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MODELS OF DESIGN: ENVISIONING A FUTURE DESIGN EDUCATION

ABSTRACT

This article offers a large-scale view of how design fits in the world economy today, and the role of design education in preparing designers for their economic and professional role. The current context of design involves broad-based historical changes including a major redistribution of geopolitical and industrial power from the West to the East. A model of six global economies delineates the challenge and opportunity for design practice and education. While the six economies developed over time, all fit together now and design creates value in different ways across them. Understanding the economic context of design education gives clarity to the educational mission, differentiating it from other forms of education. The author argues that design professionals now require a broad range of analytical, conceptual and creative skills related to the social and economic context of design along with advanced skills in a design specialty. A taxonomic chart of design knowledge delineates the range of skills and knowledge domains involved.

"Most of today's design challenges require analytic and synthetic planning skills that can't be developed through the practice of contemporary design professions alone."

THE CONTEXT OF DESIGN

> *The future is already here. It's just not very evenly distributed yet.*[1]
>
> William Gibson

The context in which we live exerts a decisive influence on the nature of education and it determines the meaning of what it is to be educated. History, economics and politics shape the nature of our times and the education that suits them. Design education today takes place in the context of a post-industrial society and the industrial society that gave rise to it. It also takes place in the context of the multiple economies that weave together to shape our times. To understand what design education is today—and what it must become—requires us to understand the changing shape of the contemporary industrial economy against the global background of the new Asia-Pacific century.

The rise of China as the world's second most powerful economy challenges the economic and political assumptions of the Western industrial democracies. Eric X. Li recently argued in *The New York Times* that the competition between the West and China is not a clash between democracy and authoritarianism with democracy as an obvious and necessary goal. He argues that a:

> *form of government, or any political system for that matter, [is] merely ... a means to achieving larger national ends.*[2]

Li poses two great Western experiments in democracy against the durability of China. Athens was the world's first experiment in

democracy. It lasted little longer than a century and a half. Democracy in the modern West is the second such experiment, but democracy as a system in which each citizen has one vote is less than a century old.

For Li, the contemporary experiment in democracy dates to the European Enlightenment and the success of the industrial revolution. He argues that the current politics of democracy is leading to the uncontrolled and unequal accumulation of wealth, a form of excess that will shape a modern version of the demagogy that destroyed Athens. Li quotes Nobel Laureate Michael Spence on the shift from "one propertied man, one vote; to one man, one vote; to one person, one vote; trending to one dollar, one vote."[3] This is the heart of special interest politics. While special interests have long played a role in Western democracies, the new form of special interest politics combined with massive wealth renders special interests different from those of the past. In the 1780s, Pennsylvania politician William Findlay articulated the central rationale for interest-group politics. This worked reasonably in the 18th and 19th centuries, a world in which America was one power among many. When America holds a position as the world's most influential economy, the triumph of special interests affect more than the greater society of the United States; they dominate the globe.[4] Today, the once-plausible democracy of Findlay's special interests has given way to the paid-for politics of the new demagogues. One result is the struggle of Western industrial economies, and the difficulty they have creating enough decent jobs to support all their citizens with dignity. Since most design professions involve shaping goods and services within large industrial economies, this political-economic context is one key to the realities of design education today and tomorrow.

The profession for which we educate designers today takes place against a context with several dimensions. One of these is the context of the democratic industrial societies that gave birth to and require design services. At the same time, other models of industrial society are reshaping the world.

The clash between Chinese dissidents and the government at Tiananmen Square in 1989 rendered the conflict between the democracy of individual freedom and organized state economies visible.[5] The conflict became visible again in the global financial crisis of the current decade. The radical power of financial interests

to uproot businesses and destroy individual lives has grown in the wake of deregulation. In this era, legislators in the world's greatest industrial economy redesigned the tax system to distribute wealth upward to the wealthiest one tenth of one percent of the population, increasing their wealth and their capacity as an interest group to reshape the economy in a way that increases the wealth of those who benefit from systemic change despite the fact that the system as a whole grows poorer. On a global basis, an even smaller percentage of the world's population shares the world's wealth. One result has been to hollow out manufacturing and the productive capacity that once defined industrial democracy.

The contest between self-interest and common concern forms the ethical background to the state of today's industrial democracies. Civic pride and a sense of the common good led Aeschylus to define himself as a citizen who fought against the Persian empire at Marathon to defend democracy. The epitaph of Aeschylus commemorates his service as a soldier and not his stature as the father of dramatic tragedy or his many honors.[6] In contrast, many leading citizens in the West today define themselves by their wealth and the businesses they control, buy and sell.

