Investigating Design: A Review of Forty Years of Design Research

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What Is Design Research?

This paper will start to answer the above question with the definition of L. Bruce Archer: "Design research is systematic inquiry whose goal is knowledge of, or in, the embodiment of configuration, composition, structure, purpose, value, and meaning in man-made things and systems." [1]

In this paper, looking at design research from the design methodology and design science perspectives restricts our view in a sense that is necessary for such a topic. Design research tries to answer the obligations of design to the humanities:

A Design research is concerned with the physical embodiment of man-made things, how these things perform their jobs, and how they work.

B Design research is concerned with construction as a human activity, how designers work, how they think, and how they carry out design activity.

C Design research is concerned with what is achieved at the end of a purposeful design activity, how an artificial thing appears, and what it means.

D Design research is concerned with the embodiment of configurations.

E Design research is a systematic search and acquisition of knowledge related to design and design activity.

The objectives of design research are the study, research, and investigation of the artificial made by human beings, and the way these activities have been directed either in academic studies or manufacturing organizations. As Simon indicates, we can call overall activities of design research, "the sciences of the artificial." [2] Some of the art, craft, and design people call what they do for art and design "research." That kind of research is not the subject of this paper. An artist's practicing activities when creating a work of art or a craftwork cannot be considered research. Yet it is possible for an external observer to do research into how an artist is working on his or her work of art to make a contribution to the common knowledge. These can be observable phenomena. As Christopher Frayling[3] says, "Research through art and design is less straightforward, but still

1 L. B. Archer, "A View of the Nature of the Design Research" in *Design: Science: Method,* R. Jacques, J. A. Powell, eds. (Guilford, Surrey: IPC Business Press Ltd., 1981), 30-47. L. Bruce Archer gave this definition at the Portsmouth DRS conference.

2 H. A. Simon, *The Sciences of the Artificial* (Cambridge, MA: MIT Press, Third Edition, 1999).

3 C. Frayling, "Research in Art and Design," *Royal College of Art Research Papers* 1:1 (1993/4).

identifiable and visible," consisting of materials research, developmental work, and action research. Architects and engineers have applied these definitions of design research since the 1960s.

All design research reports are related to the history or past activity of the subject area under study. Studies of the present are part of the past because every research report has to prove its roots in the past.[4] I will try to identify some instances of the state of the art from some research papers as well as books on design research. This paper will provide a summary of design research history concerning design methods and scientific approaches to design.

Many writers[5] have pointed to De Stijl in the early 1920s as an example of the desire to "scientize" design. The roots of design research in many disciplines since the 1920s are found within the Bauhaus, which was established as the methodological foundation for design education. After the Bauhaus closed, most of the staff moved to the U.S., Britain, or Russia, where they were well accepted and took the Bauhaus tradition to other institutions. Moholy-Nagy moved to the U.S., where he finally became the director of the "New Bauhaus," which became the Institute of Design at the Illinois Institute of Technology in 1949. Gropius went to Harvard, and brought a new line of thought to that side of the U.S. Le Corbusier described the house as an objectively designed "machine for living." He envisioned a desire to produce works of art and design based on objectivity and rationality. During this same period, Buckminster Fuller sought to develop a "design science" that would obtain maximum human advantage from a minimal use of energy and materials. In 1929, he called his concept of design "Dymaxion" or "4-D."

Role of Design Methods in Design Research

Main sources for the history of design methods and design research can be found in various publications. Some historical reviews of design methods have been written by Geoffrey Broadbent,[6] Nigel Cross,[7, 8, 9] Vladimir Hubka and Ernst Eder,[10] Nigan Bayazit,[11] Margolin and Buchanan,[12] at various conferences.[13, 14, 15, 16]

> Horst Rittel[17] made the following statement in an interview: The reason for the emergence of design methods in the late '50s and early '60s was the idea that the ways in which the large-scale NASA and military-type technological problems had been approached might profitably be transferred into civilian or other design areas.

After World War II, the new techniques that had been used in the design and development of arms and wartime equipment, and the methods and techniques used in developing many new inventions, attracted many designers. Creativity methods were developed mainly in the U.S. in response to the launching of the first satellite,

4 As Jacques Barzun and Henry F. Graf indicated in their book, *Modern Arastirmaci* (translated into Turkish from the Modern Researcher), (Ankara: TUBITAK, 1993).

5 Nigel Cross, "Designerly Ways of Knowing: Design Discipline Versus Design Science" in *Design Plus Research, Proceedings of the Politenico di Milano Conference,* Silvia Picazzaro, Amilton Arruda, and Dijon De Morales, eds. (May 18-20, 2000), 43-48.

6 G. Broadbent, "The Development of Design Methods," *Design Methods and Theories* 13:1 (1979): 41-45.

7 Nigel Cross has several publications in various conferences in "The Recent History of Post-Industrial Design Methods" in R. Hamilton, ed., *Design and Industry* (London: The Design Council, 1980).

