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Richard Buchanan

Wicked Problems in Design Thinking

Introduction

This essay is based on a paper presented at "Colloque Recherches sur le Design: Incitations, Implications, Interactions," the first French university symposium on design research held October 1990 at l'Université de Technologie de Compiègne, Compiègne, France.

Despite efforts to discover the foundations of design thinking in the fine arts, the natural sciences, or most recently, the social sciences, design eludes reduction and remains a surprisingly flexible activity. No single definition of design, or branches of professionalized practice such as industrial or graphic design, adequately covers the diversity of ideas and methods gathered together under the label. Indeed, the variety of research reported in conference papers, journal articles, and books suggests that design continues to expand in its meanings and connections, revealing unexpected dimensions in practice as well as understanding. This follows the trend of design thinking in the twentieth century, for we have seen design grow from a *trade activity* to a *segmented profession* to a *field for technical research* and to what now should be recognized as a new *liberal art of technological culture*.

It may seem unusual to talk about design as a liberal art, particularly when many people are accustomed to identifying the liberal arts with the traditional "arts and sciences" that are institutionalized in colleges and universities. But the liberal arts are undergoing a revolutionary transformation in twentieth-century culture, and design is one of the areas in which this transformation is strikingly evident.

To understand the change that is now underway, it is important to recognize that what are commonly regarded as the liberal arts today are not outside of history. They originated in the Renaissance and underwent prolonged development that culminated in the nineteenth century as a vision of an encyclopedic education of *beaux arts*, *belles lettres*, history, various natural sciences and mathematics, philosophy, and the fledgling social sciences. This circle of learning was divided into particular subject matters, each with a proper method or set of methods suitable to its exploration. At their peak as liberal arts, these subject matters provided an integrated understanding of human experience and the array of available knowledge. By the end of the nineteenth century, however, existing subjects were explored with progressively more refined methods, and new subjects were added to accord with advances in knowledge. As a

result, the circle of learning was further divided and subdivided, until all that remained was a patchwork quilt of specializations.

Today, these subject matters retain an echo of their old status as liberal arts, but they flourish as specialized studies, leading to the perception of an ever more rich and detailed array of facts and values. Although these subjects contribute to the advance of knowledge, they also contribute to its fragmentation, as they have become progressively narrow in scope, more numerous, and have lost "connection with each other and with the common problems and matters of daily life from which they select aspects for precise methodological analysis."[1] The search for new integrative disciplines to complement the arts and sciences has become one of the central themes of intellectual and practical life in the twentieth century. Without integrative disciplines of understanding, communication, and action, there is little hope of sensibly extending knowledge beyond the library or laboratory in order to serve the purpose of enriching human life.

The emergence of design thinking in the twentieth century is important in this context. The significance of seeking a scientific basis for design does not lie in the likelihood of reducing design to one or another of the sciences–an extension of the neo-positivist project and still presented in these terms by some design theorists[2] Rather, it lies in a concern to connect and integrate useful knowledge from the arts and sciences alike, but in ways that are suited to the problems and purposes of the present. Designers, are exploring concrete integrations of knowledge that will combine theory with practice for new productive purposes, and this is the reason why we turn to design thinking for insight into the new liberal arts of technological culture[3]

Design and Intentional Operations

The beginning of the study of design as a liberal art can be traced to the cultural upheaval that occurred in the early part of the twentieth century. The key feature of this upheaval was described by John Dewey in *The Quest for Certainty* as the perception of a new center of the universe.

> The old center of the universe was the mind knowing by means of an equipment of powers complete within itself, and merely exercised upon an antecedent external material equally complete within itself. The new center is indefinite interactions taking place within a course of nature which is not fixed and complete, but which is capable of direction to new and different results through the mediation of intentional operations.[4]

What Dewey describes here is the root of the difference between the old and new liberal arts, between specialization in the facts of a subject matter and the use of new disciplines of integrative thinking.

1) From Richard McKeon, "The Transformation of the Liberal Arts in the Renaissance," Developments in the Early Renaissance, ed. Bernard S. Levy (Albany: State University of New York Press, 1972), 168-69.

2) Neo-positivism, pragmatism, and various forms of phenomenology have strongly influenced design education and practice in the twentieth century. If design theory has often tended toward neo-positivism, design practice has tended toward pragmatism and pluralism, with phenomenologists in both areas. Such philosophical differences are illustrated in the split that developed between the theoretical and studio courses at the Hochschule für Gestaltung (HfG) Ulm before its closing. The split between theory and practice in design is an echo of the difference between the predominantly neo-positivist philosophy of science and the exceptionally diverse philosophies of practicing scientists. Design history, theory, and criticism could benefit from closer attention to the pluralism of views that guide actual design practice.

3) Walter Groupius was one of the first to recognize the beginnings of a new liberal art in design. In an essay written in 1937, he reflected on the founding of the Bauhaus as an institution grounded on the idea of an architectonic art: "Thus the Bauhaus was inaugurated in 1919 with the specific object of realizing a modern architectonic art, which like human nature was meant to be all-embracing in its scope. . . . Our guiding principle was that design is neither an intellectual nor a material affair, but simply an integral part of the stuff of life, necessary for everyone in a civilized society." Scope of Total Architecture (New York: Collier Books, 1970), 19-20. The term "architectonic," in this case, transcends the derivative term "architecture" as it is commonly used in the modern world. Throughout Western culture, the liberal arts have similarly been described as "architectonic" because of their integrative capacity. Groupius appeared to understand that architecture, regarded as a liberal art in its own right in the ancient world, was only one manifestation of the architectonic art of design in the twentieth century.

4) John Dewey, The Quest for Certainty: A Study of the Relation of Knowledge and Action (1929; rpt. New York: Capricorn Books, 1960), 290-91.

Dewey observes, however, that the meaning and implications of the new direction are still not fully understood.

> Nowadays we have a messy conjunction of notions that are consistent neither with one another nor with the tenor of our actual life. Knowledge is still regarded by most thinkers as direct grasp of ultimate reality, although the practice of knowing has been assimilated to the procedure of the useful arts;–involving, that is to say, doing that manipulates and arranges natural energies. Again while science is said to lay hold of reality, yet "art" instead of being assigned a lower rank is equally esteemed and honored.[5]

5) John Dewey, Experience and Nature (1929; rpt. New York: Dover Publications, Inc., 1958), 357.

Carrying these observations further, Dewey explores the new relationship between science, art, and practice. He suggests in *Experience and Nature* that knowledge is no longer achieved by direct conformity of ideas with the fixed orders of nature; knowledge is achieved by a new kind of art directed toward orders of change.

