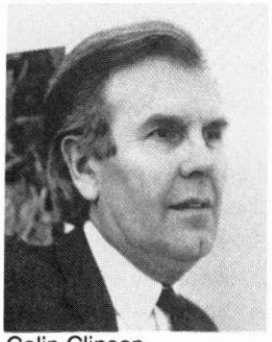
Silent, Robust, Predictable

and other ways of designing

by Colin Clipson



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This paper traces the recent emergence of some new design process and methods issues. These issues are closely related to contemporary means of production and project management. The paper speculates upon their impact on traditional methods of designing.

THERE HAS LONG BEEN A STRONG ELEMENT of doubt lurking in the minds of students and practitioners of design about the divide which exists between how designers are taught to design in schools and how designers go about learning to design in practice. One is reminded of Peter Drucker's observations about the gap between the theories of medicine and the practice of surgery in the seventeenth century.[1] Academy based doctors postulated theories and methods relying very often on Latin as the preferred language of communication, while the practice of surgical intervention was carried out by barbers on the street with the varying degrees of skill of their trade. Though the line is not drawn as dramatically in design today, and there are certainly cross-overs between theory and practice, the substance of the divide has fueled research and speculation by theorists and practitioners (but mostly theorists) about how designing is and should be done.

Literature on design process and methods began to appear in profusion in the late 1950s and 1960s. This came from a variety of professional and disciplinary backgrounds – engineering, architecture, industrial design and visual communications, operations research, and ergonomics. Encouraged by the activity several international conferences were held in Britain, the United States, and Germany and research organizations were formed such as the Design Methods Group in the United States and the Design Research Society in Great Britain, these in turn established ties with such groups as the Ergonomics Society and the Human Factors Research Society. Since that time, research activity and literature on designing has continued to grow subject to the influences of changing disciplines, emerging technologies, and funding sources. While most design education for architects, industrial designers and graphic designers remains essentially a learning experience with traditional 'design by

drawing' at the core, and technical subject and humanities around the core, design methodology researchers have speculated on the issues of growing complexity in the world of artefacts and services, and the inability of the traditional design approaches to meet the needs of today's complex project demand and delivery. The strengths and weaknesses of various approaches, traditional and new have been the subject of much of the research work of the past twenty years,[2,3] the majority of the work emanating from a relatively few academic institutions around the world. During this same time period, design education has remained faithful to the traditional design by drawing core, with some fluctuation in emphasis in the subject matter around the core. By contrast, global, economic, technical, political and social conditions have changed dramatically with deep and lasting implications for the practice of design in its various forms. Changes in the ways of making things have accelerated the pace and problems of production over the past decade. Advances in materials technology, in concert with innovative fabrication and assembly processes have resulted in so called lean production systems that are forcing producers all over the world to take stock of how things are made. Developing and managing these production systems has focused attention not only on how things are made but how they are designed. Therefore practice of design in architecture, industrial design, manufacturing engineering, visual communication both electronic and graphic, are subject to extreme changes in demand, delivery and technology brought on by market place conditions; yet both design teachers and practitioners have been slow to react to these changes. Architects in many countries are suffering levels of unemployment and lack of demand for their services unprecedented since the Great Depressions of the 1920s and 1930s, industrial designers are perplexed by the often conflicting demands of designing form and designing for manufacturing, and traditionally trained graphic designers, threatened with near extinction by digital image making and computer generated typography and printing have begun to respond by taking steps to radically alter their approaches to training and practice. Thus, research on designing, teaching designers, and practicing design uneasily coexist in this volatile environment often with only the most tenuous connections. Indeed, some serious observers of the situation have pointed to what they see as the increasing autonomy of theory, design, technology, and practice. Gutman[4] focuses on the separation of architectural theories, teaching, and practice in his recent works, and emphasizes what he calls design theory grounded in a "rhetoric of alienation" that appears to relish the inability of architects to be more effective in dealing with contemporary building problems.