8 N. Cross, *Developments in Design Methodology* (Chichester, UK: John Wiley & Sons, 1984).

9 N. Cross, "A History of Design Methodology" in *Design Methodology and Relationship with Science,* NATO ASI Series, M. J. De Vries, N. Cross, and D. P. Grant, eds. (Dordrecht: Kluwer Academic Publishers, 1993).

10 V. Hubka, E. Eder, *Design Science* (London: Springer Verlag, 1996).

11 N. Bayazit, *Endüstri ürünleri Tasariminda ve Mimarlikta Tasarlama Metotlarina Giriß* (Introduction to Design Methods in Industrial Product Design and Architecture), [In Turkish] (Istanbul: Literatur Yayinevi 1994).

12 V. Margolin and R. Buchanan, *The Idea of Design: A Design Issues Reader* (Cambridge, MA: The MIT Press, 1995).

13 *Doctoral Education in Design: Proceedings of the Ohio Conference* (8-11 October, 1998).

14 In 1986, the Design Methods Group celebrated its twentieth anniversary with some special reviews in its journal. D. Grant edited the anniversary issue of *Design Methods and Theories Journal of DMG* 20:2 (1986).

the Soviet Union's "Sputnik," which caused the American government to free up quite a lot of money to do research on creativity.[18, 19, 20]

During the 1960s, it became evident that designers no longer could rely solely on their ability to focus upon the product as the center of a design task. Due to technological developments and the implications of mass production, interest had to be shifted from hardware and form to the consideration of human needs. This required a new look at the subject of design methods.[21]

First Generation Design Methods

The influence of systems analysis and systems theory on design established the grounds for the foundation of "systematic design methods," which Horst Rittel[22] later called "first generation design methods." The *Conference on Design Methods,* which was organized by J. C. Jones and D. G. Thornley,[23] was the first scientific approach to design methods in England. The methods proposed at that conference were simplistic in character. Everyone was systematizing his or her own approach to design, and externalizing it as design method. Morris Asimow, a chemical engineer, wrote the book *Introduction to Design,* published in 1962, about engineering design. L. Bruce Archer, the previous HfG teacher, became the head of the Design Research Unit in the Royal College of Art in 1964, and published his book *Systematic Methods for Designers* in 1965. His method was based on critical path analysis, a model of operations research, and gave design research examples. These publications can be considered pioneering examples of design methods and scientific approaches to design.

The first Ph.D. thesis in design methods by Christopher Alexander,[24, 25] entitled "Notes on the Synthesis of Form," broke new ground in architecture. S. Chermayeff and C. Alexander[26] dedicated their book, *Community and Privacy,* to Walter Gropius. It applied "pattern language," using the same approach as Alexander in his Ph.D. thesis. Alexander tried to split the design problems into solvable small patterns by applying information theory. He sorted out those that interacted with each other, and solved the problems of each group by drawing a diagram in which the interactions—either fit or misfit—of user requirements were resolved between the components within and among patterns.

In 1965, Sidney Gregory's[27] paper, included in *The Design Method* proceedings of the conference he organized in Birmingham, defined for the first time the concept of "design science." That conference contained papers on design research, as well as the design methods used in different engineering disciplines. The late Nobel laureate Herbert A. Simon from Carnegie Mellon University, invited to deliver the Karl Taylor Crompton lectures at the Massachusetts Institute of Technology in the spring of 1968, used this opportunity to present the thesis that had been central to his research. It was

15 "Foundation of the Future: Doctoral Education in Design Conference" at La Clusaz, France (9-12 July 2000).

16 This conference brought together the HfG people and state-of-the-art reviewers of design research, *Design Plus Research, Proceedings of the Politecnico di Milano Conference* (May 18-20 2000).

17 In an interview with Horst Rittel in the 1972 issue "Son of Rittelthink" in *The DMG 5th Anniversary Report,* he gave the basic reasons for design methods.

18 D. H. Edel, *Introduction to Creative Design* (Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1967).

19 J. R. M. Alger and C. V. Hays, *Creative Synthesis in Design* (Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1964).

20 M. S. Allen, *Morphological Creativity: The Miracle of Your Hidden Brain Power* (Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1962).

21 B. Jerrard, R. Newport, and M. Trueman, *Managing New Product Innovation* (London, Philadelphia: Taylor & Francis, 1999).

22 H. Rittel, *The DMG 5th Anniversary Report* (1972).

23 J. C. Jones and D. G. Thornley, *Conference on Design Methods* (Oxford University Press, 1963). This conference was the turning point of design studies.

24 C. Alexander, "The Determination of Components for an Indian Village" in *Conference on Design Methods,* J. C. Jones and D. G. Thornley, eds. (Oxford University Press, 1963). The method in his Ph.D. thesis was explained for first time at this conference.

25 C. Alexander, *Notes on the Synthesis of Form* (Cambridge, MA: Harvard University Press, 1964).

26 S. Chermayeff and C. Alexander, *Community and Privacy: Toward a New Architecture of Humanism* (New York: Doubleday and Co. Inc., 1963). This book contains the radio speeches of Chermayeff and also Alexander's method for patterns on the housing neighborhood.