This vision of capitalism would hardly have seemed likely during the decades when design education entered the university. Adam Smith—the first great economist—developed the discipline of economics as an extension of moral philosophy by asking a powerful question: what conditions create productivity and prosperity for a society as a whole and for the greatest number of citizens? In an elegant essay conceived as he wrote a new introduction to Smith's *Theory of Moral Sentiments*[7], Nobel Laureate Amartya Sen notes how badly the apologists of modern wealth have distorted Smith's ideas.

We live today in a world of genuine competition between models of industrial society. The Soviet economy was an illusion, and competition between economic models was never a serious issue. The Cold War involved unequal competitors. In the West, productive industrial democracies devoted a small part of their massive surplus to political, military and economic struggle among nations. In contrast, the Soviet Union used core capacity to the same ends, destroying wealth to do so rather than using surplus. Today's geo-political competition is a stark contrast to this. The capitalist economies of Asia—including such state capitalist economies as

China—are creating wealth. The economies of the United States and many parts of Europe are destroying wealth as they shift resources from productive use to financial manipulation. While this involves complex factors, a few key issues stand out.

The first issue involves a geo-political transformation defining the end of the twentieth century and the start of the twenty-first. In 1987, I lectured at the Technological University of Delft on the role of cities in the changing world economy. I was working at the time in Finland as visiting designer at the great ceramic and glass firms Arabia and Iittala. From Helsinki, the most visible factor in the shift between East and West was so simple that an America consumed by the contest between American and Japanese automotive industries overlooked it. This is the fact that for nearly ten thousand years of recorded history, the vast majority of the world's wealth was located in Asia, along with the vast majority of the world's people. This changed over the most recent five centuries, in great part because of political decisions made by Asian governments. In the 1400s, China began a great withdrawal from the world, relinquishing its role as the world's foremost maritime power to focus on the inland regions. In the 1600s, the Tokugawa shoguns sealed Japan from the world with a closed country policy. At the same time, the Mughal emperor Jahangir permitted the British East India Company into India with powers that would eventually make India a dependency of the British crown. As a result, foreign powers determined the fate of Asian nations, deflecting the rise of Asian economies for five centuries. When this era came to a close, it seemed inevitable that natural resources and human capital would return Asia to its former status as the world's most prosperous region.[8] The condition for this rise was good governance and responsible geo-political strategy. The major economic powerhouses of Asia have in great part had both.

While Western democracies contest the politics of Asian governments as authoritarian, one must question the nature of any democracy that we can define, as Spence does, with "one dollar, one vote" politics. Whatever one can say of the West, there is no question that the "Four Tigers" of Hong Kong, Korea, Singapore and Taiwan, have joined Japan as massively successful economies. India has made major gains in recent years. Most important, some predict that China will overtake the United States as the world's most powerful economy by 2030,

though it will take slightly longer for China to surpass the West in per capita income and overall geo-political power.[9] Even so, Asia as a whole is surpassing the West. Design education takes place against the background of this global context.

SIX WORLD ECONOMIES

The professional practice of design is an economic activity. Different forms of design function in specific sectors and niches of the economy. In 1940, the Australian economist Colin Clark divided the economy into three sectors: primary, secondary and tertiary. The primary sector extracts wealth from nature through agriculture, livestock, farming, hunting, trapping, fishing, forestry and basic mining. Secondary sector industries transform extracted material through human activity in manufacturing, building, construction, mining, gas, oil and power production. The tertiary sector provides services through commerce, distribution, transport, public administration, domestic services, personal services and professional services.[10]

A quarter century later, sociologist Daniel Bell redefined economic activity in his landmark book, *The Coming of Post-Industrial Society*. Bell reworked Clark's typology, deepening and expanding it to cover the more complex economy of the post-war era. Bell's work structured a typology of economic sectors that revealed the era in which each sector emerged. The primary sector of the economy is pre-industrial, typified by agriculture, mining, fishing, timber, oil and gas. The secondary sector of the economy is industrial, expressing itself through goods production, manufactured durables, manufactured non-durables and heavy construction. In contrast, the post-industrial economy was far more variegated, with three sectors. The post-industrial tertiary sector involves transportation and utilities; the post-industrial quaternary sector involves trade, finance, insurance and real estate; and the post-industrial quinary sector involves health, education, research, government, recreation and entertainment.

More important, Bell articulated important shifts in the way societies and economies work, as well as the axiological implications of these shifts.

Modes of production shifted from pre-industrial extraction to industrial fabrication to post-industrial processing and information

technologies. The strategic resource of the pre-industrial era was raw materials. This shifted to financial capital in the industrial era and human capital in post-industrial times.

