems in ways that envision a particular relationship between the two, a relationship that places CBSM in the middle, ambivalent portion of the technocratic-strong democratic continuum. Unlike IE, CBSM focuses on social dimensions of technosocial change; but like IE, it envisions primarily passive roles for the public.

CBSM's clearest commonality with PD, underscored by its very name, is its emphasis on the local. It aims to facilitate change at the community level, the level at which McKenzie-Mohr and Smith argue social psychology research demonstrates behavioral-change initiatives to be most effective. This focus reflects recognition that technological systems' ability to degrade the environment (e.g., through global warming) are deeply embedded in the daily lives of citizens (e.g., daily residential energy consumption).

CBSM does not aim squarely at lay empowerment, however. While CBSM-based campaigns emphasize the importance of the lay public, McKenzie-Mohr and Smith seem to envision primarily passive lay roles: on one hand, participation in surveys and focus groups; on the other, adopting behavior changes designated and marketed by campaign leaders. While CBSM also emphasizes steering individuals toward problem-focused coping strategies, including direct political action, this is targeted not at empowering individuals but at enhancing the instrumental effectiveness of managers' programs. And while the authors urge that messages be structured so as to "engender a feeling of common purpose and efficacy,"[39] building community solidarity is not among CBSM's goals. Consequently, CBSM empowers not the lay public, in the sense envisioned in PD, but the environmental manager.[40] If there is skepticism in CBSM about the role of experts, it is quite limited. The authors criticize the psychological models that environmental managers traditionally have employed. But it is the methodology, not managers' role as experts, that CBSM brings into question; and the expert character of the social science "tools" on which CBSM is based is taken for granted.

39 Ibid., 92.

40 Many of the environmental managers who might benefit from CBSM programs presumably are neither scientists nor engineers, but CBSM specifically addresses them in their role as ostensible experts in designing sustainability initiatives.

Nor does CBSM share PD's focus on democratic organization. Many of the programs that CBSM aims to improve presumably arise from citizen pressure of one sort or another. But few municipal agencies have structures that permit, much less encourage, direct public participation in environmental decision making. So while some CBSM-based projects can be expected to take on a weak participatory cast, in most cases, organizations that adopt CBSM methods will undertake projects technocratically, and CBSM will not serve as a systematic goad for them to do otherwise.

Even if McKenzie-Mohr and Smith do not adequately problematize the role of experts or actively promote mechanisms for lay participation, however, it appears that CBSM offers moderately fertile ground for such participation. One approach, for example, would be CBSM-style programs to encourage laypeople to engage in sustainability-oriented PD projects (e.g., consulting with local manufacturers on the energy efficiency of their consumer products)—and, simultaneously, to encourage technologists (e.g., industrial designers) to facilitate their doing so. A complementary approach would be launching PD projects to actually design sustainability-oriented CBSM programs. Perhaps, then, we can imagine a well-integrated PD/CBSM initiative for public engagement in the design of both ecologically sustainable technological systems and the social behaviors necessary to design those systems, utilize them, and refine them. This would apply PD sensibilities and methods to the task of ecodesign, solidifying participatory strategies promoted informally by grassroots activists and others; and it would bring the theoretical, empirical, and methodological resources of CBSM into PD, making it possible to target communities of both laypeople and experts whose behavior is to be strategically modified. It would open the possibility of making sustainability-oriented CBSM projects substantially more participatory than McKenzie-Mohr and Smith seem to envision, moving the social science component of CBSM away from a scientific management model toward "democratic expertise."

Strong Precaution

When a new chemical or a new electronic device is designed, who should have the power to decide if it is environmentally benign enough to be marketed? The precautionary principle (PP) is a legal doctrine increasingly invoked in environmental agreements internationally and in environmental controversies from the local level to the international.[41] It calls for instituting potentially fundamental changes in how scientific knowledge and scientific investigation are employed in environmental policy because it "assumes that science does not always provide the insights needed to protect the environment effectively and that undesirable effects may result if measures are taken only when science does provide such insights."[42] A wide variety of articulations have been offered, but, by most accounts, the principle embodies two basic tenets:[43]

41 Raffensperger and Tickner, *Protecting Public Health;* David Freestone and Ellen Hey, "Origins and Development of the Precautionary Principle" in Freestone and Hey, *The Precautionary Principle and International Law: The Challenge of Implementation* (The Hague: Kluwer Law International 1996), 3–15.

42 Freestone and Hey, "Origins and Development," 12.

43 Freestone and Hey, *The Precautionary Principle;* and Raffensperger and Tickner, *Protecting Public Health.*

1 The proponent of a technological activity should bear the burden of demonstrating, to some established standard, that the technology will not cause serious or irreversible damage.
2 When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.

This approach runs counter to prevailing legal and cultural conventions in the United States, under which the public generally bears the burden of proving a particular technology is harmful and a technological practice routinely is allowed to continue in the face of considerable evidence of harm.[44] Indeed, it is at least potentially subversive of some of the basic assumptions underlying both liberal and socialist societies: that social good depends on economic growth (*productivism* and *industrialism*); that large, central institutions are uniquely capable of guiding this growth (*managerialism*); and, that science constitutes an objective foundation for both (*scientism*).[45] Application of the PP threatens these assumptions by exposing normally hidden ideological dimensions of science and technology—their implication in and commitment to prevailing power relations.[46]

In the face of dominant institutions grounded in risk-based decision making, there is concern that risk-based policies may be disguised with a "thin gloss of precautionary language," potentially rendering the principle "a token theoretical ideal that may be acknowledged and subsequently ignored."[47] Apparently responding, in part, to this concern, a number of authors have moved toward strong formulations of the principle.[48] Eight additional tenets[49] appear to capture much of their thinking and can serve as a preliminary articulation of *strong precaution* (SP):

3 Precaution must be an open, democratic process involving all affected parties.
4 Precaution requires examination of a full range of social and technological alternatives.
5 Precaution must become the default mode of all technological decision making.
6 Even the most fundamental of existing technologies must be subject to reexamination and precautionary reform.
7 The primary mode of regulation and regulatory science should be at the macroscale.
8 Knowledge of broad patterns trumps ignorance of detail.
9 Human society must accommodate itself to broad patterns in natural processes.
10 Environmental decisions cannot be made less political by making them more scientific, because science is inherently political.

44 Carl F. Cranor, "Asymmetric Information, the Precautionary Principle, and Burdens of Proof" in Raffensperger and Tickner, *Protecting Public Health,* 74–99.

45 R. Michael M'Gonigle, "The Political Economy of Precaution" in Raffensperger and Tickner, *Protecting Public Health,* 123–47.

46 Ibid.

47 Katherine Barrett and Carolyn Raffensperger, "Precautionary Science" in Raffensperger and Tickner, *Protecting Public Health,* 106–22, quoted at 114; and David Santillo, Paul Johnston, and Ruth Stringer, "The Precautionary Principle in Practice: A Mandate for Anticipatory Preventive Action" in Raffensperger and Tickner, *Protecting Public Health,* 36–50, quoted at 41.

48 "Wingspread Statement on the Precautionary Principle" (Consensus statement adopted during Wingspread Conference on Implementing the Precautionary Principle, Racine, Wisconsin, January 23–25, 1998); Cranor, "Asymmetric Information"; M'Gonigle, "The Political Economy of Precaution"; and several other articles in Raffensperger and Tickner, *Protecting Public Health:* Peter deFur, "The Precautionary Principle: Application to Policies Regarding Endocrine-Disrupting Chemicals," 337–48; Andrew Jordan and Timothy O'Riordan, "The Precautionary Principle in Contemporary Environmental Policy and Politics," 15–35; and Peter Montague, "Precautionary Action Not Taken: Corporate Structure and the Case of Tetraethyl Lead in the USA," 294–303.

49 Jeff Howard, "Extending the Wingspread Consensus Statement on the Precautionary Principle" (Paper presented at the annual meeting of American Association for the Advancement of Science, Anaheim, CA, January 21–26, 1999); and Jeff Howard, "Beyond Wingspread: The Tenets of Strong Precaution" (Presentation at annual meeting of Association for Science in the Public Interest, Richmond, Virginia, May 31–June 2, 2001).

While the two basic tenets of the PP are arguably in the ambivalent middle of the technocracy / strong democracy continuum, the eight additional tenets locate the principle toward the strong-democratic end. They open design decisions on chemicals, electronic products, and other technologies to greater public scrutiny, broaden the range of people engaged in such decision making, and broaden the range of alternatives considered. They also make more explicit the PP's challenge to the productivism, industrialism, managerialism, and scientism on which design decisions typically have been based. And they challenge the prevailing tendency to regard design as rational only if it assumes impacts on natural systems are secondary to economic expediency, only when it focuses on details (e.g., specific impacts of specific chemicals), and only when it assumes science (and hence applied science) to be politically neutral.

Although the principle has been invoked primarily in international contexts,[50] it also has a substantial, if largely tacit, local dimension. There is a strong sense in the emerging SP literature that environmental issues fuse global and local concerns.[51] The PP, and particularly SP, resist hierarchical decision making by institutions that, under globalization, are themselves less and less locally grounded; and M'Gonigle points out that the objectives of SP resonate with those of movements such as community forestry.[52] It has been suggested that, in the United States at least, the principle will likely first be solidified at the local and state levels rather than the national level.[53] Indeed, the principle—almost always implicitly in a strong formulation—has commonly been cited in grassroots campaigns to curb environmental health threats from, for example, chlorine-based chemical technologies.[54] Moreover, there is a clear sentiment in much of the precaution literature that the principle has arisen out of a perception that domination of technology decision making by distant corporations violates many people's everyday sense of rational policy making.[55] In the end, the movement supporting the PP, and especially SP, is connected to the local and to the daily lives of ordinary citizens much as the PD movement is: it embodies intellectual and political linkages between global and local concerns, perspectives, and actions. Sclove and Scammell suggest that "community-based research" projects oriented around precaution offer a promising outlet for precautionary thinking at the local level.[56] It seems reasonable to propose that such projects and existing precaution-oriented grassroots campaigns against incinerators and other sources of chemical pollution may be understood as efforts to engage in participatory ecodesign.

Lay empowerment, the heart of PD, is central to SP. The tenets calling for open democratic process, precaution as the default mode, and an ability to reexamine existing technologies would create opportunities for laypeople to assume a significant role in a wide range of design decisions. The tenet calling for examination of a wider range of technological alternatives would afford laypeople

50 E.g., the Rio Declaration of 1992.

51 E.g., Jordan and O'Riordan, "The Precautionary Principle," 19.

52 M'Gonigle, "The Political Economy of Precaution."

53 Carolyn Raffensperger and Joel Tickner, "To foresee and forestall" in Raffensperger and Tickner, *Protecting Public Health,* 1–11, at 9.

54 Center for Health, Environment, and Justice, "America's Choice: Children's Health or Corporate Profit: American People's Dioxin Report" (Falls Church, VA: CHEJ, 1999), http://www.chej.org/peopledioxin.html.

55 This domination is said to run roughshod over people's everyday sense of reasonable needs and reasonable means of meeting those needs; e.g., see Mary O'Brien, "Alternatives Assessment: Part of Operationalizing and Institutionalizing the Precautionary Principle" in Raffensperger and Tickner, *Protecting Public Health,* 207–19. The PP, in contrast, is said to be "a simple concept rooted in common sense"; see Raffensperger and Tickner, *Protecting Public Health,* "Lessons from Wingspread," Appendix A, 349–55, at 350.