> But if modern tendencies are justified in putting art and creation first, then the implications of this position should be avowed and carried through. It would then be seen that science is an art, that art is practice, and that the only distinction worth drawing is not between practice and theory, but between those modes of practice that are not intelligent, not inherently and immediately enjoyable, and those which are full of enjoyed meanings.[6]

6) Dewey, Experience and Nature, 357-58.

Although the neo-positivists courted Dewey for a time, it was apparent that his understanding of the development of science in the twentieth century was quite different from their understanding[7]. Instead of treating science as primary and art as secondary, Dewey pointed toward science as art.

> The consideration that completes the ground for assimilating science to art is the fact that assignment of scientific status in any given case rests upon facts which are experimentally produced. Science is now the product of operations deliberately undertaken in conformity with a plan or project that has the properties of a working hypothesis.[8]

7) The neo-positivist International Encyclopedia of Unified Science, which included Charles Morris's Foundations of the Theory of Signs, also included Dewey's Theory of Valuation. However, Dewey's Logic was ignored or ridiculed by neo-positivist logicians and grammarians.

8) John Dewey, "By Nature and By Art," Philosophy of Education (Problems of Men) (1946; rpt. Totowa, New Jersey: Littlefield, Adams, 1958), 288.

What Dewey means by "art" in this context is crucial to understanding the new role of design and technology in contemporary culture.

> After a period in which natural knowledge progressed by *borrowing* from the industrial crafts, science entered upon a period of steady and ever-accelerated growth by means of deliberate invention of such appliances on its own account. In order to mark this differential feature of the art which is science, I shall now use the word "technology." ... Because of technologies, a circular relationship between the arts of production and science has been established.[9]

9) Dewey, "By Nature and By Art," 291-92.

What Dewey defines as technology is not what is commonly understood in today's philosophy of technology. Instead of meaning knowledge of how to make and use artifacts or the artifacts themselves, technology for Dewey is an art of experimental thinking. It is, in fact, intentional operations themselves carried out in the sciences, the arts of production,[10] or social and political action. We mistakenly identify technology with one particular type of product—hardware—that may result from experimental thinking, but overlook the art that lies behind and provides the basis for creating other types of products.

10) For Dewey, the arts of production, include the fine arts. He makes no sharp distinction between fine and useful arts.

From this perspective, it is easy to understand why design and design thinking continue to expand their meanings and connections in contemporary culture. There is no area of contemporary life where design—the plan, project, or working hypothesis which constitutes the "intention" in intentional operations—is not a significant factor in shaping human experience. Design even extends into the core of traditional scientific activities, where it is employed to cultivate the subject matters that are the focus of scientific curiosity. But perceiving the existence of such an art only opens the door to further inquiry, to explain what that art is, how it operates, and why it succeeds or fails in particular situations. The challenge is to gain a deeper understanding of design thinking so that more cooperation and mutual benefit is possible between those who apply design thinking to remarkably different problems and subject matters. This will help to make the practical exploration of design, particularly in the arts of production, more intelligent and meaningful.

However, a persistent problem in this regard is that discussions between designers and members of the scientific community tend to leave little room for reflection on the broader nature of design and its relation to the arts and sciences, industry and manufacturing, marketing and distribution, and the general public that ultimately uses the results of design thinking. Instead of yielding productive integrations, the result is often confusion and a breakdown of communication, with a lack of intelligent practice to carry innovative ideas into objective, concrete embodiment. In turn, this undermines efforts to reach a clearer understanding of design itself, sometimes driving designers back into a defense of their work in the context of traditional arts and crafts. Without appropriate reflection to help clarify the basis of communication among all the participants, there is little hope of understanding the foundations and value of design thinking in an increasingly complex technological culture.

The Doctrine of Placements

By "liberal art" I mean a discipline of thinking that may be shared to some degree by all men and women in their daily lives and is, in turn, mastered by a few people who practice the discipline with distinctive insight and sometimes advance it to new areas of inno-

vative application. Perhaps this is what Herbert Simon meant in *The Sciences of the Artificial*, one of the major works of design theory in the twentieth century, when he wrote: "the proper study of mankind is the science of design, not only as the professional component of a technical education but as a core discipline for every liberally educated man."[11] One may reasonably disagree with aspects of Simon's positivist and empiricist view of design as a science[12] (as one may disagree with the pragmatic principles that stand behind Dewey's observation of the importance of intentional operations in modern culture),[13] but there is little reason to disagree with the idea that all men and women may benefit from an early understanding of the disciplines of design in the contemporary world. The beginning of such an understanding has already turned the study of the traditional arts and sciences toward a new engagement with the problems of everyday experience, evident in the development of diverse new products which incorporate knowledge from many fields of specialized inquiry.

To gain some idea of how extensively design affects contemporary life, consider the four broad areas in which design is explored throughout the world by professional designers and by many others who may not regard themselves as designers. The first of these areas is the design of *symbolic and visual communications*. This includes the traditional work of graphic design, such as typography and advertising, book and magazine production, and scientific illustration, but has expanded into communication through photography, film, television, and computer display. The area of communications design is rapidly evolving into a broad exploration of the problems of communicating information, ideas, and arguments through a new synthesis of words and images that is transforming the "bookish culture" of the past.[14]

The second area is the design of *material objects*. This includes traditional concern for the form and visual appearance of everyday products—clothing, domestic objects, tools, instruments, machinery, and vehicles—but has expanded into a more thorough and diverse interpretation of the physical, psychological, social, and cultural relationships between products and human beings. This area is rapidly evolving into an exploration of the problems of construction in which form and visual appearance must carry a deeper, more integrative argument that unites aspects of art, engineering and natural science, and the human sciences.[15]

The third area is the design of *activities and organized services*, which includes the traditional management concern for logistics, combining physical resources, instrumentalities, and human beings in efficient sequences and schedules to reach specified objectives. However, this area has expanded into a concern for logical decision making and strategic planning and is rapidly evolving into an exploration of how better design thinking can contribute to achieving an organic flow of experience in concrete situations, making such

11) Herbert A. Simon, The Sciences of the Artificial (Cambridge: M.I.T. Press, 1968), 83

12) Although Simon's The Sciences of the Artificial is cited repeatedly in design literature because of its definition of design, it is often read with little attention given to the full argument. A careful analysis from the standpoint of industrial design would be a useful contribution to the literature. Such a reading would reveal the positivist features of Simon's approach and help to explain why many designers are somewhat disenchanted with the book. Nonetheless, it remains an exceptionally useful work.

13) See Richard Buchanan, "Design and Technology in the Second Copernican Revolution," Revue des sciences et techniques de la conception (The Journal of Design Sciences and Technology, January, 1992), I:1.

14) The phrase "bookish culture" is used by literary critic George Steiner and is a theme in a forthcoming book by Ivan Illich, In the Vineyard of the Text.