The resources that transformed these from resources to goods and services while adding value to them also shifted. They went from the natural power of wind, water, draft animals and human muscle in pre-industrial times to the manufactured energy of steam, electricity, coal, oil, gas and nuclear power in industrial times to the information, knowledge processes, programming, algorithms, computers, data transmission and human interaction of post-industrial times. It is vital to note that even though transforming resources change, human beings continued to work with earlier resources and processes. We still required raw materials for manufactured goods. High quality food production in restaurants relies still on human energy as its major transforming resource. El Bulli pioneered a post-modern molecular cuisine while The Fat Duck emphasized a gourmet version of the traditional country kitchen. Both require master chefs.

Technology shifted from craft technology in pre-industrial times to machine technology in the industrial era and then to intellectual technologies of the post-industrial era. The skilled labor base shifted at the same time from pre-industrial artisans, manual laborers and farmers to industrial engineers, semi-skilled workers and skilled workers onward to post-industrial scientists, technologists and professionals, along with highly skilled workers.

Modes of work shifted as well. They went from physical labor in pre-industrial times to division of labor as the definitive mode of the industrial era to networked labor in post-industrial times.

Methods and methodology shifted from common sense, trial-and-error and experience in the pre-industrial age to empiricism and experimentation in the industrial age to models, simulations, decision theory and systems thinking in the post-industrial age.

The two greatest shifts involved time perspectives and the axial principles that define each age. The pre-industrial era was oriented to the past. The industrial era used ad hoc adaptation and experimentation, working at scale in the industrial setting. The post-industrial era is oriented toward the future with forecasting, foresight and planning. The great axial principle of pre-industrial times was traditionalism. This shifted to the guiding principle

FIG 1.
Six Global Economies
KEN FRIEDMAN

Six Global Economies	
Economy 6	Direct action on biological, molecular, and atomic structures
Economy 5	Information, knowledge services, emotional work, human networks, experience economy services, professional services, cultural services
Economy 4	Commerce, capital services
Economy 3	Transport, utilities
Economy 2	Fabricating, building, construction
Economy 1	Gathering, harvesting, hunting, husbandry

of productivity in the industrial era. In post-industrial times, codified knowledge and algorithms became the central focus.[11]

A new model of six global economies accounts for the structural elements of the economics sectors from the earliest times to the most recent. ECONOMY 1 involves gathering, harvesting, hunting and husbandry. ECONOMY 2 involves fabricating, building and construction. ECONOMY 3 involves transport and utilities. ECONOMY 4 involves commerce and capital services. ECONOMY 5 involves information and knowledge services, emotional work, human networks, the experience economy and cultural services. ECONOMY 6 is the economy of direct action on biological, molecular and atomic structures.[12]

The first economy began with our pre-human ancestors. So did the second economy, when homo habilis manufactured the first crude tools 2,500,000 years ago. While the emergence of transport as an economic sector depends on the definition of transport, the crudest forms of transport must have begun at around the same time as tool making. Definitions also affect the ways we date commerce and capital services. Long-distance trade began at least 150,000 years ago, but money as we know it is relatively recent, dating to the 6th century BCE. Commerce and capital services of different kinds appear at all stages of human civilized life, since human beings required commercial and capital services of some kind for the formation of cities, states and organized human activity. The economy of fabrication also shifts in relation to commerce, capital services and social structure, and millions of years separate

the manufacture of stone tools from the manufacture of bricks, buildings and temples. Recognizable information artifacts date back at least 20,000 years, but organized information systems emerge with the birth of the first cities. All of the first five economies have co-existed for at least 10,000 years in different configurations.

Old economies and new are interwoven: the proportions change over time. Ancient Egypt had agriculture and construction, along with information and knowledge services. Egypt employed massive numbers of agricultural workers, drafting some for construction. It had few information managers and knowledge workers. Ancient Egypt also had an experience economy, though professional experience providers primarily served the aristocracy and upper classes gathered around the royal family. Classical Athens had fewer agricultural workers than ancient Egypt relative to the population and far more professional construction workers. While there were still relatively few information managers and knowledge workers, there were far more relative to the population. The proportion of professional experience providers was significantly greater, however, with larger and wealthier merchant classes to serve along with aristocrats, and the great civic drama festivals. At any moment in human history, one can see the shift of different proportions of workers and professionals working in the different sectors.[13]

The definitive change to the 21st century economies is the birth of a new economic sector, a sixth economy of direct material technologies. These technologies use the power of new materials and new technology through direct instructions that shape artifacts at many scales. The economy of direct action on biological, molecular and atomic structures involves the important and growing sectors of biotechnology, nanotechnology, additive manufacturing and other new fields.[14]