27 S. A. Gregory, ed., *The Design Method* (London: Butterworth Press, 1966 .

published under the title *The Sciences of the Artificial* that same year.[28] He proposed applying the extensive scientific approach to the sciences of the artificial in economics as well as to engineering and other disciplines, in which the design of the artificial is the subject of its own discipline. The artificial here includes all kinds of the man-made things and organizations. He and his colleagues presented artificial intelligence (AI) in design at Carnegie Mellon University.

During that period, research approaches to design became common in Europe and the U.S. The conference/course, "The Teaching of Design—Design Methods in Architecture," was held in HfG in Ulm in April 1966, and following that at the 1967 *Design Methods in Architecture Symposium*[29] held in Portsmouth. Organized by Geoffrey Broadbent and Anthony Ward, the symposium looked at the design research approaches to design.

> Broadbent commented on the symposium as follows:
> The 1967 Symposium was held at a particular moment in history when general change in consciousness was taking place of the kind which Kuhn (1962) would have called paradigm shift. This was having profound effects on society and on social organizations in general including—which is important for us—the role of the designer in society.[30]

Design methods people were looking at rational methods of incorporating scientific techniques and knowledge into the design process to make rational decisions to adapt to the prevailing values, something that was not always easy to achieve. They were attempting to work out the rational criteria of decision making, and trying to optimize the decisions.

Some designers thought that their approaches were a waste of time. This view was not exactly true. The design problems in architecture and in engineering after World War II were severe. The postwar diminished male labor force was a very important influence, and required new production methods, and new designs to meet the new needs of the society in Europe and in the U.S. The Cold War with the Eastern Block countries gave impetus to new human requirements, with scientific approaches to design in this new era generated from political decisions.

As Broadbent[31] said after the Portsmouth Symposium in 1967:

> The Symposium had been set up by Tony Ward to include a specific confrontation between those whom he saw as behaviorists, representing a mechanized, quantified view of design and those (including himself) he saw as existentialist/phenomenologist (formerly Marxist) concerned, above all, "with the humanness" of human beings.
> His "behaviorists" included Bruce Archer; Tom Markus above all; Ray Struder, whose very title "The Dynamics of

28 H. A. Simon, *The Sciences of the Artificial,* 1 (Cambridge, MA: MIT Press, 1968).

29 G. Broadbent and A. Ward, eds., *Design Methods in Architecture* (London: Lund Humphries, 1969).

30 G. Broadbent, "The Morality of Design" in *Design: Science: Method* (1981), 309-328.

31 G. Broadbent in *Design: Science: Method* (1981): 309.

> Behavior-Contingent Physical Systems" summarized what they were all about. Design was to be "scientific"—Struder was looking for a "unit of analyses in design measurable, in his words, against dimensions that are both relevant and empirically accessible." The designer has to start by analyzing human behavior, from which he could derive "quantities, qualities, and relationships."

Meanwhile, a design methods group was established at the University of California, Berkeley in 1967, and began to publish a newsletter called *Design Methods Group (DMG) Newsletter.* [32] This newsletter provided information about research in progress, as well as publications in the fields of design research covering planning, architecture, and industrial design mainly from the U.S. and UK, but seldom from Europe.

In June 1968, the DMG International Conference was organized at MIT. The purpose of the conference was identified in the "DMG Design Methods Group Conference Purpose and Program"[33] leaflet:

> The First Annual International Conference is a research conference in the theory and application of design, planning, and engineering methodology. The purpose of the conference is twofold: first to provide a format for researchers to present their current work for evaluation from their peers and, second, to encourage dialogue between the researchers and the practitioners who are interested in the application of this work. Because the conference is directed both at the researcher and the practitioner, the responsibility for the level of communication lies with the speaker.[34]

In 1973, The Design Activity International Conference in London, in 1977, the California-Berkeley Design Methods in Action Conference, and in 1976, the Portsmouth Changing Design Conference all were indicators of the interest by designers and neighboring disciplines in design research.

In West Germany in 1970, the Institute for the Basis of Modern Architecture (Institute für Grundlagen der Modernen Architectur) began to produce a series of publications called *Studies Related to Planning Methods* (*Arbeitsberichte zur Planungsmethodik*). These studies were following the design methods movement in the U.S. and UK.[35, 36, 37, and 38]

In the '70s, two leaders who were pioneers of design methodology announced a manifesto against the design methodology of the era. Christopher Alexander[39] said:

> The odd thing is that people have lost sight completely of this objective. They have very definitely lost the motivation for making better buildings. I feel that a terrific part of it has become an intellectual game, and it's largely for

32 (DMG) Newsletter, published by Sage Publications. Gary Moore was the editor of the first issue of the second volume; and J. C. Jones, Murray Milne, Barry Poyner, Horst Rittel, Charles W. Rush, and Henry Sanoff were the Editorial Committee. C. Alexander, M. Starr, G. Nadler, W. Issard, M. B. Teitz, and B. Harris were among the members of the Review Committee for the new publication.

33 DMG Design Methods Group, "First Annual International Conference Purpose and Program," MIT (Cambridge, MA: June 2-4, 1968).