15) The design of material objects includes, of course, new work in materials science, where a highly focused form of design thinking is evident.

experiences more intelligent, meaningful, and satisfying. The central theme of this area is connections and consequences. Designers are exploring a progressively wider range of connections in everyday experience and how different types of connections affect the structure of action.[16]

The fourth area is the design of *complex systems or environments for living, working, playing, and learning*. This includes the traditional concerns of systems engineering, architecture, and urban planning or the functional analysis of the parts of complex wholes and their subsequent integration in hierarchies. But this area has also expanded and reflects more consciousness of the central idea, thought, or value that expresses the unity of any balanced and functioning whole. This area is more and more concerned with exploring the role of design in sustaining, developing, and integrating human beings into broader ecological and cultural environments, shaping these environments when desirable and possible or adapting to them when necessary.[17]

Reflecting on this list of the areas of design thinking, it is tempting to identify and limit specific design professions within each area—graphic designers with communication, industrial designers and engineers with material objects, designers-cum-managers with activities and services, and architects and urban planners with systems and environments. But this would not be adequate, because these areas are not simply categories of objects that reflect the results of design. Properly understood and used, they are also *places of invention* shared by all designers, places where one discovers the dimensions of design thinking by a reconsideration of problems and solutions.

True, these four areas point toward certain kinds of objectivity in human experience, and the work of designers in each of these areas has created a framework for human experience in contemporary culture. But these areas are also interconnected, with no priority given to any single one. For example, the sequence of signs, things, actions, and thought could be regarded as an ascent from confusing parts to orderly wholes. Signs and images are fragments of experience that reflect our perception of material objects. Material objects, in turn, become instruments of action. Signs, things, and actions are organized in complex environments by a unifying idea or thought. But there is no reason to believe that parts and wholes must be treated in ascending rather than descending order. Parts and whole are of many types and may be defined in many ways.[18] Depending on how a designer wishes to explore and organize experience, the sequence could just as reasonably be regarded as a descent from chaotic environments to the unity provided by symbols and images. In fact, *signs*, *things*, *actions*, and *thoughts* are not only interconnected, they also interpenetrate and merge in contemporary design thinking with surprising consequences for innovation. These areas suggest the lineage of design's past and present, as well as point to where design is headed in the future.

16) Some of the psychological and social dimensions of this area are illustrated in works as diverse as George A. Miller, Eugene Galanter, and Karl H. Pribram, Plans and the Structure of Behavior (New York: Holt, Rinehart and Winston, 1960); Lucy Suchman, Plans and Situated Actions: The Problem of Human-Machine Communication (Cambridge: Cambridge University Press, 1987); and Mihaly Csikszentmihalyi, Flow: The Psychology of Optimal Experience (New York: Harper & Row, 1990).

17) One of the early works of systems engineering that influenced design thinking is Arthur D. Hall, A Methodology for Systems Engineering (Princeton, New Jersey: D. Van Nostrand Company, 1962). For more recent developments in systems thinking, see Ron Levy, "Critical Systems Thinking: Edgar Morin and the French School of Thought," Systems Practice, vol. 4 (1990). Regarding the new "systemics," see Robert L. Flood and Werner Ulrich, "Testament to Conversations on Critical Systems Thinking Between Two Systems Practitioners," Systems Practice, vol. 3 (1990), and M. C. Jackson, "The Critical Kernel in Modern Systems Thinking," Systems Practice, vol. 3 (1990). For an anthropological approach to systems, see James Holston, The Modernist City: An Anthropological Critique of Brasilia (Chicago: University of Chicago Press, 1989).

18) Compare the Platonic, Aristotelian, and classic materialist treatments of parts and wholes. These three approaches to the organization of experience are well represented in twentieth century design thinking. For example, see Christopher Alexander, Notes on the Synthesis of Form (Cambridge: Harvard University Press, 1973).

It is easy to understand that industrial designers are primarily concerned with material objects. But the research reported in design literature shows that industrial designers have found new avenues of exploration by thinking about material objects in the context of signs, actions, and thoughts. For example, some have considered material objects communicative, yielding reflections on the semantic and rhetorical aspects of products. Others have placed material objects in the context of experience and action, asking new questions about how products function in situations of use and how they may contribute to or inhibit the flow of activities. (Of course, this is a significant shift from questions about the internal functioning of products and how the visual form of a product expresses such functioning.) Finally, others are exploring material objects as part of larger systems, cycles, and environments, opening up a wide range of new questions and practical concerns or reenergizing old debates. Issues include conservation and recycling, alternative technologies, elaborate simulation environments, "smart" products, virtual reality, artificial life, and the ethical, political, and legal dimensions of design.

Comparable movements are evident in each of the design professions: their primary concern begins in one area, but innovation comes when the initial selection is repositioned at another point in the framework, raising new questions and ideas. Examples of this repositioning abound. For example, architecture has traditionally been concerned with buildings as large systems or environments. For nearly twenty years, however, a group of architects have aggressively sought to reposition architecture in the context of signs, symbols, and visual communication, yielding the postmodern experiment and trends such as deconstructionist architecture. Oxymorons such as "deconstructionist architecture" are often the result of attempts at innovative repositioning. They indicate a desire to break old categories, as in the now familiar and accepted "constructivist art" and "action painting." The test, of course, is whether experiments in innovation yield productive results, judged by individuals and by society as a whole.[19] Some experiments have fallen like dead leaves at the first frost, swept away to merciful oblivion. At present, the results of deconstructionist architecture are mixed, but the experiment will continue until individuals or groups reposition the problems of architecture and shift general attention toward new questions.[20]

A strikingly different repositioning is now beginning in the profession of graphic design and visual communication. In the late nineteenth and early twentieth centuries, graphic design was oriented toward personal expression through image making. It was an extension of the expressiveness of the fine arts, pressed into commercial or scientific service. This was modified under the influence of "communication theory" and semiotics when the role of the graphic designer was shifted toward that of an interpreter of mes-

19) Such judgments are the measure of objectivity in contemporary design thinking. Without objectivity to ground the possibilities discovered in design, design thinking becomes design sophistry.