56 Sclove and Scammell, "Practicing the Principle."

crucial opportunities to participate in defining the appropriate goals of design, the human needs to be met, the problems to be solved, and appropriate means to solve them.[57] The tenets regarding the scale of technology decision making and the types of knowledge required would push this decision making out of a mode that technical elites are readily able to dominate: a focus on microscale issues concerning readily available evidence and disregarding long-term, large-scale patterns of harm and correspondingly large degrees of uncertainty. The tenet calling for human accommodation to natural systems would require discussions between laypeople and experts regarding what is known and not known about such systems, what is to be protected, and how accommodation should proceed. And the tenet acknowledging that science is inherently political would open productive discussion about the political-economic dimensions of environmental science and public policy based on this science.[58]

SP's emphasis on empowerment is driven by a sense of the enormity of past techno-ecological blunders—from PCBs and Chernobyl to CFCs and endocrine disruption—and by the conviction that these blunders stem, in no small part, from dogmatic denial that science and technology are deeply entangled with politics.[59] Under SP, a significant amount of decision making by technical elites would be revealed to rest on hidden forms of lay decision making disguised as technical expertise: engineers' and scientists' value-laden stances on the seriousness of environmental degradation, the worth of particular ecosystems, the importance of economic growth, and so forth.[60] By giving precaution-based decision making clear primacy over risk-based decision making, SP would require renegotiation of the respective roles of technical elites and laypeople. Engineers and scientists would continue to play crucial roles, of course, but they would not dominate and would serve more as helpmates than as authorities, moving toward the exercise of "precautionary science" and "democratic expertise."[61] Laypeople, drawing on their everyday understandings and aided by experts, would be called upon to take the primary responsibility to guide the path and pace of technology.

Finally, strong precaution is equally in tune with PD's emphasis on the importance of democratic organization. It represents recognition that the PP failed to take hold in the 1920s around the issue of leaded gasoline because the political clout of General Motors and other large companies trumped the political clout of public health officials.[62] It represents recognition that the PP has gained prominence in recent years only because the public increasingly understands that techno-ecological blunders signal "the inescapable presence of pervasive uncertainty in the scientific enterprise."[63] And it represents recognition that use of the PP cannot be robust unless it is institutionalized in ways that systematically restructure the relationship between technology, science, economics, and politics that is embodied in technology design. A variety of mechanisms have

57 O'Brien, "Alternatives Assessment."
58 Barrett and Raffensperger, "Precautionary Science"; and European Environment Agency, "Late Lessons from Early Warnings: The Precautionary Principle 1896–2000" (Copenhagen: EEA, 2001), ch. 16.
59 Jeff Howard, "Environmental 'Nasty Surprise' as a Window on Precautionary Thinking," *IEEE Technology and Society Magazine* 21:4 (2002/2003): 19–22; and European Environment Agency, "Late Lessons."
60 See, e.g., Jordan and O'Riordan, "The Precautionary Principle," 7, 31.
61 Barrett and Raffensperger, "Precautionary Science"; European Environment Agency, "Late Lessons," ch. 16; and Woodhouse and Nieusma, "Democratic Expertise."
62 Montague, "Precautionary Action."
63 M'Gonigle, "The Political Economy," 131.

been proposed for implementing the PP, including community-based research, consensus conferences, environmental performance bonds, corporate disclosure requirements, restrictions of corporate charters, and phaseouts of problematic classes of chemicals.[64] The relevance of such mechanisms for SP will be measured in terms of their ability to change "both the relations of economic and political power and the paradigms of analysis that are both embedded in and, in turn, underpin these relations."[65]

The strong parallels in all three of these categories—emphasis on the local, on lay empowerment, and on democracy—produce rich opportunities for intercourse between SP and PD. There is good reason to expect that precaution-oriented grassroots activists would benefit from studying the explicitly design-oriented tactics of PD proponents and, conversely, that PD proponents would benefit from studying grassroots activism. It seems likely that encountering a similar set of technical, financial, institutional, and cultural obstacles to meaningful participation has produced insights and approaches that are likewise similar and that would benefit from cross-fertilization. For example, the experience of activists who have successfully initiated programs for PD of corporate information technology systems may offer valuable models for activists who seek to pressure industry to bring community and labor organizations directly into decision making on toxic emissions or solid-waste recycling.[66] At the same time, the experience and concerns of environmental activists can be expected to improve how PD advocates think about the ramifications of technical design, how they understand the value-ladenness of technical design expertise, and how they define the communities that ought to be brought into design.[67] Recognition of SP-oriented activism as a tacit form of PD, especially at the local level, raises the possibility of an explicit and comprehensive fusion of the two.

Discussion and Conclusion

The principal objective of participatory design is empowerment of laypeople to participate deeply, and with some measure of authority, in the evolution of technological systems. The other two PD emphases—the importance of the local and the importance of organizational context—are best understood as serving this central objective, providing insights into what PD proponents believe it means for laypeople to be empowered, and how they believe this empowerment can be brought about. Interpreting PD as an emerging expression of strong-democratic control of technological systems, this paper has explored its compatibility with—and opportunities for integration with—three diverse ecological-reform frameworks that have been, or could be, pressed into service as foundations for ecodesign. A more extensive analysis would be necessary to fully characterize each region of the technocracy/strong democracy

64 Raffensperger and Tickner, *Protecting Public Health;* and Joe Thornton, *Pandora's Poison: Organochlorines and Health* (Cambridge, MA: MIT, 2000).

65 M'Gonigle, "The Political Economy," 125.

66 E.g., how "outsiders" can work their way inside a company's walls, how they can establish trust, how they can help initiate a rethinking of expertise and the objectives of design, and how they can participate in design decisions in a sustained fashion.

67 Along the way, there also would be mutual lessons from differences between the two contexts. One issue of particular concern: how cooperatively designing a single, technically determinant product or process (the focus of most PD projects) differs from cooperatively designing broader, frequently indeterminate relationships between industry, the community, and the environment (the focus of precautionary initiatives).

continuum, but the present analysis has provided initial glimpses of the larger pattern.

The technocratic approach of industrial ecology typically makes no provision for lay input and passively accepts the shape of contemporary industrial-corporate institutions. Community-based social marketing of sustainability programs offers a significant contrast, for it directly addresses social dimensions of technological systems. But whatever lay engagement CBSM envisions is largely passive, because CBSM focuses primarily on applying social-science expertise to tasks performed by the managers of sustainability programs and is neither intended nor structured to promote democratization of institutions promoting sustainability. Only strong precaution, at the strong-democratic end of the technocratic/strong-democratic continuum, consistently shares PD's emphases. SP and PD are organically related, and SP's call for public control of technological decision making can be understood as a call for lay engagement in design and for democratic restructuring of design institutions.

In a sense, this paper has asked how well IE, CBSM, and SP would serve as "institutions" for the practice of PD in the context of environmental issues. It seems there are significant opportunities for integrating PD emphases and PD-style lay engagement into all three. For industrial ecology, this engagement may be limited to introducing mechanisms allowing lay activists and others to play consultative roles—roles that would give IE a somewhat more participatory orientation but that would be unlikely to fundamentally alter its technocratic character. For CBSM, opportunities to integrate PD appear more substantial. It seems possible to orient specific CBSM projects—and to some extent CBSM itself—toward participation.

For strong precaution, too, we can distinguish between specific projects and more general considerations. At the level of individual SP-oriented projects, where PD already is tacitly occurring, the task is to bring PD and SP into direct, sustained contact in order to: facilitate the exchange of experience and tactics; enable SP activists to use PD cases as precedents for lay engagement behind corporate walls; and improve PD thinking about who should count as "relevant laypeople" and "affected communities." At a more general level, the tasks are: to explicitly draw out similarities and dissimilarities between SP theory and PD theory (with special attention to the relationship between local and global dimensions, and between intended and unintended effects of technology); to consider the theoretical and strategic significance of the realization that local-scale SP constitutes a form of PD; and to knit all of this into a cohesive account of SP and PD's relationship(s) to strong democracy.

Strong precaution clearly offers the most benign foundation for PD. Here there is every reason to believe that PD can survive and thrive as a form of "dark green" design.[68] At the same time, however, we should not underestimate the importance of IE and

68 See Madge, "Ecological Design," 52–53.

CBSM as institutional homes for PD. Given that (compared to SP) IE is now far more actively integrated in industrial affairs, and given that CBSM probably has better short- and medium-term potential to be integrated into municipal sustainability programs, efforts to integrate PD into these approaches remain promising. Even modest success could have a substantial impact on public policy.

Feldman's observation that design is an "ongoing struggle for the appropriation of homeplace"[69] underscores the importance of bringing PD perspectives and methods into the center of programs to achieve sustainability. It is far from clear that the technocratic approaches that now dominate such programs offer a viable means of protecting our biological home—and all too clear that the political home they help reify is not strong but "thin" democracy.[70] The need for these approaches to be leavened with, or supplanted by, approaches based on the goals and assumptions of strong democracy is arguably urgent. Modeling ecodesign in part on PD would promise a number of salutary effects: helping laypeople and experts alike recognize that the values that come to be embedded in technology can be democratically negotiated,[71] helping laypeople "defy images of their capabilities and overcome institutional regulations regarding their rights," especially by facilitating the development of "improved management skills, a sense of self- and group-efficacy, and credibility";[72] and, in general, demonstrating "that under appropriate conditions, [laypeople] are capable of participating actively and effectively" in technology development.[73]

Tension between technocratic and participatory impulses is quite distinct in the ecodesign literature pioneered by Victor Papanek and others.[74] And as ecodesign practice and theory come into more extensive contact with the design assumptions and implications of various ecological reform programs, the significance of this tension will grow. Attending to the thorny issue of who should steer ecodesign will take its place as an important part of the field's "steady broadening of ...scope in theory and practice" and "increasingly critical perspective."[75] Pursuing participatory ecodesign offers one means of conceptualizing and enacting ecodesign as a process that involves not just "proximate designers" but "design by society" and that helps move society toward participatory, deliberative steering of technology.[76]

This project has been supported by the U.S. Environmental Protection Agency's Science to Achieve Results (STAR) graduate fellowship program (grant number U-91593401-3). It has not been subjected to EPA review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

69 Feldman, "Participatory Design," 144.

70 See Barber, *Strong Democracy,* ch. 1; and Daniel Sarewitz, *Frontiers of Illusion: Science, Technology, and the Politics of Progress* (Philadelphia: Temple University, 1996), ch. 8.

71 Clement and Van den Besselaar, "A Retrospective Look," 34.

72 Feldman, "Participatory Design," 144, 139.

73 Clement and Van den Besselaar, "A Retrospective Look," 34.

74 E.g., Van der Ryn and Cowan's *Ecological Design,* with its dictum "everyone is a designer," shares PD's emphases much more closely than either Papanek's *The Green Imperative: Natural Design for the Real World* (New York: Thames and Hudson, 1995) or Nigel Whiteley's treatment of green design in *Design For Society* (London: Reaktion, 1993).

75 Madge, "Ecological Design," 44.76 Woodhouse and Patton, "Design by Society."

76 Woodhouse and Patton, "Design by Society."

Environmental Information Systems as Appropriate Technology

Kim Fortun

Environmental information systems—involving databases, computer modeling, remote sensing, GIS applications, and a host of other technologies—are now being developed around the world to address a range of issues, from climate change to loss of biodiversity, to economic underdevelopment.[1] The implications for the natural environment, human welfare, and democratic governance are significant. Environmental information systems structure what people see in the environment, and how they collaborate to deal with environmental problems. They shape scientific inquiry, legal argument, and how citizens participate in governance. They are technologies designed to produce new truths, new social relationships, new forms of political decision-making and, ultimately, a renewed environment.

I will discuss one particular environmental information system, an interactive Website supported by a relational database that contains profiles of more than 6,800 chemicals. Maintained by the Environmental Defense Fund, and called "Scorecard," the Website integrates local pollution information for the United States with information on health risks, and with information on relevant environmental regulations. It allows users to produce customized reports, and encourages communication with the U.S. Environmental Protection Agency, or with a polluting company. A Canadian version of Scorecard went online in April 2001, and a Japanese version is in the planning stage.[2] Scorecard could become a technology that is transferred to countries around the world.

My main argument is that Scorecard is an example of an *appropriate* environmental information system—designed in a way attuned to the material, political, and technological realities with which it works, and to the social actors who will be its users. The argument builds on the concept of appropriate (or "intermediate") technology popularized in the 1970s, with roots in Gandhian critiques of mass production articulated during the Indian independence movement.[3] Advocates argued that, in order to be "appropriate," technology should be designed to fit into its local setting, synchronized with available material resources, expertise, and labor time. I observed many such technologies in India while conducting field research in the early 1990s, and learned to appreciate how they could combine function with social, technical, and environmental sustainability. I also learned that "local settings" were inevitably punctured by flows of ideas, people, and goods from elsewhere; with

1 For examples of work on these topics in STS, see G. C. Bowker, "Biodiversity Datadiversity," *Social Studies of Science* 30:5 (2000): 643–684; P. Edwards, "Global Climate Science, Uncertainty and Politics: Data-laden Models, Model-Filtered Data," *Science as Culture* 8:4 (1999): 437-472; R. E. Sieber, *Computers in the Grassroots: Environmentalists, GIS and Public Policy* (Ph.D. Dissertation, Rutgers University, Department of Geography, 1997); D. Sarewitz, R. Pielke, Jr., and R. Byerly, Jr., eds., *Prediction: Science, Decision-Making and the Future of Nature* (Washington, DC: Island Press, 2000).