34 Ibid.

35 Siegfried Maser, Horst Rittel, Jürgen Joedicke, Hans-Otto Shulte, John Luckman, West Churchman, Horst Höfler, and many others were among the writers of these publications.

36 IGMA, *Arbeitsberihte zur Planungsmethodik 1: Bewertungsprobleme in der Bauplanung* (Stuttgart/Bern: Karl Kramer Verlag, 1970).

37 IGMA, *Arbeitsberihte zur Planungsmethodik 4: Entwurfsmethoden in der Bauplanung* (Stuttgart/Bern: Karl Kramer Verlag, 1970).

38 IGMA, *Arbeitsberihte zur Planungsmethodik 6: Nutzbeteiligung an Planungprozessen* (Stuttgart/Bern: Karl Kramer Verlag, 1972).

39 C. Alexander, "State of Art in Design Methodology: Interview with C. Alexander" *DMG Newsletter* (March 1971): 3-7.

that reason that I've disassociated from the field. I resigned from the Board of Editors of the *DMG Newsletter* because I felt that the purpose which the magazine represents is not really valuable, and I don't want to be identified with them.

Even though he rejected the idea of design methods, he continued to apply his own pattern language to design problems and user design participation utilizing ready-made patterns, in various places of the world. Although he wrote the first comprehensive book, which comprised almost all of the methods relevant to design up to the 1970s, Christopher Jones first refused to be a professor of design discipline at the Open University, and then rejected design methods in the first issue of *Design Methods and Theories Journal* in 1977. He explained that his rejection aimed at the computer use, behaviorism, and continued attempts to fix all of life into logical frameworks.[40] He moved into another field of design, literature.

People like Churchman had warned at least eight or ten years earlier of the consequences of the illegitimate simplifications of the first generation design techniques. But the reaction had led to a kind of unintentional self-elimination. The first-generation design methodology had turned into a sort of academic subculture.[41]

Second-Generation Design Methods

Herbert Simon, in his book *The Sciences of the Artificial*, defined design problems as "wicked" problems, for which finding appropriate solutions was very difficult and each solution to a problem created new problems to be solved. Reactions against design methods by Christopher Alexander surprised newcomers to the field. Horst Rittel, calling the paradigm shifts in design "generations," saved the design methods, according to Nigel Cross[42] in his article. Horst Rittel's proposal of the idea of generations for design let newcomers find new ways for themselves. First-generation design methods were simplistic, not matured enough, and not capable of meeting the requirements of complex, real-world problems. The design methodologists were trying to apply OR models and systems theory to design problems in a very abstract way for every problem. The first-generation design methods were formulated and applied by scientists and designers. The objectives of the design problem also were identified by them during the design process, which caused rigidity in design decisions and unexpected failures. These simplistic methods were necessary at the beginning.

Horst Rittel proposed new argumentative methods as "second- generation design methods." His methods, argumentative method, and IBIS (Issue Based Information System) were problem identification methods, which were influenced by the British philosopher Karl Popper. These second-generation design methods began to compensate for the inadequacy of the first-generation design methods. User involvement in design decisions and the identification of their objectives were the main characteristics of the second-

40 J. C. Jones, 'How My Thoughts about Design Methods have Changed During the Years," *Design Methods and Theories: Journal of DMG and DRS* 11:1 (January–March, 1977).

41 H. Rittel, *The DMG 5th Anniversary Report* (1972).

42 N. Cross, *Design Methodology and Relationship with Science* (1993).

generation design methods. User participation was a new democratic approach parallel to the prevailing political movements of the era. The Design Participation Conference in Manchester was organized by Nigel Cross in 1971. As indicated by Bayazit:[43, 44]

User participation to P&D is a very wide and comprehensive subject, with its political, ideological, psychological, managerial, administrative, legal and economical aspects in relation to various countries. The concept of user participation is as wide and variable as that of democracy.

The success of the participatory design process depended on the designer's awareness of user values, and obliged professionals to collaborate with social scientists as well as anthropologists to carry out design research. There were some obstacles in the application of participatory design in larger-scale projects, such as those in urban planning.

Development of Scientific Research in Design

In the manufacturing industry, design has been formally acknowledged as a separate activity for at least the last 150 years. From the beginning of the twentieth century, the concept of design systems and operations was familiar to the people who developed and used the methods of work-study. In the U.S. in 1909 and 1917, Gilbert's motion study was based on the intelligent observation of people at work. Through the end of World War I, the equipment and machines in factories used by the war industries were relatively unsophisticated. During that war, new kinds of weapons such as aircraft and tanks came into widespread use, and were designed for mechanical efficiency. The first research studies focused on the design of aircraft to improve the performance of the product. Throughout the 1920s, industrial fatigue research became the most important subject. Volkswagen was another initiator of performance studies aimed at increasing the efficiency of the car for the German public. In 1937, Volkswagen sought to produce cheap as well as physically powerful and long-lasting cars. Thousands of repeated performance tests influenced their engineering as well as industrial design, and inspired the development of new and unusual designs. It became a good model for the design of cars and a host of other products.