20) Architect Richard Rogers seeks to reposition the problems of architecture in a new perception of multiple overlapping systems, rejecting the notion of a system as "linear, static, hierarchical and mechanical order." According to Rogers: "Today we know that design based on linear reasoning must be superseded by an open-ended architecture of overlapping systems. This 'systems' approach allows us to appreciate the world as an indivisible whole; we are, in architecture, as in other fields, approaching a holistic ecological view of the globe and the way we live on it." Architecture: A Modern View (New York: Thames and Hudson Inc., 1991), 58. Rogers's notion of "indeterminate form" derives not from the ideas of literary deconstruction but from his innovative view of multiple systems. For more on Rogers's pointed criticism of postmodern architecture from the perspective of multiple systems, see Architecture: A Modern View, 26.

sages. For example, the graphic designer introduced emotional colorings of corporate or public "messages" or, in technical terms, the graphic designer "coded" the corporate message. As a result, the products of graphic design were viewed as "things" or "entities" (material texts) to be "decoded" by spectators.[21] Recently, however, a new approach in graphic design thinking has begun to question the essentially linguistic or grammatical approach of communications theory and semiotics by regarding visual communication as persuasive argumentation. As this work unfolds, it will likely seek to reposition graphic design within the dynamic flow of experience and communication, emphasizing rhetorical relationships among graphic designers, audiences, and the content of communication. In this situation, designers would no longer be viewed as individuals who decorate messages, but as communicators who seek to discover convincing arguments by means of a new synthesis of images and words.[22] In turn, this will shift attention toward audiences as active participants in reaching conclusions rather than passive recipients of preformed messages.

What works for movements within a design profession also works for individual designers and their clients in addressing specific problems. Managers of a large retail chain were puzzled that customers had difficulty navigating through their stores to find merchandise. Traditional graphic design yielded larger signs but no apparent improvement in navigation—the larger the sign, the more likely people were to ignore it. Finally, a design consultant suggested that the problem should be studied from the perspective of the flow of customer experience. After a period of observing shoppers walking through stores, the consultant concluded that people often navigate among different sections of a store by looking for the most familiar and representative examples of a particular type of product. This led to a change in display strategy, placing those products that people are most likely to identify in prominent positions. Although this is a minor example, it does illustrate a double repositioning of the design problem: first, from *signs to action*, with an insight that people look for familiar products to guide their movements; second, from *action to signs*, a redesign of display strategy to employ products themselves as signs or clues to the organization of a store.

There are so many examples of conceptual repositioning in design that it is surprising no one has recognized the systematic pattern of invention that lies behind design thinking in the twentieth century. The pattern is found not in a set of *categories* but in a rich, diverse, and changing set of *placements*, such as those identified by signs, things, actions, and thoughts.

Understanding the difference between a category and a placement is essential if design thinking is to be regarded as more than a series of creative accidents. Categories have fixed meanings that are accepted within the framework of a theory or a philosophy, and

21) Although still a common and useful way of studying visual communication, this approach has lost some of its initial force in actual design practice because it has moved into personal idiosyncracy and a search for novelty, which often distracts one from the central tasks of effective communication. This is evident, for example, among those graphic designers who have made pedestrian readings of deconstructionist literary theory the rationale for their work. Visual experimentation is an important part of graphic design thinking, but experimentation must finally be judged by relevance and effectiveness of communication. For a discussion of the limits of semiotics and design, see Seppo Vakeva, "What Do We Need Semiotics For?," Semantic Visions in Design, ed. Susann Vihma (Helsinki: University of Industrial Arts UIAH, 1990), g-2.

22) Swiss graphic designer Ruedi Ruegg has recently spoken of the need for more fantasy and freedom in graphic design thinking. Based on his approach, one might argue that efforts to introduce deconstructionist literary theory into graphic design have often led to a loss of freedom and imagination in effective communication, contrary to the claims of its proponents.

serve as the basis for analyzing what already exists. Placements have boundaries to shape and constrain meaning, but are not rigidly fixed and determinate. The boundary of a placement gives a context or orientation to thinking, but the application to a specific situation can generate a new perception of that situation and, hence, a new possibility to be tested. Therefore, placements are sources of new ideas and possibilities when applied to problems in concrete circumstances.[23]

As an ordered or systematic approach to the invention of possibilities, the doctrine of placements provides a useful means of understanding what many designers describe as the intuitive or serendipitous quality of their work. Individual designers often possess a personal set of placements, developed and tested by experience.[24] The inventiveness of the designer lies in a natural or cultivated and artful ability to return to those placements and apply them to a new situation, discovering aspects of the situation that affect the final design. What is regarded as the designer's style, then, is sometimes more than just a personal preference for certain types of visual forms, materials, or techniques; it is a characteristic way of seeing possibilities through conceptual placements. However, when a designer's conceptual placements become categories of thinking, the result can be mannered imitations of an earlier invention that are no longer relevant to the discovery of specific possibilities in a new situation. Ideas are then forced onto a situation rather than discovered in the particularities and novel possibilities of that situation.[25]

For the practicing designer, placements are primary and categories are secondary. The reverse holds true for design history, theory, and criticism, except at those moments when a new direction for inquiry is opened. At such times, a repositioning of the problems of design, such as a change in the subject matter to be addressed, the methods to be employed, or the principles to be explored, occurs by means of placements. Then, history, theory, or criticism are "redesigned" for the individual investigator and sometimes for groups of investigators.[26] As the discipline of design studies adds a reflective and philosophic dimension to design history, theory, and criticism, positive consequences are possible. Historians, for example, may reconsider the placement of design history as it has been practiced throughout most of the twentieth century and work to discover other innovative possibilities. Discontent with the results of current design history suggests that new repositionings are called for if the discipline is to retain vitality and relevance to contemporary problems.[27]

The doctrine of placements will require further development if it is to be recognized as a tool in design studies and design thinking, but it can also be a surprisingly precise way of addressing conceptual space and the non-dimensional images from which concrete possibilities emerge for testing in objective circumstances.[28] The natural and spontaneous use of placements by designers is

23) The concept of placements will remain difficult to grasp as long as individuals are trained to believe that the only path of reasoning begins with categories and proceeds in deductive chains of propositions. Designers are concerned with invention as well as judgment, and their reasoning is practical because it takes place in situations where the results are influenced by diverse opinions.

24) Some placements have become so common in twentieth-century design that they hardly attract attention. Nonetheless, such placements are classic features of design thinking, and in the hands of a skilled designer retain their inventive potential. Designer Jay Doblin sometimes employed a cascade of placements stemming from the basic placement "intrinsic/extrinsic." Doblin's placements serve as a heuristic device to reveal the factors in design thinking and product development. Other placements are described by Doblin in "Innovation, A Cook Book Approach," n.d. (Typewritten.) With different intent, Ezio Manzini recently argued that the designer needs two mental instruments with opposite qualities to examine a design situation: a microscope and a macroscope. The mental microscope is for examining "how things work, down to the smallest details," particularly in regard to advances in materials science. A further series of placements fill out the microscope to give it efficacy. See Ezio Manzini, The Materials of Invention: Materials and Design (Cambridge: M.I.T. Press, 1989), 58.

25) The ease with which placements are converted into categories should make any designer or design educator cautious in how they share the conceptual tools of their work. The placements that might shape an innovative approach for the founder of a school of design thinking often become categories of truth in the hands of disciples or descendants.

