The Challenge of Responsible Design

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"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.
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> [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.