The crucial issue here is that the era Bell identified in the 1970s as post-industrial did not mean an end to industry, but rather a shift to layered economies functioning in different ratios to times past. The increased capacity for productivity in highly informated factories means a need for increasingly valuable output in any society that hopes to keep its citizens employed. This, in turn, requires increasing improvements to products and services of all kinds. Nations that maintain a highly skilled manufacturing base with an educated population of skilled professionals and highly skilled workers have a future in today's

world. They will be able to maintain a full spectrum of economic sectors, providing goods and services both to the rest of the world's economies. Nations that lose the capacity to manufacture will be incapable of functioning across the full spectrum of sectors.[15]

WHAT DESIGNERS MUST KNOW

To work effectively in the complex contemporary economy, top-flight design professionals require a range of skills and knowledge. These include the same range of general skills and background knowledge that all practicing professionals require along with the domain-specific skills and technical skills of each professional practice.

Design is an interdisciplinary profession serving multiple needs. Designers work in transdisciplinary teams whose nature and constituency changes according to the project at hand. For this reason, it is difficult to argue for a definitive range of skills or even a specific series of knowledge domains. In educational terms, these change depending on the location and focus of the program and curriculum. Even so, it is possible to suggest a typical taxonomy of domains that one might expect to see in a strong, contemporary design school[16] (*see* FIGURE 2).

What is most to the point is the fact that designers must learn more than they once had to learn to succeed in a first-rate design program. When they graduate, they must know more than they once had to know to work at the upper levels of the profession, and they require a higher level of integrative skills to succeed.

Donald Norman describes the key issues in a recent article on the changes required for design education today.

> *In the early days of industrial design, the work was primarily focused upon physical products. Today, however, designers work on organizational structure and social problems, on interaction, service, and experience design. Many problems involve complex social and political issues. As a result, designers have become applied behavioral scientists.*

He goes on to explain the problems of contemporary design education, writing,

Learning & Leading	The Human World	The Artifact	The Environment
Problem solving	**The Human Being** - Human behavior - Information semantics - Knowledge creation - Physiology and ergonomics - Psychology - Behavioral economics - Research and methodology	**Product Development** - Methodology - Market research - Innovation research - Problematics - Product generation - Creating new products - Transforming old products - Product regeneration - Correcting problems - Improving products - Positioning - Re-engineering (lean production)	**Natural environment** - Ecology - Evolution - Environment - Impact
Interaction method			**Built Environment** - Cityscape - Economy - Social web - Infrastructure - Traffic
Coaching			**Telecommunication** - Airports - Food distribution - Human ecology
Mind mapping			**Architecture** - Informated buildings - Usage - Architecture as idea - Architecture as corporate identity - Profile architecture
Research skills			**Interior** - Furniture - Interior as corporate identity - Psychology - Function - Social structure - The shape of work - The shape of play - The shape of private life
Analysis			**Installation** - Philosophy of space - Culture theory - Art ideas - Inquiry
Rhetoric			
Logic			
Mathematics			
Language			
Editing			
Writing			
Presentation skills - Public speaking - Small group - Information graphics	**The Company** - Organizational management and behavior - Business economics - Company culture - Leadership - Administration - Future planning - Process management - Change management - Process skills - Company functions - Governance - Logistics - Production - Marketing - Finance	**Design** - Product design - Ergonomics - Product semantics - Product graphics - Functionality - Graphic design - Visual ergonomics - Typography - Corporate design - Behavioral design - Information design - Knowledge design - Process design	
	Society - Trends - Legal issues - Media - Social economics - Communication	**Manufacturing** - Technology - Operations - Statistical quality control - Logistics - Process management - Additive manufacturing - Nano-technology - Bio-technology	
	The World - World trade - European Union - USA - Asia - Cross-culture Issues - Political economics		
	Theory Basics - Culture theory - Sociology of knowledge - Reception theory - History of design - Sociology of taste - Content analysis - World history - Paradigm analysis - Models		

FIG 2.

Strategic Design Taxonomy: Design Knowledge Domains
KEN FRIEDMAN
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> *They are woefully undereducated for the task. Designers often fail to understand the complexity of the issues and the depth of knowledge already known. They claim that fresh eyes can produce novel solutions, but then they wonder why these solutions are seldom implemented, or if implemented, why they fail. Fresh eyes can indeed produce insightful results, but the eyes must also be educated and knowledgeable. Designers often lack the requisite understanding. Design schools do not train students about these complex issues, about the interlocking complexities of human and social behavior, about the behavioral sciences, technology, and business. There is little or no training in science, the scientific method, and experimental design.*[17]

The problem lies partly in the structural position that most design schools have in the larger universities that house them. Many design programs in North America or Europe are located within an art school or a faculty of art and design. In Australia, this is often combined with architecture. This is not bad—studying design, like studying art, philosophy or sociology—is a good way to prepare young people to think about life. Even so, design work now requires designers to create value for industry and business. The specialist professionals we educate for this work need two kinds of education. One is specialty training in the advanced skills of a specific design practice. The other is a broad training that involves the kinds of thinking and knowledge designers need for a wide range of professional engagements.