26) Thomas Kuhn was interested in the repositionings that mark revolutions in scientific theory. His study of this phenomenon, perhaps contrary to his initial expectations, has helped to alter the neo-positivist interpretation of the history of science. But Kuhn's

"paradigm shifts" were never developed to their fullest intellectual roots in rhetorical and dialectical invention, which are based on the theory of topics. Chaim Perelman has developed an important contemporary approach to what is called here the doctrine of placements. See Chaim Perelman and L. Olbrechts-Tyteca, The New Rhetoric: A Treatise on Argumentation (Notre Dame: University of Notre Dame Press, 1969). See also, Stephen E. Toulmin, The Uses of Argument (Cambridge: Cambridge University Press, 1958) for a modern discovery of dialectical topics. Although remote from the immediate interests of designers, these works are cited because they deal with practical reasoning and have important bearing on aspects of design theory, including the logic of decision making discussed in Simon's The Sciences of the Artificial.

27) In order to solve such problems, more attention should be given to the various conceptions of design held by designers in the past. This would reposition design history from material objects or "things" to thought and action. In other words, what designers say and do, the history of their art as philosophy and practice. For a discussion of the subject matter of design history, see Victor Margolin's forthcoming "Design History or Design Studies: Subject Matter and Methods," Design Studies.

28) The phrase "non-dimensional images" refers to all images created in the mind as part of design thinking and, in particular, to the various schematizations of conceptual placements (e.g. hierarchical, horizontal, or in matrix and table form) that may aid invention.

29) This list could also include the humanistic disciplines and the fine arts, because there is as much difficulty in communicating between some traditional humanists and designers as between designers and scientists. This is evident in the persistent view that design is simply a decorative art, adapting the principles of the fine arts to utilitarian ends, held by many humanists.

30) William R. Spillers, ed., Basic Questions of Design Theory (Amsterdam: North Holland Publishing Company, 1974). The conference, funded by the National Science Foundation, was held at Columbia University.

31) Vladimer Bazjanac, "Architectural Design Theory: Models of the Design Process," Basic Questions of Design Theory, 3-20.

already evident; an explicit understanding of the doctrine of placements will make it an important element of design as a liberal art.

All men and women require a liberal art of design to live well in the complexity of the framework based in signs, things, actions, and thoughts. On one hand, such an art will enable individuals to participate more directly in this framework and contribute to its development. On the other, professional designers could be regarded as masters in its exploration. The ability of designers to discover new relationships among signs, things, actions, and thoughts is one indication that design is not merely a technical specialization but a new liberal art.

The Wicked Problems Theory of Design

Recent conferences on design are evidence of a coherent, if not always systematic, effort to reach a clearer understanding of design as an integrative discipline. However, the participants, who increasingly come from diverse professions and academic disciplines, are not drawn together because they share a common definition of design, a common methodology, a common philosophy, or even a common set of objects to which everyone agrees that the term "design" should be applied. They are drawn together because they share a mutual interest in a common theme: *the conception and planning of the artificial.* Different definitions of design and different specifications of the methodology of design are variations of this broad theme, each a concrete exploration of what is possible in the development of its meanings and implications. Communication is possible at such meetings because the results of research and discussion, despite wide differences in intellectual and practical perspectives, are always connected by this theme and, therefore, supplemental. This is only possible, of course, if individuals have the wit to discover what is useful in each other's work and can cast the material in terms of their own vision of design thinking.

Members of the scientific community, however, must be puzzled by the types of problems addressed by professional designers and by the patterns of reasoning they employ. While scientists share in the new liberal art of design thinking, they are also masters of specialized subject matters and their related methods, as found in physics, chemistry, biology, mathematics, the social sciences, or one of the many subfields into which these sciences have been divided.[29] This creates one of the central problems of communication between scientists and designers, because the problems addressed by designers seldom fall solely within the boundaries of any one of these subject matters.

The problem of communication between scientists and designers was evident in a special conference on design theory held in New York in 1974.[30] This conference was interesting for several reasons, the most significant directly related to the content of the meeting itself. Reviewed in one of the initial papers,[31] the "wicked

problems" approach to design proved to be one of the central themes to which the participants often returned when seeking a connection between their remarkably diverse and seemingly incommensurate applications of design.[32] Also significant was the difficulty that most of the participants had in understanding each other. Although an observation of an outsider on the dynamics of the meeting, it is an excellent example of a "wicked problem" of design thinking.

The *wicked problems* approach was formulated by Horst Rittel in the 1960s, when design methodology was a subject of intense interest.[33] A mathematician, designer, and former teacher at the Hochschule für Gestaltung (HfG) Ulm, Rittel sought an alternative to the linear, step-by-step model of the design process being explored by many designers and design theorists.[34] Although there are many variations of the linear model, its proponents hold that the design process is divided into two distinct phases: *problem definition* and *problem solution. Problem definition* is an *analytic* sequence in which the designer determines all of the elements of the problem and specifies all of the requirements that a successful design solution must have. *Problem solution* is a *synthetic* sequence in which the various requirements are combined and balanced against each other, yielding a final plan to be carried into production.

In the abstract, such a model may appear attractive because it suggests a methodological precision that is, in its key features, independent from the perspective of the individual designer. In fact, many scientists and business professionals, as well as some designers, continue to find the idea of a linear model attractive, believing that it represents the only hope for a "logical" understanding of the design process. However, some critics were quick to point out two obvious points of weakness: one, the actual sequence of design thinking and decision making is not a simple linear process; and two, the problems addressed by designers do not, in actual practice, yield to any linear analysis and synthesis yet proposed.[35]

Rittel argued that most of the problems addressed by designers are *wicked problems.*[36] As described in the first published report of Rittel's idea, *wicked problems* are a "class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing."[37] This is an amusing description of what confronts designers in every new situation. But most important, it points toward a fundamental issue that lies behind practice: the relationship between *determinacy* and *indeterminacy* in design thinking. The linear model of design thinking is based on *determinate* problems which have definite conditions. The designer's task is to identify those conditions precisely and then calculate a solution. In contrast, the *wicked-problems* approach suggests that there is a fundamental *indeterminacy* in all but the most trivial design prob-

32) Graph theory, developed by the mathematician Frank Harary, also served to connect the work of researchers in many areas. It was reported by the organizers that Harary, who attended this conference and delivered the paper "Graphs as Designs," suggested that the basic structure of design theory could be found in his work on structural models. Whether or not Harary made such a suggestion, it is possible to see in graph theory, and, notably, the theory of directed graphs, a mathematical expression of the doctrine of placements. Comparison may establish a surprising connection between the arts of words and the mathematical arts of things, with further significance for the view of design as a new liberal art. "Schemata" are the connecting link, for placements may be schematized as figures of thought, and schemata are forms of graphs, directed or otherwise. For more on graph theory see F. Harary, R. Norman, and D. Cartwright, Structural Models: An Introduction to the Theory of Directed Graphs (New York: Wiley, 1965).