2 The Canadian version of Scorecard, once at www.scorecard.org/pollutionwatch, has been taken off the Web. I do not yet know the reasons. Bill Pease, the designer of Scorecard, mentioned the Japanese version in an interview with Erich Schienke in October 2001.

3 See E. F. Schumacher, *Small Is Beautiful: Economics as if People Mattered* (New York: Harper & Row, 1973). For a recent analysis that highlights the need for technology to match both users and needs in both complexity and scale, see B. Hazeltine and C. Bull, *Appropriate Technology: Tools, Choices and Implications* (New York: Academic Press, 1999).

Design Issues: Volume 20, Number 3 Summer 2004

both good and bad effects. I thus became interested in a concept of appropriate technology that would fit with the realities of globalization, and remain open to the wide array of technologies that could become local resources. Instead of assuming that appropriate technology had to be small-scale and completely controlled by the local community, I wanted to explore what "appropriate" technology meant in the high-tech, globally interconnected world of the twenty-first century.[4] My argument here extends this exploration, drawing out how information technology can attune to the realities of pollution at the local level.

My analysis draws on my own earlier work on how environmentalism has been practiced on the ground, in different settings, in the aftermath of the 1984 Bhopal disaster. In this work, I drew out the gaping information deficits that people must contend with when dealing with environmental problems, particularly as they impact human health, and the difficulties that arise when it is not possible to establish simple causal relationships between exposure and disease. I also examined how grassroots environmental groups function, and the political challenge of trying to influence corporate conduct.[5]

My analysis also draws on earlier research on the social implications of information technology. This research warns of the ill effects likely to emerge from widespread use and commercialization of information technology. It warns that information technology is likely to intensify and complicate the separation between haves and have-nots, and that the types of access people have to information will be a primary determinant of their social position, and of the opportunities available to them to change both their own positions and society more broadly.[6] It also warns of the emergence of a new "enclosure movement" that aims to make information technology, as well as information itself, increasingly proprietary.[7] Research on the social implications of information technology also has drawn out positive examples and indicators, often highlighting how information technology can enhance democracy. Examples of the way information technology can be appropriated for unexpected uses are important,[8] as are examples of the way information design can encourage creativity, and make it possible to visualize complex phenomena.[9]

I begin the essay with a description of what I think of as the "informating" of environmentalism—a trend that involves increasing use of information technologies to address environmental problems. In the next sections, I describe the Scorecard site in detail, and then explain why I think that Scorecard is an example of appropriate technology design. In the final section, I briefly comment on how appropriate technology design enables design to serve what Richard Buchanan calls "first principles."

4 The U.S. Office of Technology Assessment, for example, defined "appropriate technology" as "small scale, energy efficient, environmentally sound, labor-intensive, and controlled by the community" (cited in Hazeltine and Bull 1999, 3).

5 See Kim Fortun, *Advocacy After Bhopal: Environmentalism, Disaster, New Global Orders* (Chicago: University of Chicago Press, 2001).

6 See M. Castells *The Rise of the Network Society* (Malden, MA: Blackwell, 2000); and R. Kolko, L. Nakamur, and G. Rodman, eds., *Race in Cyberspace* (New York: Routledge, 2000).

7 See J. Boyle, *Shamans, Software, and Spleens: Law and the Construction of the Information Society* (Cambridge, MA: Harvard University Press, 1997) and "A Politics of Intellectual Property: Environmentalism for the Net?" www.law.duke.edu/boylesite/intprop.htm (1999, accessed July 2000).

8 See S. Lansing, *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali* (Princeton: Princeton University Press, 1991); P. Manuel, *Cassette Culture: Music and Technology in North India* (Chicago: University of Chicago Press, 1993); A. Melucci, *Challenging Codes: Collective Action in the Information Age* (New York: Cambridge, 1996); and R. Eglash, J. Croissant, G. Di Chiro, and R. Fouche, *Appropriating Technology: Vernacular Science and Social Power* (Minneapolis: University of Minnesota Press, 2004).

9 See R. Jacobson, *Information Design* (Cambridge, MA: MIT Press, 1999) and E. Tufte, *Envisioning Information* (Cheshire, CT: Graphics Press, 1990).

Informating Environmentalism

"Informational strategies" for dealing with environmental risk became law in the United States in 1986 through passage of the "Community Right-to-Know Act," Title III of the Superfund Amendments and Reauthorization Act (SARA). Widely regarded as the primary U.S. legislative response to the 1984 Bhopal disaster, the act mandated a range of initiatives to support emergency planning and public access to information.[10] A key component was the Toxic Release Inventory (TRI), the first federal database Congress required released to the public in a computer-readable format.[11] The goal was to allow the EPA as well as citizens to track and evaluate routine emissions from industrial facilities.

Some researchers argue that the TRI can be correlated with improved company performance on pollution.[12] Other researchers question the "market efficiency model" in general, as well as the substance of the reported emissions—arguing that the TRI is based on "engineering estimates" that are easily manipulated to create "phantom reductions." Many at the EPA nonetheless consider the TRI one of its most successful programs. And it is clear that the TRI has been a driving force in the emergence of corporate environmentalism, and in the emergence of new, information-oriented programs within environmental organizations of all sizes.[13]

Initiatives similar to those mobilized in the United States by right-to-know legislation now are being developed around the world, as recommended in Agenda 21, the guidelines for sustainable development agreed to at the Earth Summit held in Johannesburg in August 2002. Informational strategies have become a major focus at the World Bank and within UN programs, leading to environmental information initiatives in many developing countries, including Mexico and Indonesia.[14] In Europe, the right to know is the focus of the Aarhus Convention—a UN/European Economic Commission Convention on Access to Information, Public Participation in Decision-Making, and Access to Justice in Environmental Matters. Originally signed in Aarhus, Denmark in the summer of 1998, the convention establishes legally binding instruments guiding the creation of national Pollutant Release and Transfer Registers (PRTRs) in the UN/EEC region, as recommended by Chapter 19 of Agenda 21. PRTRs are databases containing information about pollution from industrial facilities, similar to the TRI in the U.S.[15] Environmental organizations such as the WorldWatch Institute considered PRTRs to be a key goal of the Earth Summit held in Johannesburg in August 2002. WorldWatch reports that there has been serious opposition to PRTRs by manufacturers since the Earth Summit 1992, and that only twenty countries have set up PRTRs as a result. WorldWatch considers PRTRs a priority because they "pinpoint the most affected communities, and the most polluting industries, thereby identifying targets for action."[16]

10 S. Hadden, "Citizen Participation in Environmental Policy Making" in S. Jasanoff, ed., *Learning from Disaster: Risk Management After Bhopal* (Philadelphia: University of Pennsylvania Press, 1994).

11 J. Young, "Using Computers for the Environment" in L. Brown, ed., *State of the World 1994* (New York: W.W. Norton & Company, 1994).

12 J. T. Hamilton, "Pollution as News: Media and Stock Market Reactions to the Toxics Release Inventory Data," *Journal of Environmental Economics and Management* 28 (1995): 98–113.

13 See J. Fillo and C. Keyworth, "Sara Title III—A New Era of Corporate Responsibility and Accountability," *Journal of Hazardous Materials.* 31:3 (1992): 219–231; and D. Grant, "Allowing Citizen Participation in Environmental Regulation: An Empirical Analysis of the Effects of Right-to-Sue and Right-to-Know on Industry's Toxic Emissions," *Social Science Quarterly* 78:4 (1997): 859–873.

14 S. Afsah, B. Laplante, and D. Wheeler "Controlling Industrial Pollution: A New Paradigm" (World Bank, Policy Research Department, Working Paper 167, May 1996); and T. Tietenberg and D. Wheeler, "Empowering the Community: Information Strategies for Pollution Control," paper presented at the Frontiers for Environmental Economics Conference (Airlie House, Virginia: October 23–25, 1998).

15 E. Petkova with P. Veit, "Environmental Accountability Beyond the Nation-State: The Implications of the Aarhus Convention" in *Environmental Governance Notes* (Washington, DC: World Resources Institute, April 2000).

16 A. P. McGinn, "From Rio to Johannesburg: Reducing the Use of Toxic Chemicals Advances Health and Sustainable Development" in *World Summit Policy Briefs* (WorldWatch Institute: June 25, 2002, e-mail edition), 3.

Right-to-know initiatives are raising difficult questions: What information must be provided to fulfill the right to know about the environment? *How* must information be provided? Must information be accessible through the Internet? Has access been realized if information is not organized for efficient use, and not correlated with other information that reveals its significance? Is the right to know, in effect, the right-to-computer models and to interactive, Web-based maps using Geographical Information System (GIS) software?

What is information provision supposed to accomplish? Is data delivery the goal, or something more complex? Should the primary goal be access to information, or should priority be given to facilitating production of dynamic, multi-authored datasets? How can information be leveraged into effective action? Should environmental information systems be envisioned as key components of efforts to build deliberative democratic processes attuned to a high-tech, globalizing world?

These questions raise difficult practical, conceptual, and ethical issues. They are, nonetheless, regularly discussed and debated—at conferences sponsored by government agencies, at community meetings, and on e-mail "listservs" that interconnect diverse stakeholders. They also are addressed through creative information technology designs.

The Scorecard Website

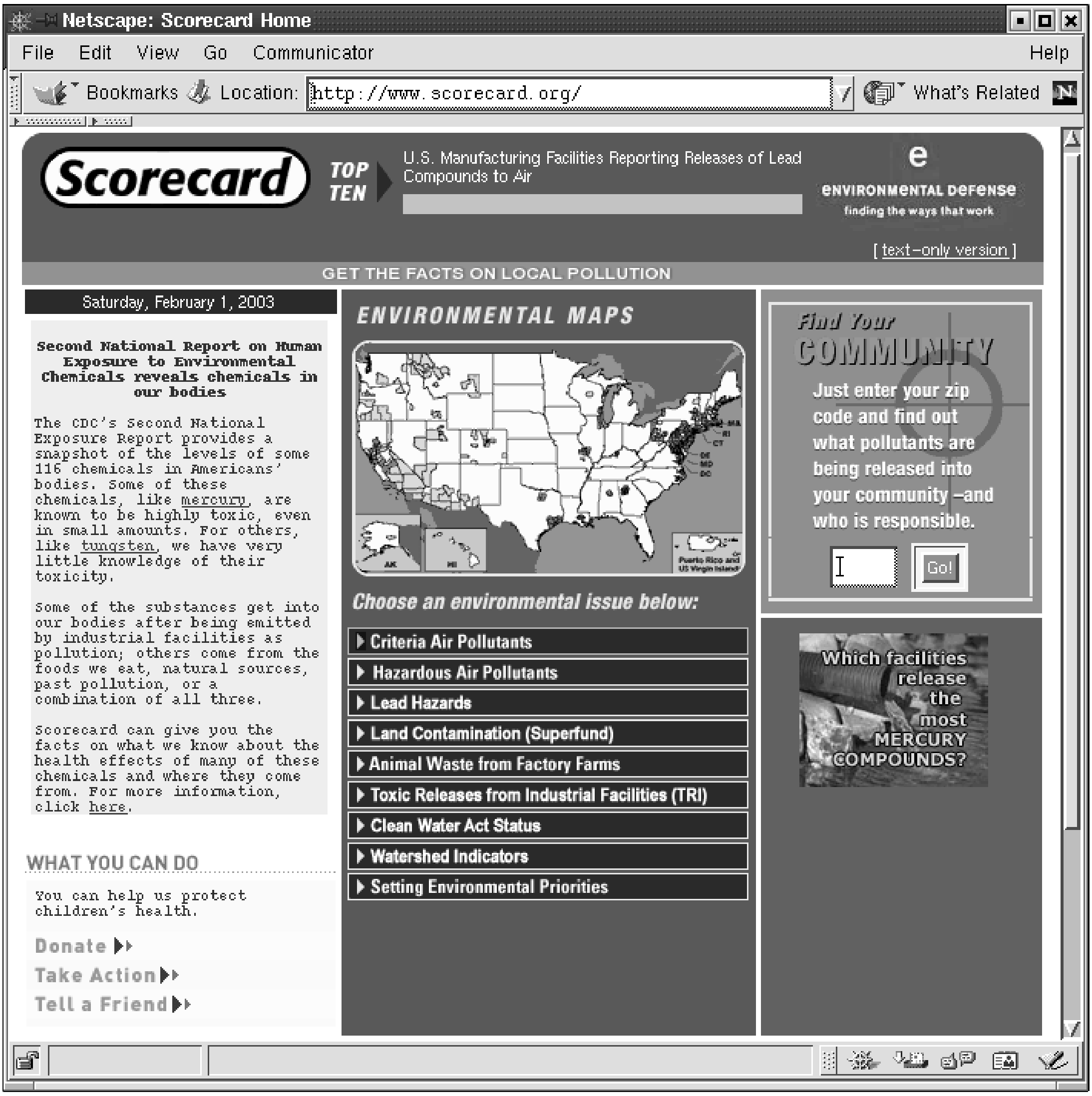
The Scorecard Website is one response to the recognition that people have a right to know about environmental problems. When the site was launched in April 1998, *Chemical Week* described it as the "Internet Bomb," because of the potential impact on the reputations of chemical companies.[17] *Oracle* Magazine featured Scorecard as an example of a well-executed and sophisticated Web application using a simple "script-based" approach.[18] Greenpeace refers to Scorecard as the "gold standard" of environmental information systems, and decided to follow EDF's lead in using the open-source arsDigital Community Systems (ACS) software for the new "Greenpeace Planet" Website, launched in June 2002. Greenpeace applauds Scorecard because it "bridges the gap between setting up passive information and creating a collaborative environment for action." [19].