In most U.S. schools, the careful layering of design studios, technical courses, professional practice and design methods, with or without research activity supporting the educational program, almost guarantees research, teaching and practice will continue in a semi-autonomous fashion.

None of this is new of course, in the United States studies supported by the Andrew Mellon Foundation more than ten years ago documented the lack of fit between architectural design education and the changing demands of practice and the market place.[5] According to these studies, students in schools of architecture receive continuous and intensive training in form-making based on fictional programs which make little or no pretense at simulating the realities of practice and real world building, economic, and user problems.

Design training is seen to be a vehicle for the advancement of the teachers' architectural theories "These involved the manipulation of built form based on selective 'high art' precedents. In all the examples, to a greater or lesser degree, this led to the independence of architectural form from building content. Not a separation but on unequal coexistence in which each developed out of separate rules but in which the romantically deduced formal principles governed."[6] In the same studies, practicing architects interviewed

stated that their academic training had not prepared them sufficiently to deal with diverse challenges of professional practice. Many of them had graduated without a working knowledge of construction, materials, building environment relationships, about how to predict the impact of a building on its users or about how to manage even modest sized projects, the network of working relationships involved, and how to manage relations with clients and users. In other words without an appreciation for a comprehensive design process and supportive methods. In 1987 an evaluation study[7] of British design schools and their relationship to other disciplines and industry identified similar problems stemming from the autonomy of design culture. The report pointed to the effects of the particular "professionalization of designers" and the consequent tendency for them to put boundaries around their expertise, thus inhibiting expertise from flowing to and from other parts of the development enterprise. One major criticism lay in the lack of integration of design training with economic, technical and social disciplines; the marginal role of engineering disciplines and knowledge of technologies being seen as a serious weakness.

Since 1970 there has been steady growth of doctoral programs in architecture in the United States, and as many as thirty schools claim to have research programs doing research on a wide range of topics including design methods, building and environmental technology, environment and behavior, history/theory, and management issues. However in my view, there is little to suggest that these recent institutional developments in doctoral education and research have had any significant impact on the prevailing methods of teaching of design in professional programs. Furthermore, few schools of industrial or graphic design have research programs or offer doctoral degrees in design studies, so that the crucial links between design research, design education, and design practice are missing, resulting in seriously disfunctional professional activity. Research on design processes and methods is therefore borrowed from other source disciplines, is sporadic in its availability, and as a result serious study of designing, and acknowledging research on the subject as an essential component of learning to design, is lacking in most schools.

In recent years the study of designing has been receiving much attention in other quarters, namely business and management schools, manufacturing engineering, computer science and cognitive science. The convergence of many issues – technical, economic, social, has made designing the center of attention in a number of different fields. The result is a fresh set of design research issues to be considered, and a new group of researchers and consortia making an impact on the study of design methods and processes. The remaining part of this presentation will attempt to explain why this has happened and why it is important to design schools.

Before doing this, I think it is worth mentioning that interest in designing has moved off the pages of design journals and on to the pages of the business press and even the popular press. To quote the influential *Fortune* magazine "The 1970's were the decade of price reduction, the 1980's were the decade of quality, the 1990's will be the decade of design."[8] *Fortune*, *Business Week*, *the Harvard Business Review* and other monthlies have begun to pick up on the results of research and practical industrial application that designing in one or other of its forms is key to product innovation, is critical in developing high levels of quality and performance, and will be a major force in differentiating products and services in highly competitive markets of the future. Further evidence of this wider appeal of design can be seen in the best selling popularity of Donald Norman's *The Psychology of Everyday Things*[9] a serious and entertaining work about the relationship between people and everyday objects and the ways we use them. Norman, a cognitive scientist, sees design at the root of all decisions about making things work for people and with people. "The designer must develop a conceptual model that is appropriate for the user, that captures the importance of the operation of