In a broad framework, designers must bring four sets of skills to bear on the problems and challenges that confront them. These four sets of skills comprise four approaches to value creation, (*see* FIGURE 3). Göran Roos labels these approaches as:

1 _____ SCIENCE AND TECHNOLOGY
2 _____ DESIGN
3 _____ ART
4 _____ HERMENEUTICS

By bringing skills and knowledge from these four domains to bear on the challenges that clients and customers bring them, designers create value in the products, services and processes they develop. For Roos,

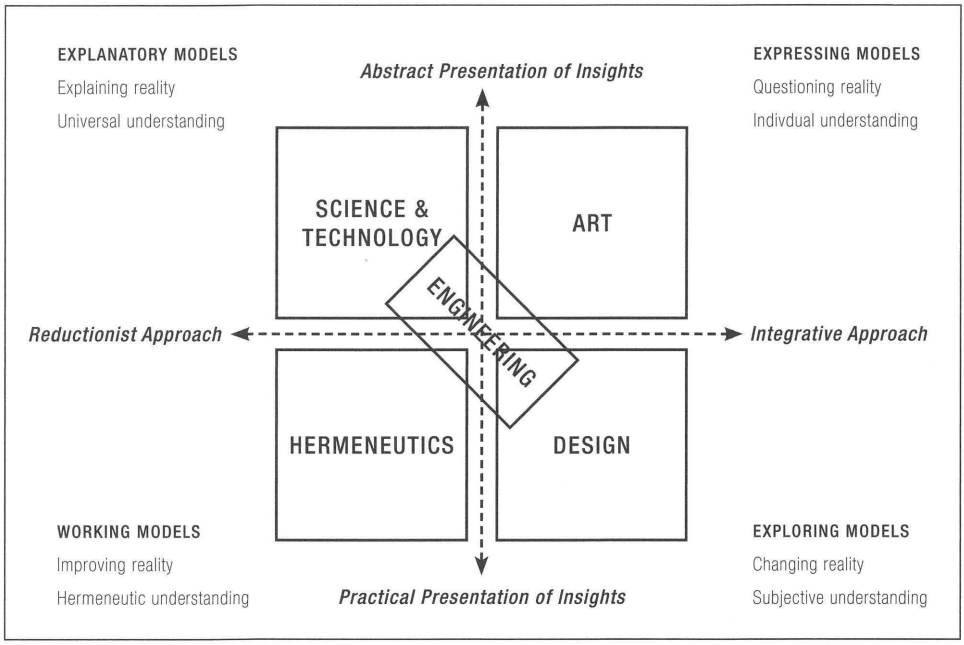

FIG 3.
Summary of Value Creation Approaches
GÖRAN ROOS

> *The most common objective of design in the innovation process is to change the behavior of individuals who use a designed artifact in such a way that the user perceives that his new behavior improves his life. As a consequence, when the user adopts the new behavior, the provider of the designed artifact also becomes better off, as do other members of the ecosystem surrounding the product or service. ... The Apple iPhone is a good example of this. Users of this artifact change their behavior due to the user interface and the capabilities of the iPhone. One aspect of this new behavior includes buying and using applications as well as increasing data use. As a consequence, the user feels better off. So do telecom operators, application providers, and Apple itself as a producer and business model innovator.*[18]

Designers use three routes to shape behavioral change: they enable desirable behavior by making the behavior easier for the user than alternate behaviors; they motivate users to modify or change behavior through education, incentives, attitude change or other mechanisms;

they sometimes push users to desirable behavior by making alternate behaviors impossible, difficult or prohibitively expensive in economic or social terms.

> *No matter which combination of these routes a designer chooses the principal design method is the same. It is basically made of the following steps:*
>
> *1 _____ Understanding the user through observation and engagement that enables the design to articulate the problems that the user perceives. This draws on design ethnography, which we can describe as a way of understanding the particulars of daily life in such a way as to increase the success probability of a new product or service or, more appropriately, to reduce the probability of failure due to the failure to understand the basic behaviors and frameworks of artifact users.*
>
> *2 _____ Generating or co-generating ideas around possible solutions. This draws on brainstorming and participatory design techniques.*
>
> *3 _____ Producing rapid prototypes or mock-ups of the selected sub-set of possible solutions. New techniques and tools including 3D printing and virtual reality simulation substantially facilitate this process.*
>
> *4 _____ Refining or co-refining embodied solutions. This is an iterative feedback loop that takes place until the desired outcome is achieved.*
>
> *5 _____ Verifying a successful outcome. This normally requires covert or overt observational techniques involving user groups that have not previously been involved in the process.*
>
> *6 _____ Implementing the product or service. This normally requires socialization activities in addition to operational activities.*[19]