33) A series of conferences on Design Methods held in the United Kingdom in 1962, 1965, and 1967, led to the formation of the Design Research Society in 1967, that today continues to publish the journal Design Studies. Parallel interest in the United States led to the establishment of the Design Methods Group in 1966, which published the DMG Newsletter (1966-71), renamed the DMG-DRS Journal: Design Research and Methods, and then renamed in 1976 and published to the present as Design Methods and Theories. For one attempt to describe and integrate a set of methods used in design thinking, see J. Christopher Jones, Design Methods: Seeds of Human Futures (1970; rpt New York: John Wiley & Sons, 1981). Many of the methods Jones presents are consciously transposed from other disciplines. However, they all can be interpreted as techniques for repositioning design problems, using placements to discover new possibilities.

34) Rittel, who died in 1990, completed his career by teaching at the University of California at Berkeley and the University of Stuttgart. For a brief biographical sketch, see Herbert Lindinger, Ulm Design: The Morality of Objects (Cambridge: M.I.T. Press, 1990), 274.

lems—problems where, as Rittel suggests, the "wickedness" has already been taken out to yield determinate or analytic problems.

To understand what this means, it is important to recognize that *indeterminacy* is quite different from *undetermined. Indeterminacy* implies that there are no definitive conditions or limits to design problems. This is evident, for example, in the ten properties of *wicked problems* that Rittel initially identified in 1972.[38]

(1) *Wicked problems* have no definitive formulation, but every formulation of a *wicked problem* corresponds to the formulation of a solution.
(2) *Wicked problems* have no stopping rules.
(3) Solutions to *wicked problems* cannot be true or false, only good or bad.
(4) In solving *wicked problems* there is no exhaustive list of admissible operations.
(5) For every *wicked problem* there is always more than one possible explanation, with explanations depending on the *Weltanschauung* of the designer.[39]
(6) Every *wicked problem* is a symptom of another, "higher level," problem.[40]
(7) No formulation and solution of a *wicked problem* has a definitive test.
(8) Solving a *wicked problem* is a "one shot" operation, with no room for trial and error.[41]
(9) Every *wicked problem* is unique.
(10) The *wicked problem* solver has no right to be wrong—they are fully responsible for their actions.

This is a remarkable list, and it is tempting to go no further than elaborate the meaning of each property, providing concrete examples drawn from every area of design thinking. But to do so would leave a fundamental question unanswered. *Why are design problems indeterminate and, therefore, wicked?* Neither Rittel nor any of those studying *wicked problems* has attempted to answer this question, so the *wicked-problems* approach has remained only a description of the social reality of designing rather than the beginnings of a well-grounded theory of design.

However, the answer to the question lies in something rarely considered: the peculiar nature of the subject matter of design. Design problems are "indeterminate" and "wicked" because design has no special subject matter of its own apart from what a designer conceives it to be. The subject matter of design is potentially *universal* in scope, because design thinking may be applied to any area of human experience. But in the process of application, the designer must discover or invent a *particular* subject out of the problems and issues of specific circumstances. This sharply contrasts with the disciplines of science, which are concerned with understanding the principles, laws, rules, or structures that are necessarily embodied in existing subject matters. Such subject matters are undetermined or

35) Bazjanac presents an interesting comparison of linear models and the wicked problems approach.

36) The phrase wicked problems was borrowed from philosopher Karl Popper. However, Rittel developed the idea in a different direction. Rittel is another example of someone initially influenced by neo-positivist ideas who, when confronted with the actual processes of practical reasoning in concrete circumstances, sought to develop a new approach related to rhetoric.

37) The first published report of Rittel's concept of wicked problems was presented by C. West Churchman, "Wicked Problems," Management Science, (December 1967), vol. 4, no. 14, B-141-42. His editorial is particularly interesting for its discussion of the moral problems of design and planning that can occur when individuals mistakenly believe that they have effectively taken the "wickedness" out of design problems.

38) See Horst W. J. Rittel and Melvin M. Webber, "Dilemmas in a General Theory of Planning," working paper presented at the Institute of Urban and Regional Development, University of California, Berkeley, November 1972. See also an interview with Rittel, "Son of Rittelthink," Design Methods Group 5th Anniversary Report (January 1972), 5-10; and Horst Rittel, "On the Planning Crisis: Systems Analysis of the First and Second Generations," Bedriftsokonomen, no. 8: 390-96. Rittel gradually added more properties to his initial list.

39) Weltanschauung identifies the intellectual perspective of the designer as an integral part of the design process.

40) This property suggests the systems aspect of Rittel's approach.

41) Rittel's example is drawn from architecture, where it is not feasible to rebuild a flawed building. Perhaps the general property should be described as "entrapment" in a line of design thinking. Designers as well as their clients or managers are often "entrapped" during the development phase of a new product and are unable, for good or bad reasons, to terminate a weak design. For a brief illustration of entrapment in the product development process of a small midwestern company, see Richard Buchanan, "Wicked Problems: Managing the Entrapment Trap," Innovation (Summer, 1991), 10:3.

under-determined, requiring further investigation to make them more fully determinate. But they are not radically indeterminate in a way directly comparable to that of design.[42]

Designers conceive their subject matter in two ways on two levels: general and particular. On a *general level*, a designer forms an idea or a working hypothesis about the nature of products or the nature of the humanmade in the world. This is the designer's view of what is meant, for example, by the "artificial" in relation to the "natural." In this sense, the designer holds a broad view of the nature of design and the proper scope of its application. Indeed, most designers, to the degree that they have reflected on their discipline, will gladly, if not insistently, explain on a general level what the subject matter of design is. When developed and well presented, these explanations are philosophies or proto-philosophies of design that exist within a plurality of alternative views.[43] They provide an essential framework for each designer to understand and explore the materials, methods, and principles of design thinking. But such philosophies do not and cannot constitute sciences of design in the sense of any natural, social, or humanistic science. The reason for this is simple: design is fundamentally concerned with the particular, *and there is no science of the particular.*

In actual practice, the designer begins with what should be called a *quasi-subject matter*, tenuously existing within the problems and issues of specific circumstances. Out of the specific possibilities of a concrete situation, the designer must conceive a design that will lead to *this* or *that* particular product. A *quasi-subject matter* is not an undetermined subject waiting to be made determinate. It is an indeterminate subject waiting to be made specific and concrete. For example, a client's brief does not present a definition of the subject matter of a particular design application. It presents a problem and a set of issues to be considered in resolving that problem. In situations where a brief specifies in great detail the particular features of the product to be planned, it often does so because an owner, corporate executive, or manager has attempted to perform the critical task of transforming problems and issues into a working hypothesis about the particular features of the product to be designed. In effect, someone has attempted to take the "wickedness" out. Even in this situation, however, the conception of particular features remains only a possibility that may be subject to change through discussion and argument.[44]