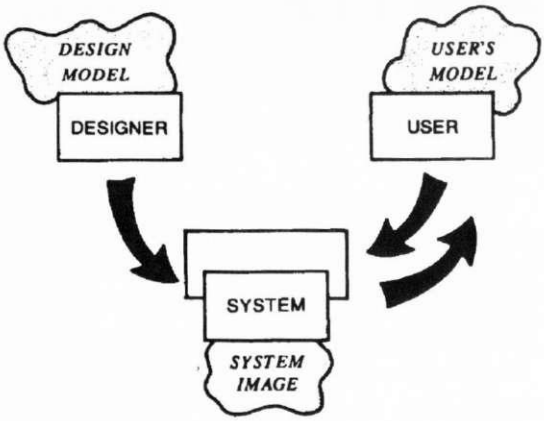

Figure 1. From Norman 1986. Three Aspects of the Conceptual Model: the design model, the user's model, the system image.

the device, and that is understandable to the user ... three different aspects of the model must be distinguished: the design model, the user's model, and the system image. The design model is the conceptualization that the designer has in mind, the user's model is what the user develops to explain the operation of the system. Ideally, the user's model and the design model are equivalent. However, the user and designer communicate only through the system itself: its physical appearance, its operation, the way it responds, and the manuals and instructions that accompany it. Thus the system image is critical: the designer must ensure that everything about the product is consistent with and exemplifies the operation of the proper conceptual model."[10]

Current practices in co-determination, codesigning, covisioning, serve to emphasize the importance of designing as a ubiquitous activity in which many actors may play significant roles and must be considered as sources of expert knowledge alongside professional designers. The research of Von Hippel[11] documents the role of users as the originators of many innovations from household products, to computers, to medical electronics. Building the user into the design process has received periodic attention in design research but has not received the research integration it deserves in design programs. To many of us in the United States and Britain, the progressive climate for participatory design and decision making in Scandinavia has served as a model for our more modest efforts at developing design methods that are both more democratic and innovative in their incorporation of the user as designer and innovator.[12,13]

During the 1980s there was a massive international investment in developing processes and tools to improve quality, performance and cost of all types of artefact and services. Initially inspired by such researchers as Deming and Juran and culminating in what has been called in Japan and elsewhere The Quality Movement, the investment is resulting in the "re-engineering" of all types of enterprises. Research on the control of manufacturing and process engineering, identified design as the cause of over 60% of the quality defects in manufactured goods; a significant attribute whichever way you look at it. Japanese researchers like Shigeo Shingo[14] in collaboration with Japanese manufacturers have developed new production systems, in which many types of designing play a crucial and strategic role.

Multinational corporations like Philips of Eindhoven, (one of the world's largest producers of consumer electronic products) have radically

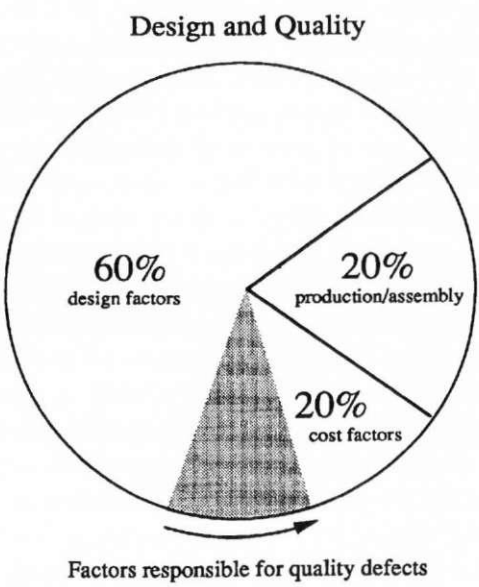

Figure 2.