While Roos takes a technological approach to these issues, he is keenly aware of the human dimensions of the products and services we design.[20] In effect, products and services shape the world around them through their interaction with human users. Henry Petroski charts the interplay between products, those who use them, and the

next generation of each evolving product in *The Evolution of Useful Things*, a book discussing the tools that humans create from forks and paper clips to hammers and zippers.[21] To paraphrase Winston Churchill's comment on architecture,

> *We make our tools and then our tools make us.*

The difference between design education today and design education over the past century is that designers must now strategize the tools they shape through the post-industrial processes that Bell described. Where design once relied on craft guild traditions functioning in slow evolutionary patterns based on common sense, trial-and-error and experience we now use models, simulations, decision theory and systems thinking in the post-industrial age. To do this successfully, designers need a wider range of skills based on research. W. Edwards Deming describes this as profound knowledge, comprised of:

> *four parts, all related to each other: appreciation for a system; knowledge about variation; theory of knowledge; psychology.*[22]

No matter which range of issues and domains any designer must master, the design profession now rests on a range of disciplines (*see* FIGURE 4). The broad disciplines of

1 _____ THE NATURAL SCIENCES
2 _____ THE HUMANITIES AND LIBERAL ARTS
3 _____ THE SOCIAL AND BEHAVIORAL SCIENCES,

inform those areas of the design professions that serve:

4 _____ THE HUMAN PROFESSIONS AND SERVICES
5 _____ THE CREATIVE AND APPLIED ARTS
6 _____ TECHNOLOGY AND ENGINEERING

As a practice, design faces ten major challenges today: three performance challenges, four substantive challenges and three contextual challenges. The performance challenges of design are to:

1 _____ Act on the physical world.
2 _____ Address human needs.

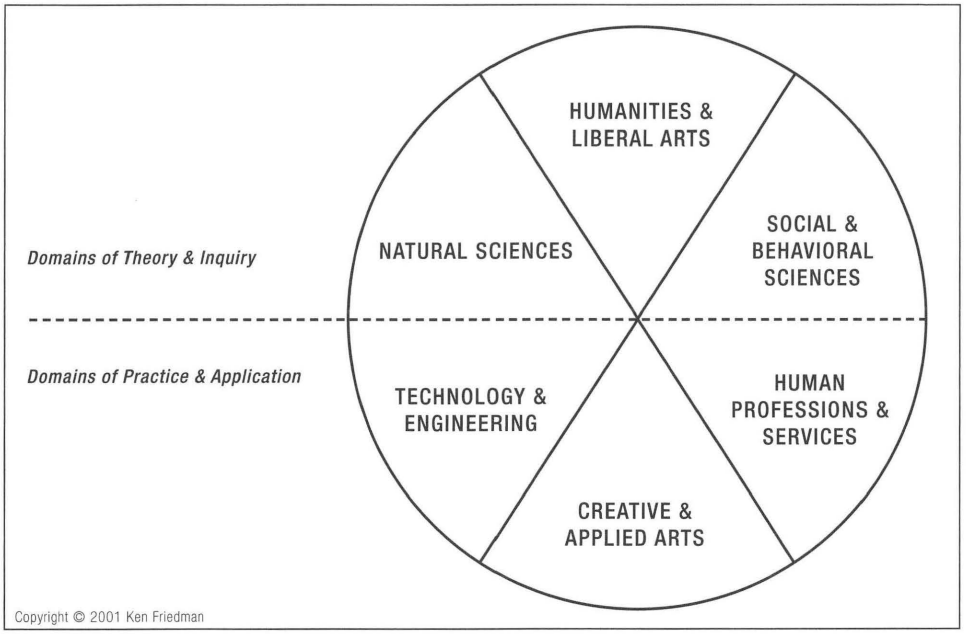

FIG 4.
Design Domains and Disciplines
KEN FRIEDMAN

3 _____ Generate the built environment.

These challenges require frameworks of theory and research to address contemporary professional problems and solve individual cases. The professional problems of design involve four substantive challenges:

4 _____ Increasingly ambiguous boundaries between artifacts, structures and processes.
5 _____ Increasingly large-scale social, economic and industrial frames.
6 _____ An increasingly complex environment of needs, requirements and constraints.
7 _____ Information content that often exceeds the value of physical substance.

In an integrated knowledge economy, design also involves three contextual challenges. These are:

8 _____ A complex environment in which many projects or products cross the boundaries of several organizations, stakeholder, producer and user groups.