The goal of Scorecard is to provide the information base for sustained effort to reduce pollution risks. Putting pressure on polluting facilities through disclosure of their emissions is a key strategy. EDF also wants it to be commonplace for people to use local environmental information when making decisions about what city or neighborhood to live in, or about what products to buy. A critical side effect will be greater recognition of the uneven distribution of pollution risk among social groups. Fred Krupps, president of EDF,

17 P. R. Fairley and A. Foster, "Scorecard Hits Home: Web Site Confirms Internet's Reach," *Chemical Week* (June 3, 1998).

18 K. Wiseth, "Next Generation Web: The Evolution of Thin," *Oracle Magazine* (November 1998). www.oracle.com/oramag/oracle/98-Nov/index.html?68cov.html (accessed June 25, 2002).

19 See "The Story Behind Greenpeace Planet" (June 24, 2002). www.greenpeace.org/features/details?features%5fid=14977 (accessed July 1, 2002).



wrote in an introductory letter posted on the Website that EDF's goal was "to make the local environment as easy to check on as the local weather." [20]

EDF, one of the "big ten" environmental organizations, with an annual budget of approximately $40 million and more than 300,000 members, is best known for its science-based lobbying to protect the environment.[21] It was launched in 1967, and played a lead role in winning a U.S. ban on the pesticide DDT. This was not a grassroots effort. In EDF's own account, it was an example of "how a handful of individuals can use science and law to bring about national reform." Today, EDF prides itself for having "more Ph.D. scientists and economists on staff than at any other such [environmental] organization," and for building teams of specialists that can investigate and devise solutions for environmental problems.[22]

Scorecard both extends this approach, and has taken EDF in new directions. Like other EDF projects, Scorecard is presented as

20 F. Krupp, "A Letter from EDF's Executive Director" (April 1999). www.scorecard.org/about/about-why.tcl (accessed July 5, 2002).

21 See Michael Stein's interview with Bill Pease, April 11, 2001 entitled "Environmental Defense: From Brochureware to Actionware" on the Benton Foundation Website. www.benton.org (accessed July 1, 2001).

22 See the EDF Website, www.environmentaldefense.org/aboutus.cfm?subnav=aboutus (accessed January 13, 2003).

authoritatively scientific. Unlike previous EDF projects, Scorecard has a local-level focus, though it also works on other scales. Scorecard is also EDF's first venture into cutting edge Web-based servers.

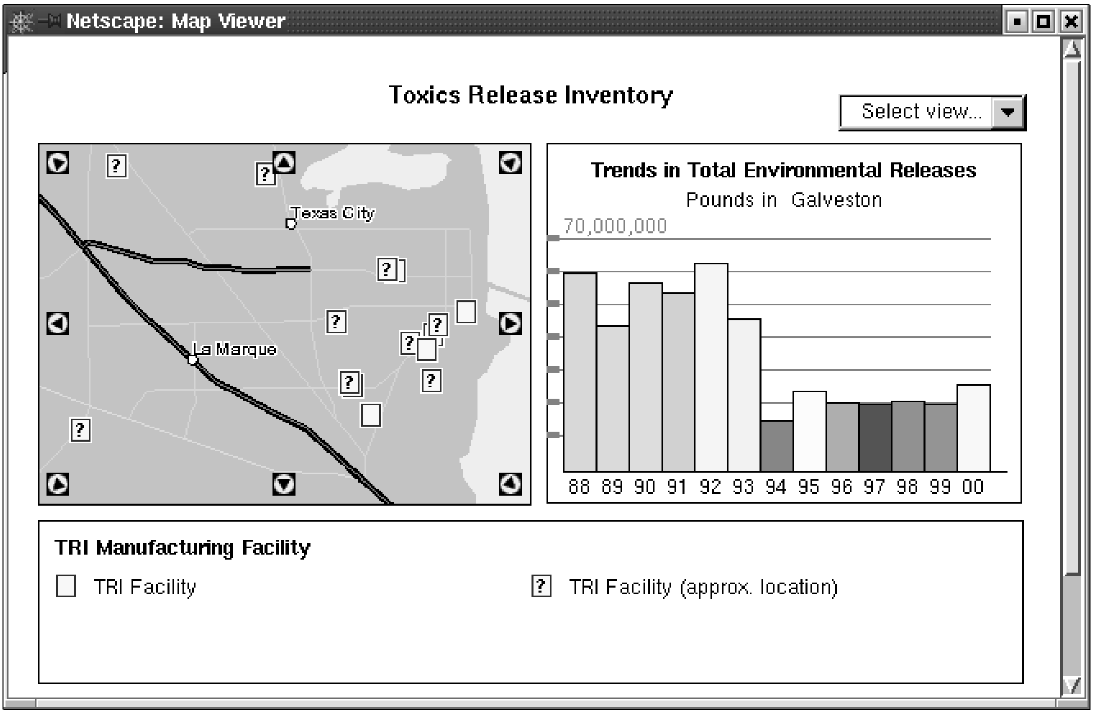
Scorecard runs on a Sun server running Solaris, Sun's proprietary version of UNIX, and is built on an Oracle 8i relational database manager and AOLserver. Original code was developed by arsDigita, and is now maintained by Get Active Software, a company run by Bill Pease and others on the original design team for Scorecard at EDF. The ACS codebase supports user administration and tracking, discussion forums, and other core functions. While the OpenACS component and AOLserver are open source, the Oracle and Solaris components are proprietary. Oracle (the second largest software company in the world after Microsoft) donated their relational database manager (an industry standard) to EDF.[23]

Scorecard's combination of (donated) proprietary and open-source software is important, as is the relationship between the nonprofit EDF and Get Active Software, a commercial firm with customers mostly in the nonprofit sector. It is because of such arrangements that Scorecard is technically, socially, and informationally sustainable. The database application created for Scorecard, for example, is able to generate Web pages dynamically, and this is critical given the complexity of the system. More than a billion pages potentially can be produced in Scorecard. If these were static files, the task of compiling them would be overwhelming, and the information on each page would quickly become stale. To deliver an up-to-date, customized page to a user, Scorecard accesses in excess of seven gigabytes of data, distilled down from more than 100 gigabytes of contributing databases.

The distillation of data by Scorecard is one of its most important functions. Scorecard pulls from more than 400 government and scientific databases containing information on chemical toxicity and toxic emissions. Information from these databases is in different units of analysis, and structured for a variety of uses. This data must be extensively massaged to be compatible with Scorecard's data model.

Scorecard also provides interpretations of environmental information. In addition to providing extraordinary integration of datasets, the site also provides rankings of health risks from pollution. The ranking system was developed by EDF and peer reviewed by *Environmental Science and Technology.* Viewers are not simply told how many pounds of toxics were released in a given year by a given facility. They also are told about probable risk—body system by body system—based on a hazard ranking system that relates all chemicals to the risk of benzene, a known carcinogen—to indicate "cancer potential"—or to toluene, a developmental toxin—to indicate "non-cancer risk." This ranking system provides users with relatively stable reference points for thinking about an otherwise confusing array of health risks. It is a purposeful simplification.

23 Stein, "Environmental Defense: From Brochureware to Actionware."



Pollution maps, the centerpieces of the Scorecard site, also provide users with familiar reference points.[24] Based on U.S. Postal Service Zip codes, these maps display the manufacturing facilities in a particular area that report their emissions to the EPA as part of the Toxic Release Inventory. The surfaces of the maps are interactive. A user selects the scale and type of information he or she wants with a click of the mouse. Pop-up charts display data associated with specific geospatial areas. The maps also allow users to compare and rank pollution situations across the United States.

Scorecard carefully notes that the maps do not cover all pollution sources, and—even for those it does cover—only accounts for the approximately 650 chemicals that are reported under the TRI. The information that is provided, however, is sufficient to provide a glimpse into pollution and health hazard realities—while also reminding users that important information gaps and uncertainties remain.

Scorecard allows users to zoom in to the local, and out to the national, clicking through graphs that provide snapshots of pollution dispersion, and through to chemical profiles that characterize pollution hazards. The experience of Scorecard can be dizzying. But Scorecard takes on some of the most recalcitrant problems within environmental politics—the need to deal with too little, as well as too much, information; the need to deal with contested scientific findings and intractable uncertainty about long-term effects; the need to think locally, as well as comparatively and globally.

24 Maps showing pollution distributions are made with ArcView (another industry standard, for Geographic Information Systems), which was donated by Environmental Systems Research Institute through their Conservation Support Program. The maps pre-produced for Scorecard with ArcView are displayed on the Website through a java-based Practical Map Server developed by EDF GIS consultant Karl Goldstein.

Appropriate Design for Contemporary Environmentalism

The design of the Scorecard site has not gone uncriticized. Some people have pointed out that Scorecard does not provide users with raw data, or with the software with which they can make their own maps—leaving them dependent on EDF's "cartographic gaze." Nor does Scorecard allow users to add their own data. Data collected through house-to-house health surveys, or through local air monitoring, cannot be integrated. The questionable quality of TRI also has been pointed out. Because TRI data is self-reported by polluting companies, and never audited, errors as well as misrepresentations are not unlikely.

The most basic criticism of Scorecard is that it is far from straightforward to use. One has to drill down through many layers to get what one wants. This takes a lot of navigational skill and patience. According to this criticism, the site provides too much information, and thus threatens to overwhelm and paralyze the user. The path to fax a polluting company or the EPA is a meandering one. Users of the Scorecard site are encouraged to wander through different kinds of information, visualizing comparisons, and noting connections between things. Users are not told final truths. Instead, users are interconnected—with different types of information, with the regulatory process, with people in both similar and different locales, with ways of visualizing and spatializing phenomena that usually are represented in abstract, impersonal terms.

The high level of information literacy required by Scorecard can be cause for criticism. It also can be argued that the way Scorecard requires and supports high levels of information literacy makes it an appropriate technology for contemporary environmentalism. Though Scorecard can be difficult to use, it nonetheless accomplishes many things. It consolidates and cross-links an extraordinary amount of environmental data. It leverages different kinds of expertise. It is adaptable to many different uses. It puts pressure on corporations to decrease legal as well as illegal toxic emissions. It makes creative, civic use of advanced technological capabilities. It cultivates advanced scientific literacy, and tolerance for both complexity and uncertainty. All of these things are important in the environmental field today.