Facing social and economic problems after World War II, and for the purpose of solving complex design problems and meeting user requirements, the fact of design was considered as a problem-solving and decision-making activity. The scientific developments during World War II made great contributions to the solutions of design problems, especially in the engineering disciplines. Multidisciplinary teams were set up consisting of engineers, industrial designers, psychologists, physiologists, and above all, statisticians. Especially on the engineering side after the war, it was

43 N. Bayazit, Abstracts: Architectural Design: "Interrelations among Theory, Research, and Practice," *Design Methods and Theories,* 12:3/4 (1978).

44 N. Bayazit, (Guest Editor of the issue), Papers: Architectural design. "Interrelations among Theory, Research, and Practice," *Design Methods and Theories* 13:3/4, (1979).

45 H. A. Simon, "Rational Choice and the Structure of the Environment," *Psychological Review* 63 (1956): 129–138.

46 L. B. Archer, *Systematic Methods for Designers* (London: The Design Council, 1965).

47 G. Pask, "The Conception of a Shape and the Evolution of a Design" in J. C. Jones and D. G. Thornley, eds., *Conference on Design Methods* (Oxford: Pergamon Press, 1963).

48 G. Broadbent, *Design in Architecture* (London: John Wiley and Sons, 1973), 115.

49 Leading design researchers of the era were Peter Cowan at the University of Sydney, Herbert A. Simon and Alan Newell at Carnegie Mellon University, and Horst Rittel at the University of California at Berkeley.

50 M. Langfort, *Personal Hygiene Attitudes and Practices in 1000 Middle-Class Households* (Ithaca, New York: Cornell University Agricultural Experiment Station, New York State College of Home Economics, 1965).

51 A. Kira *The Bathroom* (New and expanded edition), (Ithaca, New York: The Viking Press, 1966).

52 Cornell researchers also did various studies on housing. See G. H. Beyer, *Housing and Personal Values,* Memoir 364 (Ithaca, New York: Cornell, University Press, 1959); office furniture, as well as different energy-consuming activities of workers in E. C. Bratton, *Oxygen Consumed in Household Tasks* (Ithaca, New York: Cornell University Press, 1950); E. C. Bratton, *Some Factors of Cost to the Body in Standing and Sitting to Work Under Different Postural Conditions* (Ithaca, New York: Cornell University Press,1959); E. Knowles, *Postures and Other Physiological Responses of the Working Surfaces in Household Ironing* (Ithaca, New York: Cornell University Press, 1943).

necessary to move faster and faster to reconstruct Europe from its rubble. Cybernetics developed during the war by Norbert Wiener as the science of management became the model for rational behavior employed in economics, and obtaining information and making decisions using computer systems.[45] Consequently, cybernetics influenced many design methodologists and design theoreticians. Design theoreticians such as L. Bruce Archer[46] and Gordon Pask[47] saw the similarities between designers' design behavior and the organisms' self-control systems, and developed their own theories accordingly.

The study of human performance and man-machine relationship developed great momentum. Ergonomics and work-study were well known by many people, and applied to designs during the war. Scientific management gave workers a healthier environment, and introduced new designs of office furniture, thereby improving worker comfort. Changing postures with furniture reduced fatigue, and made workers happier and more efficient.

As Broadbent[48] said:

> After the war, it became necessary, therefore, to identify their combined interest in such a way that they could continue to contribute to it with a real sense of purpose. So, in 1949, Murrell and others arranged an interdisciplinary meeting of anatomists, physiologists, industrial medical officers, industrial hygienists, design engineers, architects, illuminating engineers, and so on, out of which the Ergonomic Research Society was formed.

These experiences stimulated interest in design research in the 1950s.

Cornell University, MIT, the University of Sydney, Carnegie Mellon University, and the University of California were the centers for this development line, especially in the design science and computer aids to design by the leading theorists.[49] One of the first social research studies was conducted at the Cornell University Agricultural Experiment Station on one-thousand army personnel to investigate hygienic behaviors and attitudes.[50] That was followed by one of the ergonomics as well as cultural studies on bathroom and sanitary fixtures, which was conducted by Alexander Kira,[51] and influenced the sanitary fixture market with its new approach to human body and cleanliness concepts all over the world, starting in the U.S. and the UK.[52] Cultural anthropology and its influence on design began during the 1950s.[53, 54, 55, 56] In the UK, the application of social psychology to design started in the 1960s.[57, 58, 59, 60] In Sweden, various ergonomics studies were made on housing, especially on bedrooms and other home spaces.[61, 62, 63, 64] In the UK, Loughborough was another center for scientific research related to ergonomics. At the Royal College of Art, Misha Black and L. Bruce Archer were

53 A. Forty, *Objects of Desire: Design and Society, 1750–1980* (London: Thames and Hudson, 1986), 131-132

54 Ibid., 131-132

55 S. Giedion, *Mechanization Takes Command* (New York: Oxford University Press, 1948).

56 M. Mead, *Cultural Patterns and Technical Change* (UNESCO, 1955).

57 J. Noble, "How and Why of Behaviour: Social Psychology for the Architect," *The Architects' Journal* (March 6, 1963).

58 F. J. Langdon, "The Design of Mechanized Offices," *The Architects' Journal* (May 1 and 22, 1963).

59 P. Manning, ed., *Office Design: "A Study of Environment, Department of Building Science,"* University of Liverpool (Liverpool: Pilkington Research Unit, 1965), 27.