9 _____ Projects or products that must meet the expectations of many organizations, stakeholders, producers and users.

10 _____ Demands at every level of production, distribution, reception and control.

These ten challenges require a qualitatively different approach to professional practice than was needed in earlier times. Past environments were simpler. They made simpler demands. Individual experience and personal development were sufficient for depth and substance in professional practice. While experience and development are still necessary, they are no longer sufficient. Most of today's design challenges require analytic and synthetic planning skills that can't be developed through the practice of contemporary design professions alone.

Today, professional design practice involves advanced multi-disciplinary knowledge that presupposes interdisciplinary collaboration and a fundamental change in design education. This knowledge isn't simply a higher level of professional education and practice. It is a qualitatively different form of professional practice. It is emerging in response to the demands of the information society and the knowledge economy to which it gives rise.[23]

We already face the challenges of future design education. If, on the one hand, these challenges are not evenly distributed, neither are the skills or capacities that design schools need to meet them. The design education we need today is increasingly similar to the requirements of professional education in engineering—or, perhaps better said, it is increasingly similar to the requirements of education in health care and medicine. To succeed, outstanding professional design requires a foundation based on science and on research. To serve human beings, outstanding professional designers must master an art of human engagement based on ethics and on care. Design education must foster such skills and knowledge.

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According to Wood, "Findlay set forth a rationale for modern democratic interest-group politics that has scarcely been bettered. Findlay argued that since everyone had interests to promote, self-made middling men like himself, who had no lineage, possessed no great wealth, and had never been to college, had as much right to political office as wealthy gentry who had gone to Harvard or Princeton. This was what American equality meant, he said. Furthermore, since everyone did have interests to promote, it was now quite legitimate for candidates for public office to campaign for election on behalf of the interests of their constituents."

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11 *Bell, Daniel. 1999 [1976]. The Coming of Post-industrial Society. A Venture in Social Forecasting. New York, NY: Basic Books, lxxxv.*

12 *Friedman, Ken. 2005. Six Economies for Design Research. Keynote Speech. Founding Conference of the International Association of Societies of Design Research. November 1-4. 2005. National Yunlin University of Science and Technology, College of Design, Yunlin, Taiwan.*

13 *This is not an analysis of social and economic growth through history, but a descriptive background to the factors affecting design education today and in the future. For an example of how some of these factors affect design, see: Friedman, Ken. 1997. Design Science and Design Education. In McCrory, Peter, editor. The Challenge of Complexity. Helsinki: University of Art and Design Helsinki UIAH. For a broader timeline of sociotechnical and scientific change, see: Ochoa, George and Corey, Melinda. 1995. The Timeline Book of Science. New York, NY: Ballantine. For a broad, readable analysis of the ways in which culture and technology have grown through time, see such books as: Burke, James and Robert Ornstein. 1997. The Axemaker's Gift: Technology's Capture and Control of Our Minds and Culture. New York, NY: Tarcher Putnam; Watson, Peter. 2006. Ideas: A History of Thought and Invention, from Fire to Freud. New York, NY: Harper Perennial; Boorstin, Daniel. 1985. The Discoverers. New York, NY: Random House. These kinds of growth and development take place against the sweep of history and the multiple backgrounds of culture. Joseph Needham's series from Cambridge University Press titled Science and Civilization in China is an example. Needham summarized many of the key issues with comparisons to Greek, Arabic and Indian culture. In Needham, Joseph. 1981. Science in Traditional China. Cambridge, MA: Harvard University Press. Another excellent account is Temple, Robert K.G. 2007. The Genius of China: 3,000 Years of Science, Discovery, and Invention. Rochester, VT: Inner Traditions. Fernand Braudel examines the relations between science, technology, culture and societies, books that are narrower in temporal scope but equally useful; Braudel, Fernand. 1983. Civilization and Capitalism, 15th-18th Century, Volume 1: The Structures of Everyday Life. Berkeley, CA: University of California Press; Braudel, Fernand. 1992. The Wheels of Commerce: Civilization and Capitalism, 15th-18th Century, Volume 2. Berkeley, CA: University of California Press; Braudel, Fernand. 1992. The Perspective of the World: Civilization and Capitalism, 15th-18th Century, Volume 3. Berkeley, CA: University of California Press. Similar books include: Pacey, Arnold. 1992. The Maze of Ingenuity. Ideas and Idealism in the Development of Technology. Cambridge, MA: The MIT Press; Petroski, Henry. 1994. The Evolution of Useful Things. New York, NY: Vintage Books; or Flichy, Patrice. 1995. Dynamics of Modern Communication. The Shaping and Impact of New Communication Technologies. London: Sage Publications. The point here is not an essay in history, but rather an understanding of the context and background against which industry and technology emerge to affect what has become of the professional practice of design.*