This is where placements take on special significance as tools of design thinking. They allow the designer to position and reposition the problems and issues at hand. Placements are the tools by which a designer intuitively or deliberately shapes a design situation, identifying the views of all participants, the issues which concern them, and the invention that will serve as a working hypothesis for exploration and development. In this sense, the placements selected by a designer are the same as what determinate subject

42) There is one case in which even the subject matters of the sciences are indeterminate. The working hypotheses of scientists invariably reflect distinctive philosophic perspectives on and interpretations of what constitutes nature and natural processes. This is a factor in accounting for the surprising pluralism of philosophies among practicing scientists and suggests that even science is shaped by an application of design thinking, developed along the lines of Dewey's notion of "intentional operations." Even from this perspective, however, scientists are concerned with understanding the universal properties of what is, while designers are concerned with conceiving and planning a particular that does not yet exist. Indeterminacy for the scientist is on the level of second-intention, while the subject matter remains, at the level of first-intention, determinate in the manner described. For the designer, indeterminacy belongs to both first- and second-intention.

43) For a brief discussion of different conceptions of subject matter on this level held by three contemporary designers, Ezio Manzini, Gaetano Pesce, and Emilio Ambaz, see Richard Buchanan, "Metaphors, Narratives, and Fables in New Design Thinking," Design Issues VII-1 (Fall, 1990): 78-84. Without understanding a designer's view of subject matter on the general level, there is little intelligibility in the shifts that occur when a designer moves, for example, from designing domestic products to graphic design or architecture. Such shifts are usually described in terms of the designer's "personality" or "circumstances," rather than the continued development of a coherent intellectual perspective on the artificial.

44) Failure to include professional designers as early as possible in the product development process is one of the sources of entrapment in corporate culture. Professional designers should be recognized for their ability to conceive products as well as plan them.

matters are for the scientist. They are the *quasi-subject matter* of design thinking, from which the designer fashions a working hypothesis suited to special circumstances.

This helps to explain how design functions as an integrative discipline. By using placements to discover or invent a working hypothesis, the designer establishes a *principle of relevance* for knowledge from the arts and sciences, determining how such knowledge may be useful to design thinking in a particular circumstance without immediately reducing design to one or another of these disciplines. In effect, the working hypothesis that will lead to a particular product is the principle of relevance, guiding the efforts of designers to gather all available knowledge bearing on how a product is finally planned.

But does the designer's working hypothesis or principle of relevance suggest that the product itself is a determinate subject matter? The answer involves a critical but often blurred distinction between design thinking and the activity of production or making. Once a product is conceived, planned, and produced, it may indeed become an object for study by any of the arts and sciences—history, economics, psychology, sociology, or anthropology. It may even become an object for study by a new humanistic science of production that we could call the "science of the artificial," directed toward understanding the nature, form, and uses of humanmade products in all of their generic kinds.[45] But in all such studies, the activities of design thinking are easily forgotten or are reduced to the kind of product that is finally produced. The problem for designers is to conceive and plan what does not yet exist, and this occurs in the context of the indeterminacy of *wicked problems*, before the final result is known.

This is the creative or inventive activity that Herbert Simon has in mind when he speaks of design as a science of the artificial. What he means is "devising artifacts to attain goals" or, more broadly, "doctrine about the design process."[46] In this sense, Simon's science of the artificial is perhaps closer to what Dewey means by technology as a systematic discipline of experimental thinking. However, Simon has little to say about the difference between designing a product and making it. Consequently, the "search" procedures and decision-making protocols that he proposes for design are largely analytic, shaped by his philosophic view of the determinacies that follow from the natural laws that surround artifacts.[47]

For all of the insight Simon has in distinguishing the artificial as a domain of humanmade products different from objects created by natural processes, he does not capture the radical sense in which designers explore the essence of what the artificial may be in human experience.[48] This is a synthetic activity related to indeterminacy, not an activity of making what is undetermined in natural laws more determinate in artifacts. In short, Simon appears to have conflated two sciences of the artificial: an inventive science of design thinking which has no subject matter aside from what the designer

45) The earliest example of this science is Aristotle's Poetics. Although this work is directed toward the analysis of literary productions and tragedy in particular, Aristotle frequently discusses useful objects in terms of the principles of poetic analysis. "Poetics," from the Greek word for "making," is used by Aristotle to refer to productive science or the science of the artificial, which he distinguishes both from theoretic and practical sciences. Few investigators have recognized that poetic analysis can be extended to the study of making "useful" objects. When designer and architect Emilio Ambaz refers to the "poetics of the pragmatic," he means not only esthetic or elegant features of everyday objects, but also a method or discipline of analysis that may contribute to design thinking.

46) Simon, The Sciences of the Artificial, 52-53.

47) For Simon, the "artificial" is an "interface" created within a materialist reality: "I have shown that a science of artificial phenomena is always in imminent danger of dissolving and vanishing. The peculiar properties of the artifact lie on the thin interface between the natural laws within it and the natural laws without." Simon, The Sciences of the Artificial, 57. This is

one expression of the positivist or empiricist philosophy that guides Simon's theory of design.

48) For Simon, the equivalent of a wicked problem is an "ill-structured problem." For Simon's views on how ill-structured problems may be addressed, see "The Structure of Ill-Structured Problems," Models of Discovery (Boston: D. Reidel, 1977), 305-25. This paper has interesting connections with the doctrine of placements because placements may be used to organize and store memories, and Simon is particularly concerned with the role of long-term memory in solving ill-structured problems. But Simon's methods are still analytic, directed toward the discovery of solutions in some sense already known rather than the invention of solutions yet unknown.

49) Although Simon's title, The Sciences of the Artificial, is a perfectly adequate translation of what we have come to know in Western culture as Aristotle's Poetics, Simon seems unaware of the humanistic tradition of poetic and rhetorical analysis of the artificial that followed from Aristotle. This is not an antiquarian issue, because the study of literary production—the artificial formed in words—prefigures the issues that surround the study of the artificial in all other types of useful objects. Aristotle carefully distinguished the science of the artificial from the art of rhetoric. When Aristotle comes to discuss the thought that is presented in an artificial object such as a tragedy, he pointedly refers the reader to his treatise on the inventive art of rhetoric for the fullest elaboration of the issue. However, Simon deserves less criticism for overlooking this connection than humanists who have been amazingly neglectful, if not scornful, of the rise of design and technology in the twentieth century.