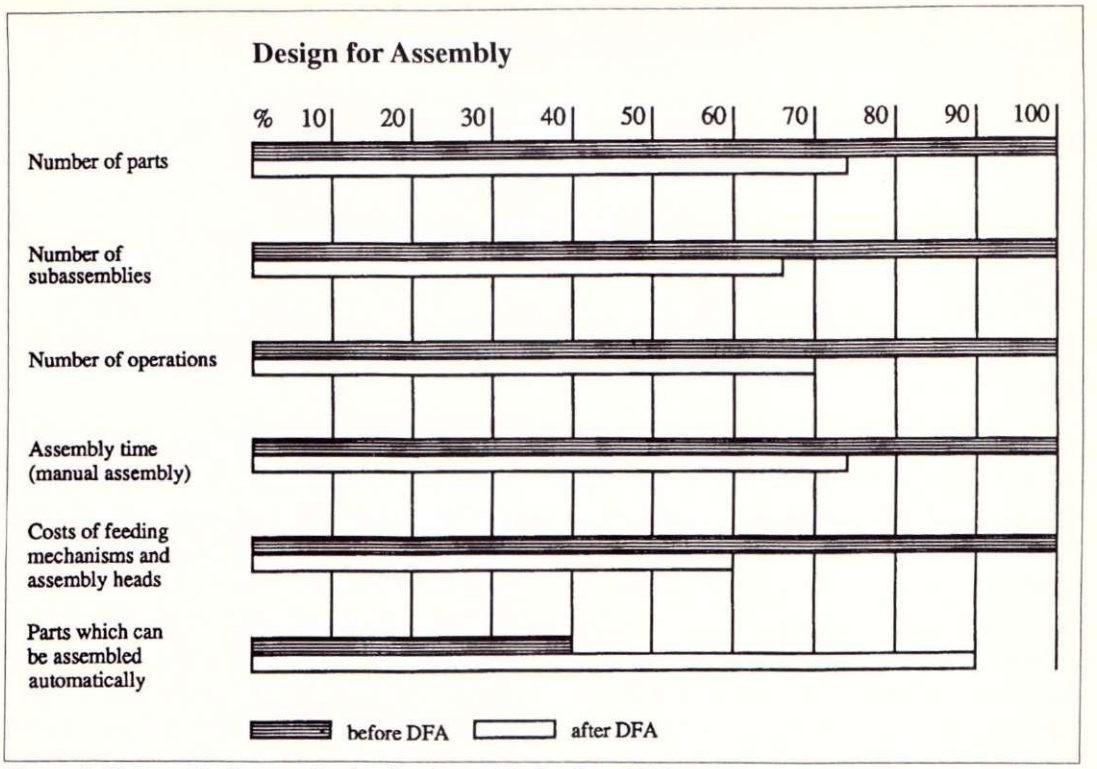

Figure 3. Philips, Eindhoven. Design for Assembly Studies, 1988.

"redesigned themselves" (in the words of Philips managing director of design Robert Blaiche) to develop a product cycle, and product quality that is as competitive as Sony and Sharp. Studies of Philips Design for Manufacturing and Assembly processes (DFM, DFA) demonstrate the critical importance of using designing as a strategic tool for improving product quality and performance. Figure 3 illustrates the manufacturing performance before and after DFA.

Redesign at Philips has resulted in reduction of some product cycles from 14–16 months in 1980 to 7 months in 1988. Much of the research be-hind these changes is of course proprietal and we can only speculate on the impact of these powerful forms of designing on other sectors; but it is safe to assume, I think, that such experience will have a profound effect on our view of design processes and methods in general terms.

Business schools and management institutes throughout the world have begun to pay attention, and to focus on how designing can be channeled and managed as a business resource. Design management studies and programs are springing up everywhere; courses, programs and texts[15] are being produced in most European countries, Britain, the United States and of course countries on the Pacific Rim. I suspect that as more and more evidence is available on the impact of design on quality, performance, cost to produce, and customer satisfaction, so business schools will begin to lead the way in Design Management research and practice.