14 *These ideas were scientific speculation when Richard Feynman delivered his 1959 lecture, There's Plenty of Room at the Bottom. http://www.zyvex.com/nanotech/feynman.html (Accessed 2012 February 19) Within three decades, new fields of basic and applied research emerged even as science fiction writers began to describe the worlds that might flow from them. See, for example: Stephenson, Neal. 1995. The Diamond Age, or, A Young Lady's Illustrated Primer. New York, NY: Spectra. A decade and a half further on, the fictional systems and services that Stephenson described are real with processes tested at scale in laboratory or prototype conditions. Today, every research-intensive design school has a 3-D printer and many have more advanced equipment. On the day I finished checking footnotes for this article, a team of physicists at University of New South Wales and Purdue University announced the successful creation of a transistor built of a single atom. Markoff, John. 2012. Physicists Create a Working Transistor From a Single Atom. The New York Times, 2012 February 20. http://www.nytimes.com/2012/02/20/science/physicists-create-a-working-transitor-from-a-single-atom.html?_r1&hp (Accessed: 2012 February 20)*

15 *Economist and journalist Eamonn Fingleton has long made a case for the necessity of hard industries in the mix of a prosperous economy. See: Fingelton, Eamonn. 1999. In Praise of Hard Industries: Why Manufacturing, Not the Information Economy, Is the Key to Future Prosperity. New York, NY: Houghton Mifflin Harcourt; Zakaria, Fareed. 2012. The Case for Making it in the USA. Like it or not (I don't), we need a manufacturing policy to stay competitive. Time Magazine, 2012 January 26. http://www.fareedzakaria.com/home/Articles/Entries/2012/1/26_The_Case_for_ Making_It_in_the_USA.html (Accessed 2012 February 18)*

16 *Friedman, Ken. 1992. Strategic Design Taxonomy. Oslo: Oslo Business School. Reprinted in: Friedman, Ken. 2001. Creating Design Knowledge: From Research into Practice. In Norman, E.W.L. and P.H. Roberts, editors. Design and Technology Educational Research and Development: The Emerging International Research Agenda. Loughborough, UK: Department of Design and Technology, Loughborough University, 31-69. http://www.hdl.handle.net/2134/1360 (Accessed 2012 February 18) Also: Friedman, Ken, 2002. Conclusion: Toward an Integrative Design Discipline. In Squires, Susan and Bryan Byrne, editors. Creating Breakthrough Ideas: The Collaboration of Anthropologists and Designers in the Product Development Industry. Westport, CT: Bergin and Garvey.*

17 *Norman, Don. 2010. Why Design Education Must Change. Core77, 2010 November 26. http://www.core77.com/blog/columns/why_design_education_must_change_17993.asp (Accessed 2012 February 20)*

18 *Roos, Göran. 2012. Introducing Strategic Design. Strategic Design Letter. Melbourne, Australia: Swinburne University of Technology Faculty of Design. [In press.] See also: Roos, Göran. 2011. How to Get Paid Twice for Everything You Do. Part 1: Integrated Innovation Management. Ericsson Business Review, 2, 2011, 55-57; Roos, Göran. 2011. How to Get Paid Twice for Everything You Do. Part 2: Value–appropriating Innovations. Ericsson Business Review, 3, 2011, 56-61; ICS Ltd. 2010. Victorian Design Roadmap Project. Report Prepared for the Department of Innovation, Industry and Regional Development of Victoria, April 2010.*

19 *Roos, Göran. 2012. Introducing Strategic Design. [In press.]*

20 *Göran Roos is chairman of VTT International, the Technical Research Center of Finland, and he is professor of strategic design at Swinburne University of Technology in Melbourne, Australia. Originally trained in mathematical physics, he became an engineer, and the founder of over a dozen companies in different fields of technology.*

21 *Petroski, Henry. 1994. The Evolution of Useful Things. New York, NY: Vintage Books.*

22 *Deming, W. Edwards. 1993. The New Economics for Industry, Government, Education. Cambridge, MA: Massachusetts Institute of Technology, Center for Advanced Engineering Study, 96. See also: Friedman, Ken. 1997. Design Science and Design Education. In McGrory, Peter, editor. The Challenge of Complexity. Helsinki: University of Art and Design Helsinki UIAH, 54-72. http://hdl.handle.net/1959.3/189707 (Accessed 2012 February 18)*

23 *Friedman, Ken. 2002. Towards an Integrative Design Discipline. In Byrne, Bryan and Susan E. Squires, editors. Creating Breakthrough Ideas: The Collaboration of Anthropologists and Designers in the Product Development Industry. Westport, CT: Bergin and Garvey, 200-214.*