50) One example of such reflection is the interdisciplinary conference "Discovering Design," organized by R. Buchanan and V. Margolin and held at the University of Illinois at Chicago in 1990. The collected papers from this conference will be published as Discovering Design: Explorations in Design Studies.

51) Richard McKeon, "Logos: Technology, Philology, and History," in Proceedings of the XVth World Congress of Philosophy: Varna, Bulgaria, September 17-22, 1973 (Sofia: Sofia Press Production Center, 1974), 3:481-84.

conceives it to be, and a science of existing humanmade products whose nature Simon happens to believe is a manipulation of material and behavioral laws of nature.[49]

Design is a remarkably supple discipline, amenable to radically different interpretations in philosophy as well as in practice. But the flexibility of design often leads to popular misunderstanding and clouds efforts to understand its nature. The history of design is not merely a history of objects. It is a history of the changing views of subject matter held by designers and the concrete objects conceived, planned, and produced as expressions of those views. *One could go further and say that the history of design history is a record of the design historians' views regarding what they conceive to be the subject matter of design.*

We have been slow to recognize the peculiar indeterminacy of subject matter in design and its impact on the nature of design thinking. As a consequence, each of the sciences that have come into contact with design has tended to regard design as an "applied" version of its own knowledge, methods, and principles. They see in design an instance of their own subject matter and treat design as a *practical demonstration* of the scientific principles of that subject matter. Thus, we have the odd, recurring situation in which design is alternately regarded as "applied" natural science, "applied" social science, or "applied" fine art. No wonder designers and members of the scientific community often have difficulty communicating.

Design and Technology

Many problems remain to be explored in establishing design as a liberal art of technological culture. But as it continues to unfold in the work of individual designers and in reflection on the nature of their work,[50] design is slowly restoring the richer meaning of the term "technology" that was all but lost with the rise of the Industrial Revolution. Most people continue to think of technology in terms of its *product* rather than its form as a *discipline of systematic thinking*. They regard technology as things and machines, observing with concern that the machines of our culture often appear out of human control, threatening to trap and enslave rather than liberate. But there was a time in an earlier period of Western culture when technology was a human activity operating throughout the liberal arts.[51] Every liberal art had its own *technologia* or systematic discipline. To possess that technology or discipline of thinking was to possess the liberal art, to be human, and to be free in seeking one's place in the world.

Design also has a *technologia*, and it is manifested in the plan for every new product. The plan is an argument, reflecting the deliberations of designers and their efforts to integrate knowledge in new ways, suited to specific circumstances and needs. In this sense, design is emerging as a new discipline of practical reasoning and argumentation, directed by individual designers toward one or another of its major thematic variations in the twentieth cen-

tury: design as *communication*, *construction*, *strategic planning*, or *systemic integration*.[52] The power of design as deliberation and argument lies in overcoming the limitations of mere verbal or symbolic argument—the separation of words and things, or theory and practice that remains a source of disruption and confusion in contemporary culture. Argument in design thinking moves toward the concrete interplay and interconnection of signs, things, actions, and thoughts. Every designer's sketch, blueprint, flow chart, graph, three-dimensional model, or other product proposal is an example of such argumentation.

However, there is persistent confusion about the different modes of argumentation employed by the various design professions. For example, industrial design, engineering, and marketing each employ the discipline of design thinking, yet their arguments are often framed in sharply different logical modalities. Industrial design tends to stress what is *possible* in the conception and planning of products; engineering tends to stress what is *necessary* in considering materials, mechanisms, structures, and systems;[53] while marketing tends to stress what is *contingent* in the changing attitudes and preferences of potential users. Because of these modal differences in approaching design problems, three of the most important professions of design thinking are often regarded as bitter opponents in the design enterprise, irreconcilably distant from each other.[54]

What design as a liberal art contributes to this situation is a new awareness of how argument is the central theme that cuts across the many technical methodologies employed in each design profession. Differences of modality may be complementary ways of arguing—reciprocal expressions of what conditions and shapes the "useful" in human experience. As a liberal art of technological culture, design points toward a new attitude about the appearance of products. Appearance must carry a deeper, integrative argument about the nature of the artificial in human experience. This argument is a synthesis of three lines of reasoning: the ideas of designers and manufacturers about their products; the internal operational logic of products; and the desire and ability of human beings to use products in everyday life in ways that reflect personal and social values. Effective design depends on the ability of designers to integrate all three lines of reasoning. But not as isolated factors that can be added together in a simple mathematical total, or as isolated subject matters that can be studied separately and joined late in the product development process.

The new liberal art of design thinking is turning to the modality of *impossibility*. It points, for example, toward the impossibility of rigid boundaries between industrial design, engineering, and marketing. It points toward the impossibility of relying on any one of the sciences (natural, social, or humanistic) for adequate solutions to what are the inherently *wicked problems* of design thinking. Finally,

52) For Rittel's view of argumentation in design, see Rittel and Webber, Dilemmas, 19. Also discussed in Bazjanac, "Architectural Design Theory: Models of the Design Process," Basic Questions of Design Theory. Students report that late in his career Rittel came to recognize the affinity between his approach and rhetoric.

53) The necessary is sometimes referred to as "capacity" or "capability" in engineering. For a useful introduction to engineering design, see M. J. French, Invention and Evolution: Design in Nature and Engineering (Cambridge: Cambridge University Press, 1988).

54) Philip Kotler, the internationally recognized expert on marketing, has suggested that what many industrial designers object to in marketing should not be regarded as marketing itself, but as bad marketing. For new developments in marketing, see Philip Kotler, "Humanistic Marketing: Beyond the Marketing Concept," *Philosophical and Radical Thought in Marketing*, eds. A. Fuat Firat, N. Dholakia, and R. P. Bagozzi (Lexington, Massachusetts: Lexington Books, 1987).

it points toward something that is often forgotten, that what many people call "impossible" may actually only be a limitation of imagination that can be overcome by better design thinking. This is not thinking directed toward a technological "quick fix" in hardware but toward new integrations of signs, things, actions, and environments that address the concrete needs and values of human beings in diverse circumstances.

Individuals trained in the traditional arts and sciences may continue to be puzzled by the neoteric art of design.[55] But the masters of this new liberal art are practical men and women, and the discipline of thinking that they employ is gradually becoming accessible to all individuals in everyday life. A common discipline of design thinking—more than the particular products created by that discipline today—is changing our culture, not only in its external manifestations but in its internal character.

55) "Neoteric" is a term often associated in Western culture with the emergence of new liberal arts. Neoteric arts are arts of "new learning." For a discussion of neoteric and paleoteric liberal arts, see Richard Buchanan, "Design as a Liberal Art," Papers: The 1990 Conference on Design Education, Education Committee of the Industrial Designers Society of America (Pasadena, CA, 1990).