Before Scorecard, the task of gathering data on pollution in a particular area, or related to a particular health risk was overwhelming. Bill Pease, the designer of Scorecard, learned about this in his first few months at EDF in 1995. As EDF's senior environmental health scientist, he was swamped with requests from grassroots groups needing help obtaining and interpreting information about toxics in their community. Pease needed a way to save people the time required to go from government office to government office, to the public library, and to the polluting facility in search of information that often wasn't easily available without argument or delay. He also needed to provide grassroots groups with tools for interpreting the data they collected. His solution was to build an internal database, and to hire a team of environmental scientists and database consultants. Their plan, until they consulted with MIT computer scientist Phillip Greenspun, was to build a standalone program that could be downloaded, or distributed on CD-ROM. Greenspun convinced him to go the way of the Web.

In the mid-1990s, Phillip Greenspun was concerned about the collapse of noncommercial activity on the Internet, in particular because supporting software and systems didn't scale well. One of his antidotes was to spend some of his time working with EDF developing collaboration software for their specific needs, and then offering it for free to other potential users. His goal was to "make sure that Web publishers [could] adopt the modern collaboration religion without selling their souls to the banner ad devils."[25] He also believed that information could be power, if it could be interpreted and manipulated to be relevant at the local level. Greenspun came to this belief in part through his experience with the passage of Proposition 65 in California in 1986. Unlike the federal TRI, which simply required industry to report what they emitted, Proposition 65 required industry to report both what they emitted *and* whether the substances emitted were carcinogens or reproductive toxicants. The result was that California cut emission of chemicals covered by Proposition 65 to one-quarter of previous usage, while the TRI only led industry to cut emissions by half. What Greenspun learned from this is that "disclosure plus interpretation is more powerful that disclosure alone."[26]

Providing grassroots groups with the means to both aggregate and interpret pollution data was a significant social and technical challenge. While masses of data on pollution existed, alongside masses of data on the hazards of particular chemicals, the work of correlating these data was (and still is) at a preliminary stage, even at the EPA and at public health organizations like the Center for Disease Control. Pease, Greenspun, and their design team wanted something better. Using the Internet, they could pull together 750 megabytes of data on toxic releases and on the health effects of various chemicals, in customized formats. The result provided unprecedented consolidation and cross-linkage of environmental data. This could not have been accomplished without leveraging many kinds of expertise.

Scorecard also has the potential to be a resource for people with different kinds and levels of expertise. Scorecard itself is a very complex information resource, but it was designed to be linked to a wide range of interfaces. Bill Pease talks of the possibility of building a simplified rating system that would show users a green or red light, without any words or numbers at all, using distributive plotting. He also speaks of linking Scorecard to investors and consumers. Investors would have easy access to corporate environmental records while they made daily investment decisions. Consumers could consult a PDA while they shopped to access the

25 P. Greenspun, "Better Living Through Chemistry" in *Phillip and Alex's Guide to Web Publishing* (Morgan Kaufman Publishers, 1999), 3 (online version).

26 Ibid., 4.

environmental records of Tupperware, and other consumer plastics manufacturers.[27]

Scorecard works through disclosure. The intent is to regulate conduct that affects the environment through the circulation of information rather than expressly through law. Instead of dictating what polluting industries do, it publicizes what they do. The effect is impressive, even if "command" environmental regulations remain important. Bill Pease, for example, refers to the quiet changes that corporations make to get off of "top ten" pollution lists.[28] Phillip Greenspun points to Dupont's "The Goal Is Zero" advertising campaign as an index of Scorecard's success. Such campaigns are important because they address what now are *legal* emissions. All emissions reported through the TRI, and through many other reporting structures, are legal emissions. Scorecard thus provides a way to work with corporations beyond the reach of the law, encouraging corporate greening and "voluntary compliance."

The disclosure strategy built into Scorecard can help drive changes in industrial production processes that result in less pollution. Disclosure also breeds more disclosure. Consider, for example, EDF's successful campaign to get the Chemical Manufacturers' Association (CMA) to test high-production chemicals for toxicity. In an interview, Bill Pease explained how industry had been resisting this kind of testing for decades, and how the EPA was unable to get an agreement to do the testing on a reasonable timeline. Completion of the testing was expected to take until 2110! Using Scorecard, EDF "launched a campaign to get industry to commit to faster testing—threatening companies with public disclosure that they were using chemicals that they could not prove were safe. Industry caved in, and an extensive, expedited testing program (all toxicity data within three years) was designed and agreed to by EPA, CMA, and EDF" in 1999.[29] By circulating information about environmental problems, Scorecard drives awareness of the importance of such information. It helps change a culture in which corporate pollution information is considered proprietary.

Scorecard is also helping to undermine the tendency of information technology itself to be proprietary. Because it is designed with a combination of open-source and donated, proprietary software, Scorecard is economically sustainable within the nonprofit sector. The result is a high-end, non-commercial space on the Internet. Such spaces are crucial for dealing with environmental issues today. They support broad participation in deliberations about environmental issues, and help to expand the expertise that can be called upon to make environmental decisions. Public space on the Internet also enables comparative perspective and collective action. Scorecard, for example, tells users whether pollution in their community is worse than pollution in other communities. Such information can be used to enroll elected officials, or to argue against the siting of a new industrial facility that would be a new source of pollution. Public

27 Schienke 2001, 11.

28 Stein, "Environmental Defense: From Brochureware to Actionware," 4.

29 Ibid.

space on the Internet also facilitates collaboration among people who are geographically dispersed. This is particularly important in the environmental field because of transnational environmental issues and the need for international environmental campaigns, and also because of the way power often operates at the local level. A community working to reduce pollution at an Exxon plant in their community has little leverage when working alone, especially when jobs are at stake. Joining a network of groups working to clean up Exxon makes a big difference. Expertise can be shared. What has worked in one community can be pursued in another. Mainstream media coverage becomes more likely. Exxon soon encounters a big enough public relations problem that local environmental groups begin to be heard.

The comparative perspective enabled by Scorecard is politically significant. It can help shift power among citizens, corporations, and governments. The comparative perspective enabled by Scorecard is also culturally significant. Too often, decision-making is held up by a lack of definitive proof that something is wrong. The complexity of environmental issues shuts down action. Scorecard is designed to help users skirt this problem. Comparative perspective on pollution in different communities, for example, provides a basis for remedial action even when it is difficult to demonstrate a direct correlation between pollution and adverse health effects. There is a reason to take initiative even in the absence of definitive proof. This significantly challenges conventional ways of doing and thinking about things. The scientistic culture that has made it so difficult to deal with environmental problems is undermined, and a culture that deals well with complexity begins to take shape. Scorecard supports this cultural shift through its facilitation of a particular kind of scientific literacy. Users are provided with many kinds of scientific information, with information about missing information, and with tools for drawing different kinds of information together to make judgments and decisions. The complexity of environmental problems is acknowledged by design.

Appropriate Design as Design for Society

I have argued that Scorecard is an example of appropriate technology design for contemporary environmentalism because the design of Scorecard is attuned to the particular needs that arise from the tangle of issues, organizations, scientific challenges, and political forces that constitute the environmental field today. The design of Scorecard also takes advantage of new technologies in a way that responds both to environmental concerns and to broader concerns about the ways technological change is shaping society and politics. This synchronization is impressive on many fronts. It shows what can happen through design when social and technical expertise is effectively integrated. And it shows how design can become a means to address complex social problems.

The potential role of design in solving social problems has been elaborated on by design scholar Richard Buchanan. Reporting on the way design has been conceived in relation to the new constitution of South Africa, he stresses how design is "an essential instrument for implementing and embodying the principles of the Constitution in the everyday lives of all men, women, and children. Design is not merely an adornment of cultural life, but one of the practical disciplines of responsible action for bringing the high values of a country or a culture into concrete reality, allowing us to transform abstract ideas into specific, manageable form."[30] Buchanan emphasizes how design should aim to accomplish first principles—regarding human rights and dignity, for example—as well as practical ends. He does not discount the need for technical problem solving and cost-reasonableness. He does insist that the purpose of design is more complex.

Scorecard is built around a conception of the user as a citizen, and around a conception of democracy that requires ongoing participation by citizens, even in matters that are extremely complex, both scientifically and politically. Scorecard is effective because it is designed to respond to *particular* challenges faced by citizens and democracies in a historical period marked by massive pollution, scientific uncertainty about the health effects of pollution, and domination of political decision making by corporations. These characteristics of the contemporary period cannot be disentangled. It is their combination, or what toxicologists call "cumulative effect," that is so powerful. Scorecard addresses this cumulative effect by design. Scorecard is *appropriate* for the context in which it works, and thus is able to serve high ideals in concrete, practical ways.[31]

30 See R. Buchanan, "Human Dignity and Human Rights: Thoughts on the Principles of Human-Centered Design," *Design Issues* 17:3 (Summer 2001): 35–39.

31 Thanks to Erich Schienke, Alex Sokoloff, Ned Woodhouse, Jason Patton, and Dean Nieusma for help with both conceptual and technical aspects of this paper.

The Challenge of Responsible Design

Jesse S. Tatum

"Design," conceived broadly as the process of joining the possible and the desirable, poses a singular challenge to the individual, to society, and to political institutions. As a creative process once the strict preserve of superhuman (mythical or divine) beings, design in Western practice today descends, at times, if not to the basest level of pecuniary interest, then at least to previously unplumbed depths of a seemingly unselfconscious hubris. "Why not change the world?" asks the new (surely well-intentioned) advertising motto of my own elite engineering university, without any of the reticence that might be expected to flow from the fact that "the world" does not necessarily "belong" to those students or faculty openly, audaciously, and it may appear unilaterally engaged in changing it. From a time in which the mere investigation of the workings, say, of the human body was a forbidden blasphemy, we seem to have arrived at a stage at which change and the redesign (re-"creation") not only of the conditions of life, but of life itself, may be taken without further qualification as the very definition of improvement.[1]

The cat is, however, definitely out of the bag. Given the state of knowledge in the modern world, a measure of design is inevitable, if only in the sense of choosing "by design" *not* to develop or adopt certain technological instantiations of that knowledge. At a certain level, given what we know, we cannot help but be designers, if not actively then by default. And again the design task we have taken upon ourselves poses a profound challenge both to individual and collective wisdom, and to the political traditions and institutions to which we are constitutionally committed in all matters of public choice.

The question I will pursue here is: "Can the insights central to the contemporary study of science, technology, and society make us more *responsible* designers?" The process of joining the possible with the desirable already calls on the full range of human knowledge from science and engineering to human and social studies. What, after all, is possible? What is desirable? But as makers or remakers of the world—as designers—can the insights of a relatively new interdisciplinary pursuit, the study of science, technology, and society (STS), make us "better" designers? Can those insights, for example, enhance accountability or contribute to a more forthright handling of material reality?

1 Cf. L. Marx, "Does Improved Technology Mean Progress?" *Technology Review* (January, 1987): 33–41, 71.

My particular stimulus in pursuing this question is a new design program drawing resources from architecture, engineering, and STS at my home institution, Rensselaer Polytechnic Institute, in Troy, New York. Named in a way that helps to draw different interests together, the "Product Design and Innovation" program consists of a double major between mechanical engineering, engineering science, or building science (architecture school) and science and technology studies, bridged by design studios in all eight semesters of a student's four-year undergraduate curriculum. These studios loosely follow an architecture model, with flavoring from engineering design studios, as they move progressively from more narrowly focused or constrained design exercises to full-form design work in all of its human and material complexity.