60 Ibid., 45-51.

61 More than 928 different anthropometric measurements, as well as dimensional literature on dwelling equipment, under the title of "Anatomy for Planners" were collected by the National Swedish Institute for Building Research Ergonomic Studies were necessary in these countries because people in the past were sleeping in a sitting posture, and had bed lengths shorter than the height of an average person which was not healthy.

62 E. Berglund, *Bord* (Stockholm: Svenska Slöjdföreningen, 1957).

63 E. Berglund, *Skap* (Stockholm: Svenska Slöjdföreningen, 1960).

64 Styrelsen Kugl, *God, Bostad* I dagt och I morgon, (Stockholm: Bostada 1964).

65 L. B. Archer, *Systematic Method for Designers* (London: The Design Council, 1965).

66 S. E. Harrison, Work Study Officer of the North East Metropolitan Regional Hospital Board, conducted the trials. During the research study, no less than one million items of information were recorded. At the same time, sociologists under the direction of Joan Woodward of the Imperial College of Science and Technology were engaged in finding out the opinions of patients and staff about conventional and prototype bedsteads at King Edward's Hospital (Design of Bedsteads, King Edward's Hospital, London, 1967).

doing extensive design research for industry. In his book, L. Bruce Archer[65] mentions research work on hospital beds that derived from work-study observations in the "Design of Hospital Bedsteads." [66, 67]

The Environmental Design Research Association (EDRA) was founded in 1970, and the first EDRA conference was organized by Henry Sanoff that same year, and continued annually, mainly in the U.S. Their research topics were concentrated on evaluative studies of architecture and environmental planning. The first collaborative studies for the investigation of user requirements were made by sociologists, psychologists, social psychologists, and design professionals, and began to develop research methods for the artificial. Also man-environment research (MER) began in various universities in the U.S., and new journals such as *Environment and Behavior* and the *Journal of Architectural Planning and Research* began to be published in the United States. Sometime later in Europe, the International Architectural Psychology Society (IAPS) was established, and served as the European counterpart of EDRA and MER.

Meanwhile, the Design Research Society (DRS) was founded in London in April 1966. Design Methods Group (DMG) and DRS started to publish the *DMG-DRS Journal* instead of the *DMG Newsletter* until 1979, when DRS started the *Design Studies* journal, edited by Nigel Cross since then. In 1980, the Design: Science: Method Conference was organized at Portsmouth, in which design research and the contribution of science to design were the subjects of discussion. The conference organizers put forward the question to all of the members of the Design Research Society, as did L. Bruce Archer in his paper in the conference entitled, "What Is Design Research that It Is Different from Other Forms of Research?" [68] At that same conference, the author of this paper presented the existing situation in design research. That paper was published in *Design Studies*.[69] We tried to categorize the research areas in that paper such as profession-based theories, user-based theories, user-profession-based theories, theories dealing with building appearance, and theories dealing with the profession. Also, fundamental design research tools and techniques up to that time were classified in the same paper. The Design Policy Conference brought together increasing numbers of design researchers in 1982 at the Royal College of Art. That conference was the most comprehensive one of that period. The influence of British philosopher Karl Popper showed itself on the design theory building and scientific formulations of design research.

Four years later, between 1986 and 1993, the Institute of Design (ID) at the Illinois Institute of Technology began to issue the *Design Processes Newsletter,* edited by Charles Owen. That newsletter was concerned with design research approaches of ID, design management, and design policy. It contained articles on a variety of topics of interest to the design community. They were presenting the

67 Kenneth Agnew, along with a supporting team, designed the bedstead in the Royal College of Art, as cited by L. B. Archer in "Systematic Method for Designers" (1965).

68 L. B. Archer, *Design: Science: Method* (1981).

projects and the research works of their faculty, as a leading design research institution in industrial design in the world.

In the meantime, in official government organizations and in other international organizations such as National Bureau of Standards in the U.S., CSTB in France, the Building Research Station in England, the Center International de Batiment (CIB) in Holland, Government Research Centers in Sweden and Denmark, and in many other countries, user requirement studies began in the 1960s and continued up the 1980s. Research in Europe concentrated on housing design and performance problems, because there still was a great shortage of housing in Europe after World War II, and the prefabricated buildings were indispensable.

Prefabricated building design, and research on the coordinated building elements and the building layout optimization, were well-accepted research subjects in the universities as well as in the research centers. Building performance studies were initiated in government research centers and universities, mainly in engineering design, applying scientific methods to design problems in new housing construction. Various environmental characteristics of housing were subject to evaluation in these studies. In the U.S., during the Cold War, the government supported environmental studies on topics such as windowless buildings, and school environmental research (SER).[70] Starting in the 1960s, research areas such as acoustics, heat transfer, and climatic comfort in architecture were well accepted, and continued to develop.