The way in which a company understands and organizes design can have a profound impact on its performance and ability to innovate. Business researchers are beginning to see special roles for managers as essential "silent designers" who have far reaching responsibilities for choosing and integrating the various types of design and other resources into an effective product development process. Dumas and Mintzberg in "Managing the Form, Function and Fit of Design" (1991)[16] outline four models each of which describes a design process with particular methods

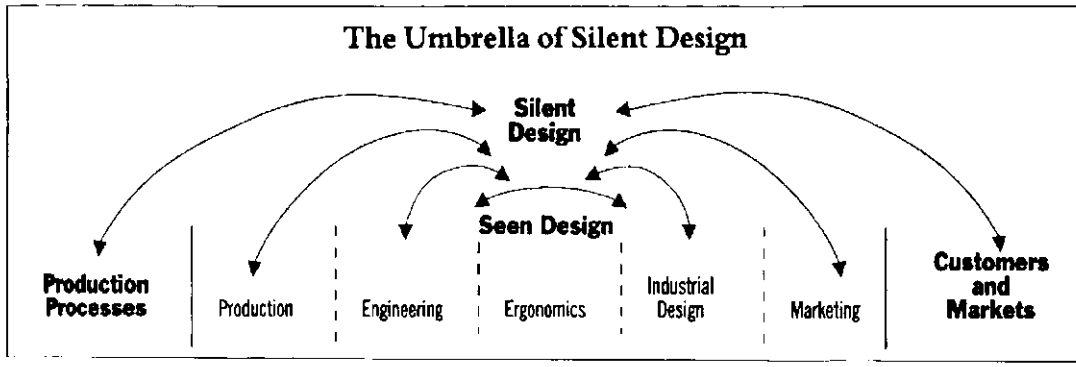

Figure 4. Dumas and Mintzberg, 1991.

for integrating and phasing the design activity. In one of their models – entitled Cooperative Design they spell out the roles for engineering and industrial designers but also for what they call 'silent designers', silent designing being the responsibility of those who deal with the function and fit of the whole process from inception of the idea to the customer. In the view of Dumas and Mintzberg (and other researchers like Peter Gorb) 'silent designers' have a responsibility to establish a design reality which is as important to success of the enterprise as the work of industrial designers, architects and engineers. Thus managers practice 'silent design' to control the many decisions taken to integrate all the resources of a project (no matter how unaware the form designers may be of their impact). These researchers point to examples from automobiles to kitchen products, department stores, museums, and discotheques that are developed by 'silent design' as the 'umbrella' for the other form-making ways of designing.

Industrial research and industrial experience of the past decade suggest some major themes for design research and practice. According to research by Whitney[17] in studies of the manufacture of automobile components at General Motors, 70% of the cost is determined by the design stage. At Rolls Royce design determines 80% of the final production costs of 2 000 components. While managers used to think of 5% improvements in costs as being good, industry leaders have goals today for slashing costs by 30% to 50%, and design plays a crucial role whether by intention or default. New design tools like mechanical computer-aided engineering design systems (MCAE) permit design teams to simulate and test designs before they are built so that they can improve quality, reliability, and performance, through design variations. The key to this approach is **designing for predictability.** In manufacturing terms, a well designed product is a predictable product, and one that presents no surprises or problems during fabrication, assembly, and use. MCAE systems reduce the number of design trials and prototypes by reducing the complexity of the design, reducing the number of parts, simplifying sub-assemblies, and simplifying types of fasteners and manual finishes.