In a transdisciplinary setting of this sort, the question becomes, "What messages do STS scholars have for designers?" What insights would such scholars consider essential to responsible design that might, at present, be under appreciated or missing from the curriculum of classical engineering and other design programs? Experience teaching in Rensselaer's new Product Design and Innovation program leads me to suggest critical lessons in at least seven areas that will be the focus of this article:

> **Underdetermination**—Underdetermined by natural facts, technology and science itself inevitably arise from some process of choice.
> **Realm of Possibility**—The realm of technological and socio-cultural possibility is overwhelmingly large in comparison with traditional conceptions of the domain of choice.
> **Consequentiality**—The consequences of technological choices within the realm of the possible are profound in the lives of ordinary people.
> **Political Construction**—The shaping (design) of a technological world is a quintessentially political process.
> **Competing Images**—Designers need to have experienced the pull of competing, equally appealing, images of reality.
> **Ultimate Ends**—Democratic choice in design necessitates open and direct consideration of ultimate ends.
> **Embrace of Patterns**—Every design represents a selective embrace of one pattern at the relative expense of others.

After elaborating on each of these, I will return to the (eminently contestable) notion that a vigorous grasp of all seven is essential for "responsible" design.

Underdetermination

One of the defining insights in STS is the notion that science is "underdetermined" by natural facts, and that technology, in turn, is underdetermined by science.[2] The science we have, and the technology we have both are always and inevitably a function not simply of "reality," but of where our attention happens to be focused. MIT's David Rose once came very close to the point in simple English:

> We see what we focus on, and can hear a bird's song above the city noise. The mother, oblivious to danger, rescues her child from the burning house; the soldier rushes to meet the enemy, the martyr to meet his god. Love is blind and memory selective, fortunately.
>
> [Simple survival] requires both selective attention and inattention, or we would choke in a froth of detail. [3]

Stated in this way, underdetermination seems an unexceptional, even painfully obvious, truism. Carried to its logical conclusion with respect to science and to technology choice, it is more controversial, perhaps threatening our sense of order and control—even that deep sense of security in the knowability of the world that we find psychologically essential as we get out of bed each morning.

In practice, we routinely dismiss those points of transition in our knowledge of the world that otherwise stand as glaring evidence of underdetermination. We embrace the modern "reality" of "ecology," for example, and forget the earlier "reality" of individual pests pursued by crusading organic chemists. The way the world works has not changed; we choose now to attend to certain mechanisms (e.g., secondary effects of DDT use as a pesticide) which, before Rachel Carson's crusading efforts, had simply remained beyond our attention. Each image, "ecological" and "chemical," is, by its own standard, equally "true," neither is dictated or determined by reality alone. Similarly, we now embrace (in theory if not in ordinary practice) a world in which the dimensions and mass of an object are no longer invariant, but "relative" to an observer's frame of reference (special relativity), even though this may seem to fly in the face of all of our direct experience with the world. The world has not shifted gears; rather, it is a change in the focus of our interests that has contributed to a new image of that world. Yet again, we add acupuncture to our tool kit as a practice that, we find, qualifies under our pragmatic standards of scientific "truth," even though we have as yet no science that explains how it may work.

We do all of this more with a sense that we are closing in on truth, than that we are only successively asking different sets of questions, adopting different notions of "relevant" data, and agreeing to work together from what we take to be updated representations of reality. In daily practice, we dismiss the notion that the particular "science" we embrace at any particular time is underdetermined by

2 See, for example, T. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press [rev. 2nd ed., 1970]); B. Latour, *Science in Action* (Cambridge, MA: Harvard University Press, 1987); and W. Bijker, T. Hughes, and T. Pinch, eds., *The Social Construction of Technological Systems* (Cambridge, MA: MIT Press, 1987).

3 D. Rose, "Continuity and Change: Thinking in New Ways about Large and Persistent Problems," *Technology Review* (February/March, 1981): 54.

reality: that more than one science, more than one set of questions, more than one notion of "most relevant" data, and more than one set of truth tests applied to theory (e.g., ecological vs. chemical/pest)—in short, more than one reasonable pattern of "selective attention"—appears always to be possible.

Similarly, with respect to technology, especially in a design context, we tend to proceed along singular developmental paths as if only one technology were possible. We ask: "What is the most efficient?" or "What is the most cost effective?" and imagine that such a narrow technical analysis can guide us to the best answers. Assuredly, in this process, we may compare six different alternatives for digital data storage and retrieval; but we proceed as though the task itself had been set for us in the nature of the world, rather than selected as a product of our own focus of attention. (Why, digital data at all, as opposed to some other channel of development? Does "reality" propel the home computer as sustainable solar electricity, for example, languishes in the wings?)

Again, there is an apparent orderliness and a sense of control in this blinding practice. But again careful attention suggests that technology, like science, is more accurately, "underdetermined" as well. STS scholars have now certainly set out a convincing case to this effect.[4] Popular understanding of the supposedly logical and apolitical advance of technology also have been thoroughly debunked as historians and anthropologists have, for example, vividly exposed modern economic theory and practice as an artifact of culture comparable to the pottery shards of an archeological dig.[5]

A great many technologies undeniably "work," as amply demonstrated by the range of technological practice at play in the world even today. Within a single (Western) scientific tradition, to cite just one perhaps extreme example, one may choose to embrace either "modern" agriculture or the practices of the Amish. One can purchase power from the utility grid, or produce it from one's own photovoltaic, micro-hydro, or small wind generator.[6] Science alone does not begin to dictate modern or Amish agriculture, fossil/nuclear or renewable energy technology solutions.

Underdetermination creates an opening for design that is, at best, a little unsettling and, at worst, threatening, even positively frightening. Its take on the world is less declaratory than perpetually interrogatory. Life, knowledge (science), and practice (technology) become matters of continuing interaction with a world that is far more than mere resource, mere matter to be molded at will.[7] The world becomes a subtly but profoundly variable partner, ultimately unknowable and infinitely fascinating and important in its own right. Where designers answer the question, "What is the world like?" with underdetermination, technology becomes a realm not of singular solutions to specific challenges, but of almost infinitely variable choice. An underdetermined knowledge of the world and an

4 For some groundbreaking classical examples, see D. Noble, *Forces of Production* (New York: Knopf, 1984); or W. Bijker, T. Hughes, and T. Pinch, eds., *The Social Construction of Technological Systems.*

5 See especially M.I. Finley, *The Ancient Economy* (Berkeley: University of California Press, 1973) and M. Sahlins, *Stone Age Economics* (New York: Aldine Publishing Company, 1972).

6 J. Tatum, "Technology and Values: Getting Beyond the 'Device Paradigm' Impasse," *Science, Technology, & Human Values* 19:1 (1994): 70–87.

7 In the contrasting view of Martin Heidegger, it is a characteristic of modern, technologically enframed world views to think of the world as mere resource. M. Heidegger, *The Question Concerning Technology and Other Essays,* William Lovitt, trans.(New York: Harper and Row, 1977).

underdetermined technology open design to a mind-boggling realm of possibilities far beyond any ordinary conception. And the design problem becomes one of choice and political legitimacy.

The Realm of Possibility

Any given state of knowledge, of course, has some constraining effect on practice, just as reality in some (ultimately indeterminable) way constrains knowledge.[8] The practices of acupuncture would have been far less likely to emerge from Western knowledge than a drug for treating back pain, for example. Within any given state of knowledge, any particular "science," however, the realm of technical and socio-cultural possibility still remains almost infinitely vast.

Ordinarily, we allow ourselves to be tightly constrained by what some policy analysts have termed the range of "political feasibility."[9] No plan for entirely avoiding the prospect of further contributions to global warming is seriously entertained, for example, not because the implied shifts away from fossil fuel consumption would, in fact, be technically unachievable (even under the present state of knowledge), but because the changes in present patterns of life that would seem to be implied are regarded as *politically* infeasible. Systematic moves away from our present reliance on the automobile also fail to come up for consideration not because automobiles are, in fact, essential to our present way of life, but because, in a world that has in large measure been designed around the auto, they *appear* to be essential, and alternatives are regarded as *politically* infeasible. (Well-established interest groups—e.g., auto manufacturers and oil companies—obviously play a significant supporting role in the practical politics of delineating the boundaries of "political feasibility.")

Possibilities for the design of single artifacts are much more open than we ordinarily imagine. A refrigerator designed for use in a traditional setting may, for example, be radically different from one designed for use in a home with its own independent renewable electric power supplies. Variability in electric power availability in the latter case, along with concerns about electricity storage and the higher cost of power from photovoltaic and other renewable sources, may suggest thicker insulation, separate compressors for refrigerator and freezer compartments—even a "built-in" configuration sharing insulation with the building's exterior walls, and moving the condenser (heat-dissipating coils of the refrigerator) outdoors to reduce energy use in winter months when less solar energy is available. The design of machinery to slaughter and prepare chickens for market is likely to be radically different in the small-farm context of "community supported agriculture" than it is in the mass production plants more common today. And the design of a vehicle for local grocery shopping by low-income single parents may not resemble the highway-capable "car" that now is almost the only option available.

8 I part company, here, with the strictest of the "strict constructionists" if, in the final analysis, there are any in the STS community.

9 W. Rosenbaum, *Environmental Politics and Policy,* Second Edition (Washington, DC: CQ Press, 1991).

When we move from single artifacts to whole technological systems,[10] the possibilities multiply rapidly. If we reconsider not only the refrigerator, but the whole of home energy use and the full range of electricity supply systems, homes employing recently developed LED light sources, horizontal-axis clothes washing machines, solar-heated dryers, and other appliances vastly reducing electricity use (along with our redesigned refrigerator) may tap independent renewable electricity supplies in ways that begin to compete in absolute cost terms with present, energy inefficient appliances and conventional electricity supply systems—especially if the reduced usage in independent homes also escapes monthly utility service and billing charges.[11] Tax and land use policies, and a range of technology development efforts favoring local community supported agriculture, could lead to substantial shifts in demographic patterns and food and agricultural practice. (Would we see a reduced emphasis on things such as Monsanto's genetically altered crops and an expansion in organic agriculture?) And the design of short-range, low-performance vehicles for the local shopping and other travel needs of low-income people might be combined at a systems level with efforts to overlay a complete grid of low-speed streets on the present, commuter-oriented, high-speed-dependent road system.

The realm of engineering or technical possibility (what we *could* do, given what we know of material nature) is vastly more expansive than the range of what we ordinarily consider to be within the limits of political possibility. If we add to this a layer of sociocultural possibility, considering the full range of human experience and of what may be considered desirable, or even just the range of what remains observable in the world today between East and West, and North and South, the realm of possibility becomes almost infinitely large. Even modest organizational departures from present corporate and capitalist models, such as those implicit in the decentralized volunteer home building successes of Habitat for Humanity, for example, greatly expand our sense of the realm of the possible. The task of design, in turn, becomes a far greater and far more engaging challenge. What design criteria should we apply? Who should participate in the design process? And how should choices be made among the countless possibilities available to us?

Consequentiality

Designers also need a grasp of the profound "consequentiality" of their work. Not only are the possibilities almost limitless, the choices we make among those possibilities carry profound and far-reaching implications for how we will live.

As perhaps best explained in Langdon Winner's book, *The Whale and the Reactor,*[12] technology has profound significance beyond its immediate purpose, expressing and shaping who we are and how we relate to each other and to the natural world.

10 Bijker, et al., *The Social Construction of Technological Systems;* and T. Hughes, *Networks of Power* (Baltimore, MD: Johns Hopkins University Press, 1983).

11 So-called "home power" alternatives along the lines outlined here actually have been widely pursued in the United States and now afford a well-developed range of new technological alternatives. See J. Tatum, "Technology and Values: Getting Beyond the 'Device Paradigm' Impasse."

12 L. Winner, *The Whale and the Reactor* (Chicago: University of Chicago Press, 1986).

> In an important sense, we become the beings who work on assembly lines, who talk on telephones, who do our figuring on pocket calculators, who eat processed foods, who clean our homes with powerful chemicals.[13]

Particular technology choices, in a sense, define particular "forms of life." [14] They take on, at times, a law-like character, shaping, for example, the exercise of civic freedoms (as computerized surveillance systems may in our own future), or who can participate in public life (as stairs and other barriers to the handicapped once did). From a political standpoint, technology choice over time may effectively rewrite constitutional provisions governing "membership, power, authority, order, freedom, and justice." [15] "Citizens" may, for example, be displaced by "experts" in certain matters of choice taken to require special expertise. Ostensibly "democratic" political order may be displaced by a "technological" order as what are taken to be advances in technology gain precedence over the unexplored or even dogmatically suppressed preferences of an ordinary population.