Researchers began to produce interactive computer graphics systems. Wireframe and polygonal modeling schemes were developed. Mosley[71] developed one of the first layout optimization programs for hospital operating units. Beginning in the 1970s, computer scientists became interested in systematic design methods and design science. They were trying to program and evaluate building performance to justify scientific design decisions. At the National Bureau of Standards in the U.S., the first International Congress on Performance Concept in Building was organized in 1972. It brought a new perspective to design research in architecture. Thomas A. Markus[72] and Thomas Maver had been working on building performance at Strathclyde University. Thomas Maver, a computer-aided design programmer, started to work on the programming of environmental building performance evaluation programs. Also, Peter Cowan established the building research center at the University of Sydney in Australia. Building science and computer-aided design were well developed by the end of 1960s, and the beginning of 1970s. They still are leaders in the field of artificial intelligence in design.[73, 74, 75, 76]

On the engineering side, Morris Asimow,[77] Thomas Woodson,[78] Vladimir Hubka,[79, 80] Vladimir Hubka and Ernst Eder,[81, 82] introduced a new generation of systematic design methods. As Vladimir Hubka and Ernst Eder wrote:

69 N. Bayazit, N. Esin, and A. Ozsoy, "An Integrative Approach to Design Techniques," *Design Studies,* 2:4 (1981).

70 C. T. Larson, ed., SER2: *School Environmental Research*, University of Michigan (1965).

71 L. Mosley, "A Rational Design Theory for Planning Buildings, Based on the Analysis and Solutions of the Circulation Problems," *The Architects' Journal,* (September 11, 1963): 525-537.

72 T. A. Markus, ed., *Building Performance* (New York: John Wiley, 1972).

73 J. Gero, *Computer Applications in Architecture* (London: Applied Science Publishers, 1977).

74 J. Gero, "Artificial Intelligence in Design," *Proceedings of the Fourth International Conference on the Applications of Artificial Intelligence in Engineering,* Cambridge, UK (Southampton: Springer-Verlag, 1989).

75 J. Gero, *Artificial Intelligence in Design '91* (Oxford, UK: Butterworth-Heinemann, 1991).

76 J. Gero, *Artificial Intelligence in Design '94* (Boston: Kluwer Academic Publishers, 1994).

77 M. Asimow, *Introduction to Design* (Englewood Cliffs, New Jersey: Prentice-Hall Inc, 1962).

78 T. T. Woodson, *Introduction to Engineering Design* (New York: McGraw-Hill, 1966).

79 V. Hubka, *Konstruktionwissenschaft* (Design Science in English translation), *VDI-Zeitschrift* 116:11 (1974): 899-905, and 1087-1094.

80 V. Hubka, *Principles of Engineering Design* (Guilford, UK: Butterworth Scientific Press, 1982).

81 V. Hubka and E. Eder, "A Scientific Approach to Engineering Design," *Design Studies* 8:3 (1987): 123-137.

82 V. Hubka and E. Eder, *Design Science* (London: Springer Verlag, 1996), 49-66.

> The first evidence of change originates from the period of the Second World War, and from the reconstruction and construction period. [What] were the particular features of these situations which have caused the need for improvements? On one hand [there was] an unusual pressure toward performance in a highly developed industry, especially new and very demanding needs.... Up to [the] year 1967, we could only find some widely scattered and isolated groups or individual experts who proposed [a] certain solution for [the] improvement of [the] design work. The next period after about 1967 until today and especially in the seventies, can be labeled as the prime time for the initial development of design science.

Vladimir Hubka organized the first International Conference on Engineering Design (ICED, a series since 1981) in 1967. Vladimir Hubka established "Workshop-Design-Construction, WDK," and called their approach "design science," which we can call a theoretical scientific approach to engineering design methods. They were the representatives of the European engineering designers. In their own words, they differentiate themselves from English-speaking researchers:

> Continental Europeans tend to being outward-looking and trans-national, but also more formal and systematic; English-speakers tend to become more insular and isolationist, with any "foreign" language as a perceived cultural barrier, but also more intuitive and casual, and less formal.[83]

Vladimir Hubka and Ernst Eder both spent several years in industry, working and/or leading design teams. They defined design science in the same book as: "The term 'design science' is to be understood as a system of logically related knowledge, which should contain and organize the complete knowledge about and for designing."

English-speaking engineering design methodologists were Morris Asimow,[84] John Christopher Jones,[85] Nigel Cross,[86] L. Bruce Archer,[87] T. T. Woodson,[88] Stuart Pugh,[89] David Ullman,[90] and many others.