ITI DESIGN "BACKWARDS" PROCESS

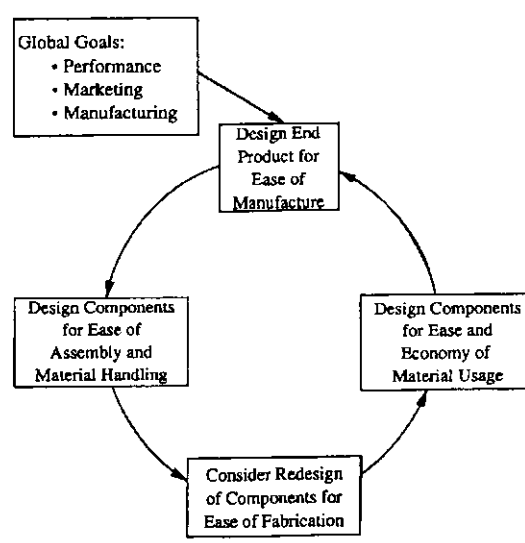

Figure 5.

Backed by expert systems which evaluate the best solutions from a manufacturing process and cost viewpoint **Design for Predictability** will have a significant influence on all types of architectural and industrial design where ease of producibility is important.

To look at these design tools in terms of architectural design methods is difficult at the present time because we do not know how many architects use computer aids for the simulation of **conceptual design**, and use computer models to test the producibility of their designs, and the environmental/land use impacts of their building forms. It is more clear that CAD/CAE are being used widely to detail the lower level design functions and to detail structural and construction information. Given what we know about the use of expert systems and MCAE in manufacturing, and the interest of large construction organizations involved in the application of these to large scale developments (e. g. Shimizu Corporation) we can expect that this type of project automation will begin to have a real impact on the management of Design-Construction process. Cost estimating, scheduling, material selection and control, architectural programmer checks, reductions of change orders, spec. verifications; all of which lend themselves to integration into a project design database from which project delivery is managed.

While a great deal has been written about flexible and predictable manufacturing by design, **robust design**, or the development of adaptable product design families has received less attention, though it is as important from a design process and methods viewpoint. Rothwell and Gardiner (1985)[18] studied the performance of products and categorized them as **'robust'** and **'lean'** designs. Robust designs are those which result in products that can be continuously modified to accommodate market changes, and flexibility in use over a long product life; such products are described as having a great deal of "stretch." Lean designs on the other hand, are less adaptable, less able to accommodate new demands, and thus are less adaptable as subjects for incremental innovation and reuse. Aircraft, cars, machine tools and many other products may be categorized as having robust or lean designs, and this attribute will have an impact on their success in the marketplace. Robust design may be achieved by developing Product Design Families which allow design variations of a product to be developed within an open ended modular concept, with flexible response to changing user requirements or sudden market shifts. Robust design through product families emphasizes the need to develop design attributes which afford adaptable features and assemblies while maintaining high performance and quality (e. g. Nikon, Sony). Robust design has been much in evidence in volatile, highly competitive markets.

Earlier, I argued that traditional schools of design – architecture, industrial design, visual communications, have settled for a traditional design core of 'design by drawing' and model making surrounded by a periphery of technical and other subjects. In the latter part of this paper I have suggested that another design core is emerging, one which includes 'design by drawing' but places the traditional design approach in with an array of production and management design process techniques, some of them implemented by new types of designers.

Much of what is still being taught about design today in schools of architecture and industrial design may be due to either unawareness of the new ways of making things, or to the still widely held belief that designers practice a semi-autonomous art in what clients, markets, and end users regard as the least autonomous of professional cultures. Whatever the reason, there is a critical need to study and evaluate both traditional and new methods of designing in our field. Thirty years of research into design methods and processes has shown that while traditional design methods may be too simple to handle todays complex problems, designers are reluctant to adopt new methods until they are proven successful and user friendly. Design researchers have yet to do much research that satisfies these last two points.

In his textbook on *Design Methods* (1970)[19] Chris Jones asked some crucial questions about traditional design methods and emerging new methods, and what are the strengths and weaknesses of both.

- What is designing?
- In what ways are modern design problems more complicated than traditional ones?
- What are the interpersonal obstacles to solving modern design problems?
- Why are new kinds of complexity outside the scope of traditional design process?

As Jones said over twenty years ago these are ... "Difficult questions but worthy of a great deal of research."

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