Consequentiality may inhere in what would seem the most innocuous and marginal of designs. The radio-controlled garage door opener, for example, at first may seem an obvious and inevitable device for easing an equally obvious manual burden. But think back to the design of homes and garages of half a century or more ago. Garages often were set back from the road, and at some distance from a house. Doors often would be left open, and neighbors could readily see whether or not anyone was at home by whether or not the car was in the garage. Neighbors might well meet or exchange words in the course of a journey between house and garage, or while they were out of their cars to open or close the doors. Homes, moreover, had highly functional front and back doors that were used regularly for entry and exit. Today, by contrast, the garage may be the most prominent feature at the front of the house, and has become the primary means of entry and egress. Doors are systematically closed whether a car is inside or not. And residents are rarely encountered outdoors because they move directly between the interior of the house and the interior of the car. While radio-controlled door openers are not alone in bringing about these changes, they undoubtedly have been a significant, recent contributor. As facilitators of the suburban commuter's pattern of life, moreover, they further underwrite, in their own small way, the patterns of automobile use, pollution, work, play, and even child rearing that are characteristic of this pattern of life, while (at least in relative terms) disadvantaging potentially competing patterns that might have been facilitated by different technological innovations.

There is, perhaps, no more powerful mechanism in our grasp for shaping the choice of a way of life than the accumulated increments of design (technology) that progressively and selectively underwrite certain patterns at the relative expense of others. Within

13 Ibid., 12.

14 Ibid., 3–18.

15 Ibid., 47.

the vast realm of technological and socio-cultural possibilities, designers, even designers of seemingly innocuous devices such as garage door openers, need a vivid appreciation for the reach of their work in its consequences in ordinary lives.

Political Construction

Within the realm of material possibility, there are many forces that routinely operate in the political construction of technology. These shaping forces range from the grand scale of history and culture, to the more immediate effects of who happens to be present or represented in a particular design setting.

Although we are not generally aware of it, the world we live in is one in which technological innovation is an institutionalized fact.[16] Our economic system, our patent practices—our very frame of reference as we are constantly challenged by technology to get things under control as resources[17]—all are geared for technological advance. While we speak routinely of "technological revolution," the genuine revolution in our world would be to stand against technological change. The burden of proof lies very much with those who would prevent or impede the latest invention, from new chemical, or genetically engineered organism, to artificial intelligence or newly automated production process. And very few arguments beyond immediate physical peril to specific individuals are politically admissible as legitimate objections.[18]

The leading edge of change, moreover, often appears to be a function of the location of the latest "frontiers."[19] Frontier sectors have ranged from the untapped forests of the New World, to biotechnology and the Internet, and are typified by the apparent limitlessness of their resources and by the incomplete nature of their mechanisms for regulation and accountability for (externalized) costs. These are the zones in which there is, relatively speaking, "a killing" to be made. And as such, they attract disproportionate investment and a gold rush of entrepreneurial zeal. A privileged vanguard—politically privileged because it is technologically "at the cutting edge"—brings us everything from railroads and systems of industrial production, to the latest in information technology, though each may leave much waste and destruction in its path.

The momentum that is characteristic of large technological systems[20] also profoundly affects the course of technology development in ways that can seem, in the short run, to confound ordinary distributions of political power. Public transit alternatives might seem to serve the best interests of the vast majority of the population in this country, but arguably continue to languish in the face of the colossal momentum of highway funding and giant oil and auto manufacturing interests. New commitments to nuclear power production might seem to have been clearly undesirable long before the momentum of federal support and electric utility investment

16 D. Mowery and N. Rosenberg, "The Institutionalization of Innovation, 1900–1990" in *Paths of Innovation: Technological Change in 20th-Century America* (Cambridge: Cambridge University Press, 1998).

17 D. Strong, "The Technological Subversion of Environmental Ethics" in *Research in Philosophy and Technology: Technology and the Environment* 12 (1992): 33–66.

18 L. Winner, *The Whale and the Reactor,* 50–51; and J. Tatum, "Technology and Liberty: Enriching the Conversation," *Technology In Society* 18:1 (1996): 41–59.

19 T. Princen, "The Shading and Distancing of Commerce: When Internalization Is Not Enough," *Ecological Economics* 20 (1997): 235–253.

20 Bijker, et al., *The Social Construction of Technological Systems*, 76–80.

could be brought to rest in a moratorium on new construction. And two-income families continue to be caught up in unrelenting work patterns that seem at times to bar parents from raising their own children, even when those parents may be profoundly disturbed by this outcome and appear to be among the nation's most privileged and influential leaders in shaping our patterns of life.

At a more immediate level, everything from the present design of the bicycle[21] and delays in the implementation of fluorescent lighting systems[22] to the development of numerically controlled machines[23] can be described in terms of the politics of design. How was the design effort initiated and who was involved in defining the problem to which it responds? How were alternative designs generated and by whom? What alternatives were and were not considered? How were the selection criteria generated, and by whom? In short, what interests, what conceptions of the world are and are not reflected in any particular outcome?[24]

In all of these respects, design can be seen as a process of political construction of technology. At each level, choices are implied. Do we recognize and set aside, or simply accept and accommodate, traditional cultural biases in favor of new inventions? Do we allow the latest frontiers to capture our design agendas or do we choose by law or other means to deflect this "gold rush" influence? Do we acquiesce in, or choose to counter, the momentum of technological systems? Do we accept the patterns of participation and representation characteristic of particular design efforts, or do we work to change them? The choices we make in shaping and responding to the politics of the design process will, in turn, profoundly affect technological outcomes and hence the way not only designers but the population at large may live.

Competing Images of the World

In the final analysis, there may be no substitute in the education of a designer for vigorous and direct experience with alternative ways of seeing the world. The human significance of underdetermination and of political construction cannot be fully appreciated until the designer him or herself experiences the dilemma of competing, equally valid and appealing "takes on the world."

At an intellectual level, one can undeniably tap elements of history, philosophy, anthropology, and other disciplines to gain some notion of different perspectives on the world. Because students often can dismiss these as "outdated," "irrelevant," or "unrealistic," however, more vigorous and direct experience in the form of direct ethnographic exposures may be required. And here I do not mean the kinds of instrumental application of ethnographic techniques to narrowly defined design problems that now is popular in many design programs,[25] useful as these also may be for particular purposes. What is required is experience that leaves students with *genuinely divided allegiances*—i.e., with a sense that two

21 Ibid., 28–40.

22 W. Bijker, "The Social Construction of Fluorescent Lighting, or How an Artifact Was Invented in Its Diffusion" in W. Bijker and J. Law, eds., *Shaping Technology/Building Society* (Cambridge, MA: The MIT Press, 1992), 75–104.

23 D. Noble, *Forces of Production.*

24 One of the critical concerns in the STS community is the degree to which the politics of design remain genuinely democratic. See, for example, R. Sclove, *Technology and Democracy* (New York: Guilford Press, 1995). At perhaps the most obvious level, there may be room for concern that market forces allow each dollar one vote in the shaping of technology, and that this distribution of power is at variance with democracy's principle of one citizen one vote.

25 J. Cagan and C. Vogel, "Clarifying the Fuzzy Front End of New Product Development: Teaching Engineering and Industrial Design Students Ethnographic Methods to Foster Interdisciplinary Inquiry into Consumer Needs," *Proceedings of DETC 99, 1999 ASME Design Engineering Technical Conferences* (September 12–15, 1999).

or more incommensurable ways of seeing the world have genuine and roughly equal validity and appeal. Experience in a public service internship setting (e.g., working in a homeless shelter) or with "other directed" design projects (e.g., design in support of nascent patterns such as community supported agriculture) may be among the most easily accessible academic mechanisms for gaining the kinds of perspective required here.

As a concise, if otherwise somewhat artificial, illustration of the sort of competing images of the world I have in mind, consider the experience of a serious automobile accident. The sense of order and control one has before ever having an accident draws a sharp contrast with the altered sense of things one has during and immediately after an accident. In the first instance—call it the "selected trajectory" perception—one is entirely comfortable in the heated and air- conditioned, thermally and acoustically insulated cocoon of the automobile. And one has a strong sense of order (cars pass on the right) and the ease of precise control. ("I can go where I want to go.") But during and after the accident—call this the "billiard ball" perception—one may have a brutalized sense of profound disorder (those closest to us may be abruptly and inexplicably injured or killed) and a sense of being entirely out of control in every significant sense—feeling, in fact, like nothing more than a billiard ball propelled by unchosen forces into unintended trajectories from which highly destructive (mortally threatening) collisions, even as we see them coming, cannot be avoided. It may take some time to recover enough of the selected trajectory perception after a major accident simply to function as a driver again. And, while it may superficially seem easy to communicate across the divide between these two perceptions—all of the names are the same: car, street, curb, pedestrian—there is no question but that two radically different apprehensions of the world are involved, nor can one imagine that those who have never experienced a major accident might genuinely appreciate that perception. The two experiences, normal driving and a major accident, offer two seemingly complete but incommensurable perceptions of the same reality, neither one of which is in any meaningful sense accessible from the other. Each is, in some sense, fully accurate and equally commanding in its description of the world.

What is required for the designer is a vigorous awareness that the way the world is put together for them—i.e., their *reality*—is by no means objective or unvaryingly shared among sane and rational people. Much of disciplinary education, certainly in engineering fields, runs contrary to this message, instead reinforcing singular images of reality, and bounding out competing images offered even by other disciplinary perspectives on a single university campus. If design is to be politically responsive (democratic?)—if indeed it is not to be blind-sided by the ascendancy of alternative views—it must proceed from a firm awareness of the ordinary existence of competing views. Such an awareness can, I believe, only flow from direct encounters that force students beyond their own habitual perceptions and into the experience of divided allegiances to competing takes on the world.

Ultimate Ends[26]

If technological advance is not to proceed simply by its own internal logic,[27] and if, moreover, it is to proceed *democratically*[28] where this may imply departures from a free-market governance, some attention to ultimate ends will be necessary. What ends are to be served by design? What priorities should be assigned to those ends? Are there important ends to be pursued as a part of the process itself, in the mechanisms employed in arriving at a working agreement on ends, and in the design process itself?

Design students typically spend a great deal of time developing and honing technical skills in the areas of engineering, architecture, or industrial design. Increasingly, they also gain experience in design groups that attempt to integrate technical, manufacturing, marketing, and other elements of design, and intended to prepare students for design practice as it actually occurs in the working world. Little or no time may be spent, however, in a direct and open consideration of the ends that are to be served by design. Perhaps this is because no final agreement can be expected on ends, and because no simple analytical practice can be universally accepted as a means for arriving at such ends. Ultimate ends are matters of politics and of individual choice.

Yet these should not be accepted as excuses for allowing ultimate ends to remain unexamined—everywhere implicit in design, but nowhere explicitly identified, analyzed, or discussed. Every design serves certain interests, certain objectives, to the relative disadvantage of other real or possible interests and objectives. Ignoring this fact is no less a moral or value-based position than attending to the matter explicitly.

This is not to say that students should be "instructed" as to "correct" ends and priorities—only that they should be required to attend to the ends and objectives inherent in every design, and to develop and carefully examine both their own sense of desirable directions and their commitments to processes for arriving at social and political definitions of desirable directions and objectives for society. In what sense is it appropriate, for example, for engineers to design *for* society? And to what degree, by contrast, is direct public participation in design, for all its "messiness," simply essential?

The issue of ultimate ends can easily begin to be explored by considering a range of possible ends with contemporary popular appeal. Environmental sustainability, enhanced community, and satisfying work would be obvious candidates for discussion, beginning with careful consideration of what each might entail, and ending with analysis of how one or another particular design might serve or undermine each of these goals. What, for example, does

26 I borrow this term from Herman Daly's excellent essay distinguishing "economic" from "ultimate" ends. H. Daly, "Introduction to the Steady-State Economy" in H. Daly, ed., *Economics, Ecology, Ethics* (San Francisco: W.H. Freeman and Company, 1980).

27 Much of the early STS literature has been critically concerned with precisely this tendency to allow technology to proceed by its own internal logic, and with a call for more active direction and participation on the part of the public. See especially J. Ellul, *The Technological Society* (New York: Random House, 1964); L. Mumford, *The Myth of the Machine: Vol. 1. Technics and Human Development* (New York, Harcourt Brace Jovanovich, 1967); and L. Mumford, *The Myth of the Machine: Vol. 2. The Pentagon of Power* (New York: Harcourt, Brace, Jovanovich, 1970). I think that Langdon Winner's notion of "technological somnambulance," whereby we allow ourselves to "sleepwalk" through the reshaping of our own lives through technology, is the best metaphor for contemporary practice. L. Winner, *The Whale and the Reactor.*

28 I use this term primarily in the sense developed by Benjamin Barber in his book *Strong Democracy* (Berkeley: University of California Press, 1984). Critical elements of this notion of democracy include the openness of political exchange implied by "political talk," the reliance on "politics as epistemology" (rather than on institutionalized "science" or "religion" as authoritative), and the importance of public seeing and public doing. See also J. Tatum, *Muted Voices: The Recovery of Democracy in the Shaping of Technology* (Bethlehem, PA: Lehigh University Press, 2000).

"community" mean? What aspect of community do people miss and wish to see enhanced? What aspects of community might people, in fact, wish to rid themselves of even today? And how might the desirable aspects of community be enhanced by technology or by the pursuit of specific design features in a given technology?[29]

One also could begin such discussions at the other end of the abstract-concrete continuum: e.g., what "ultimate end" is, or is not, served by a particular design proposal? In what precise respect could a new digital technology, a new traffic plan, or other proposal be regarded as "progress" over what came before?

The issues are undeniably subtle. Is it appropriate, for example, to take market behavior as the definitive word on what is desirable—i.e., if people buy it, they must want it? To what degree should designers consider the possibility that what is available on the market strongly shapes consumer behavior? Do consumers, in fact, know their own interests? And are designers not inevitably acting from judgments regarding the best interests and ultimate ends of society, whether they take market data, opinion polls, or their own instincts as guides? Under these circumstances, how are they best to proceed?[30]

Some of what can only be described as resistance to explicit consideration of ultimate ends may stem from a sense that this is a politically liberal move and a kind of advocacy for the relatively powerless. Simply by pointing out the ends served in routine design thought and practice, there may be some tendency to recognize the degree to which that practice is necessarily more responsive to better established and more powerful interests. Design always must have a patron. And those who are best able to pay for it necessarily will have their perceptions and interests more actively represented. Any explicit examination of the ends inherent in design poses a kind of challenge to the status quo: simply making existing conditions explicit raises the possibility for questions that otherwise could not be asked.

Pretending that issues of this sort do not exist, however, runs contrary to founding principles of open exchange and of universities as (tax-exempt) institutions affected with the public interest.[31] In surprising ways, moreover, the momentum of technological systems may now lead to design that does not, in fact, best serve the interests even of the more powerful segments of society. One may ask, for example, whether the availability of cellular phones really makes up for the time social elites must now spend in commuter traffic. One may ask whether the desires of two-income families are actually served or only symbolically pacified by the image of constraints overcome through the ownership of a "sport utility vehicle." The simple momentum of the automobile and of modern work patterns, in these cases, may in fact at times subvert the interests of the most powerful segments of society. In such instances, a design education that confronts the ends of design uncompromisingly may prove to be

29 Aristotle's notion of "community" turns out to be surprisingly topical and makes one possible starting point for discussion of community as an ultimate end. See B. Yack, *The Problems of a Political Animal* (Berkeley: University of California Press, 1993).

30 For an insightful placement of these issues in a context of the history of design, see Nigel Whiteley's book, *Design For Society* (London: Reaktion Books, 1993). For a discussion of "real interests" in a context of the theory of political power, see S. Lukes, *Power: A Radical View* (London: The MacMillan Press, Ltd., 1974).

31 Cf. E. Press and J. Washburn, "The Kept University," *The Atlantic Monthly* (March 2000): 39–54.

as politically conservative as it is liberal. And students in programs such as RPI's Product Design and Innovation program may hope for classical financial rewards by uprooting as much as by endorsing or furthering established patterns in their design work.

Advancing Patterns

In the final analysis, the effect of design is to highlight, underwrite, enhance, or advance certain patterns over others. The automatic garage door opener discussed earlier facilitates the commuter patterns of suburban professionals and "soccer moms." Cellular phones and the Internet facilitate certain kinds of "connectivity." Nuclear and other modern energy supply systems facilitate relationships with the natural environment entirely different from the more restrained connections inherent in the construction and use, for example, of the Erie Canal.[32]

As certain patterns are enhanced through design (not always precisely according to intent), others are, in relative if not absolute terms, undermined. (Here again, not necessarily strictly according to intent.) The relationships of neighborhood before the garage door opener may be altered by its introduction and use. Face-to-face and voice (telephone) contact to some degree may be displaced by the Internet. And a sense of working as a junior partner to natural phenomena (before the Erie Canal) may be displaced by a sense that natural systems are almost entirely subject to human control and management.

If we embrace an STS image of the world; if we accept the underdetermination of science and technology, the vastness of the range of technical and socio-cultural possibilities, and the consequentiality of technology; and if we accept the political construction of technology, the existence of competing images of reality, and the discursive significance of ultimate ends; then designers play a role of profound significance in the world. They make, or participate in the making of, the choices that shape the patterns by which we live.

Responsible Design

I believe that the task of educators (and more broadly of adults with respect to younger people) is to point toward what we conscientiously take to be significant aspects of reality in order to save those we teach the pains of relearning lessons already encountered in human experience, and in order to give them a leg up on the world as they go out to meet it. They will, of course, both as individuals and in each new generation, end with their own notions of significant realities. And what we have to offer them in some cases will be inappropriate to their needs and/or simply wrong. The best we can do is the best we can do. And while the task can never be done "right," less than our very best amounts to an abdication of intergenerational responsibility.

32 Cf. C. Sheriff, *The Artificial River* (New York: Hill and Wang, 1996).

Among STS scholars, these are significant realities:

- Underdetermination of science and technology
- Vast realm of technological and socio-cultural possibility
- Consequentiality of technology choice
- Political construction of technology
- Competing images of the world
- Discursive significance of "ultimate ends"
- Design as an embrace of selected patterns.

And responsible design is possible only where these realities are taken into account. This is, perhaps, the central message STS scholars would have for designers.

There are, without doubt, many significant realities that might be included in a designer's education—many more, undoubtedly, than there is time to communicate them. Early experience with Rensselaer's new program in product design and innovation[33] suggests that the approach of a dual major (engineering and STS) with a continuing integrative studio may be an improvement over more traditional curricula in which the usual distribution requirements in humanities and the social sciences tend not to connect with student interests (i.e., tend not to convey "significant realities") in the way that the STS application of those perspectives does. The details of how this program will perform, however, remain to be fully worked out in practice.

STS scholars would be among the last to claim that their notion of reality can claim authority as "truth" over any other, and among the last to suggest that any absolute standard can be found to gauge the accuracy of one notion compared to another. In advancing their own perspectives for inclusion in design (and other) education, however, it may be that the standard they apply rests in a concern with justice and fair play that surely is among the most deeply seated and widely held (universal?) of human concerns.

Design that proceeds from narrowly rational images of the world, that entirely accepts the politically feasible of a given time as its boundary, for example, or fails to recognize or respect fundamentally different conceptions of the world is, in the end, unjust. It fails to respect not only the fundamental principles of democracy, but ordinary human dignity.[34] Where it is insistent and intransigent, it, like any other abuse of power, ultimately will lead to violence and to revolutionary change. In cases that are more mild, it will simply lead to alienation, popular dissent and discontent, and the disappointments of a failure to enlist spirited commitment in the achievement of individual and collective human potential.

Every educator and every student ultimately must be left to his or her own best judgment regarding what "rings true" and what is and is not a "significant" reality. The candidates that STS scholars might urge on our attention call upon us to consider more

33 F. Bronet, R. Eglash, G. Gabriele, D. Hess, and L. Kagan, "Product Design and Innovation: Evolution of an Interdisciplinary Design Curriculum," Mudd Design Workshop III, 305–318. (Social Dimensions of Engineering Design, Proceedings of a Workshop, 17–19 May, 2001, Clive L. Dym and Langdon Winner, eds.).

34 M. Meyer and W. Parent, eds., *The Constitution of Rights: Human Dignity and American Values* (Ithaca, NY: Cornell University Press, 1992).

conscientiously who the designer is, who they design for or with, and what their purposes are in design. They call for strengthened notions of accountability in place of practices that, for example, implicitly assign the consideration of ultimate ends to "others." And they embrace rather than avoid the seemingly palpable realities of politics and of underdetermination in the material world. In all of these respects, I argue, they make an essential contribution to more responsible design.

If design is to be seen as the joining of the possible and the desirable, *responsible* design must begin as far as possible in unstinted realities. And it must respond democratically to a general population, even where this may not coincide precisely with the financial incentives of the marketplace. In both respects, designers and the society that supports them would be well served by attention to the insights of the new field of science and technology studies.

A Reminiscence in Honor of Rob Roy Kelly

Joe Ballay

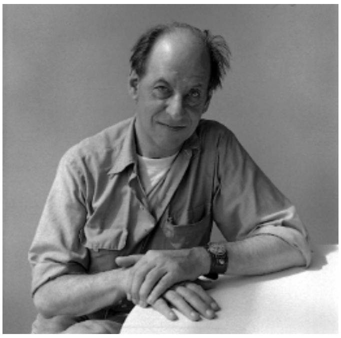


Photo: Charlee Brodsky

The first time I met Rob Roy Kelly he was riding the crest of his teaching at Kansas City Art Institute. We had invited him to be a speaker and critic for a couple of days at Carnegie Mellon University. In that short time I didn't get to know him well, but I was left with the impression of a designer who eschewed style and trends in graphic design in favor of a clear personal vision, common sense, and hard work.

Our paths crossed again at Carnegie Mellon some years later, but this time he was coming to join the faculty of our Department of Design. At this point he had left behind any ambitions to head a program—been there, done that. But he assumed, almost as second nature, the role of a senior faculty member—a voice for reflection and reason, a supporter of design education based on enduring principles.

Whatever Rob got involved in, it was all the way. Many know of his collections; wood type, of course, but also trivets, succulents, and probably others I never saw. As he would travel from his apartment in Squirrel Hill, through parts of Schenley Park to the Carnegie Mellon campus he noticed that many trees in the area were afflicted with burls, areas of bulbous irregular growth along their trunks or branches. His curiosity was piqued and so it began again. To my knowledge, Rob never cut down a tree just to get it's burl, but somehow he amassed the largest collection of burls—trimmed, polished, mounted—that I had ever seen.

It would miss the point to interpret these collections as obsessions or mere infatuations. I believe they were an outward expression of Rob Roy's way of seeing and understanding the world. He was one of two colleagues I knew (Arnold Bank was the other) who learned, and taught by focusing on a specific object, phenomenon or principle, and then following it to its utter depth and accounting for everything that it touched along the way. And it touched, almost literally, everything. So wood type led to the origins of the decorative vernacular style, to nineteenth century principles of typography, to printer's records, to the manufacturing and handling of wood type, and on and on.

Of course, his cognitive style affected his teaching too. For several years Rob Roy, Mark Mentzer, and I team-taught the Freshman Design Studio at Carnegie Mellon, Rob doing the 2D design, Mark the drawing, and I did the 3D. I saw in Rob's teaching the beauty of simple things done exceedingly well. One of his projects early in the year was to design a convex shape or "blob." It was to be based on a circle, but not *be* a circle; to deviate from a circle about as much as an orange or peach deviates from a sphere (you might say, something like the shape of a burl). It began simply but became deeper and deeper. At first he pushed the student for something resembling a circle. "Come on! Does that look like a circle to you? It's flat over here. Try again." Then, not to be too easily satisfied, the criticism would shift to, "Ok, that's better, but look how this part of the curve over here needs to have a tension with that part of the curve over there. Try again." And eventually, if the student worked hard enough, it would get down to, "That's pretty good, but what about this little bump here? Did you mean that? It looks like a slip of the brush. Try again and see what you can do about that." While students may have been frustrated along the way with Rob, at the end of the journey they had produced beautiful work and were proud of it. That's good education.