In the U.S. in 1984, Nam Suh, who was then the assistant director for engineering at the National Science Foundation (NSF), created the Design Theory and Methodology Program. Among his goals in creating this program was developing a science of engineering design and then establishing design as an accepted field of engineering research. From 1986 to 1988, this program was directed by Susan Finger, followed by Jack Dixon.[91]

Some of the design researchers and design methodologists were working in the field of computer-aided design, and developing their methods in relation to architectural and engineering design problems, applying the models of OR and systems analysis. These

83 Ibid., 50.

84 M. Asimow, *Introduction to Design* (1962).

85 J. C. Jones, *Design Methods: Seeds of Human Futures* (2nd rev. ed.), (New York: Reinhold Van Nostrand, 1992).

86 N. Cross, *Engineering Design Methods: Strategies for Product Design* (Chichester, UK: John Wiley and Sons, 1994).

87 L. B. Archer, *Technological Innovation* (London: Science Policy Foundation Special Publication Series, 1971).

88 T. T. Woodson, *Introduction to Engineering Design* (1966).

89 S. Pugh, "The Design Audit: How to Use It," *Proceedings of Design Engineering Conference,* NEC, Birmingham: NEC, 1979).

90 D. G. Ullman, *The Mechanical Design Process* (New York: McGraw-Hill, 1992).

91 S. L. Newsome, W. R. Spillers, and S. Finger, *Design Theory '88* (New York: Springer-Verlag, 1989).

approaches caused some problems in the fields of design methodology and design research, because they were thought to be too restrictive in nature.

There was a close relationship between design research and the developments in the IT field, especially in cognitive sciences, and "artificial intelligence" (AI) and expert systems. Marvin Minsky,[92, 93] was one of the leaders in the application of cognitive science to AI. Studies on AI researchers affected the development of studies on designers, as experts. "Think-aloud" techniques and "protocol analysis" [94] were adopted by designers. Charles Eastman[95] was a computer-aided design practitioner as well as a design theoretician. He published an article related to intuitive bathroom design and, for the first time, focused on the designer's behavior. Donald Schön[96] at MIT opened a new paradigm in design research, and his book, *Reflective Practitioner,* did not seem to relate to computer science at first, but it actually was about the designing behavior of expert designers.

Immense efforts have been made, mainly by the scientists somehow related to computer-aided design, in the development of the cognitive aspects of expert designers all over the world.[97–101] One of the first contributions to this field was by Omer Akin,[102] at the 1978 "Architectural Design: Interrelations among Theory, Research and Practice" conference.[103, 104] His Ph.D. thesis, "Psychology of Architects," [105] at Carnegie Mellon University was one of the recognized research works and first publications in this field.

The 1980s and 1990s opened a new era in design research. Many U.S. departments of design began to establish new academic research units, which were brought about from the government's release of funds on design research, and the encouragement and demand by American industry. The "Ohio Conference on Doctoral Education in Design" in 1998 was one of the first research appeals to education in design (in industrial design and in graphic design) in the U.S. According to Buchanan:

> The *Proceedings of the Ohio Conference on Doctoral Education in Design* focus on the nature and current state of doctoral education in design around the world. This volume explores the foundations of design as a field of inquiry, the role of research in alternate models of doctoral education, the relationship between doctoral education and professional practice, and other issues that are central to the development of design as an emerging field of investigation. Included are discussions of many existing and planned doctoral programs around the world.[106]

Significant growth in all areas of design research took place during the 1990s. New professional demands on design research, and the new educational confrontations for restructuring knowledge changed the context of design. Universities around the world are developing models of doctoral education in design. Philosophies and

92 M. Minsky, "Steps toward Artificial Intelligence," Proceedings of the IRE 49 (1961): 8-30.

93 M. Minsky, *Semantic Information Processing* (Cambridge, MA: MIT Press, 1968).

94 K. A. Ericsson and H. A. Simon, *Protocol Analysis: Verbal Reports as Data* (Cambridge, MA: MIT Press, 1993).

95 C. Eastman, "On the Analysis of Intuitive Design Process" in G. Moore, ed., *Emerging Methods in Environment and Planning* (Cambridge, MA: MIT Press, 1970), 21-37.

96 D. A. Schön, *The Reflective Practitioner* (New York: Basic Books, 1983).

97 O. Akin, "An Exploration of the Design Process," *Design Methods and Theories,* 13 (1979): 115-119.

98 N. Cross, K. Dorst, and N. Roozenburgh, eds., *Research in Design Thinking* (Delft, The Nederlands: Delft University Press, 1992).

99 N. Cross, H. Cristiaans, and K. Dorst, eds., *Analysing Design Activity* (Chichester, UK: John Wiley & Sons Inc., 1996).

100 J. Gero, *Artificial Intelligence in Design* (1991).

101 K. Dorst, *Describing Design: A Comparison of Padigms* (Vormgeving Rotterdam: Grafisch Ontwerp en druk, 1997).

102 O. Akin, *An Exploration of the Design Process* (1979).

103 N. Bayazit, *Abstracts: Architectural Design: Interrelations among Theory, Research, and Practice* (1978).

104 N. Bayazit, *Papers: Architectural Design: Interrelations among Theory, Research, and Practice* (1979).

105 O. Akin, *Psychology of Architectural Design* (London: Pion Ltd, 1986).

106 *Doctoral Education in Design: Proceedings of the Ohio Conference,* (8-11 October, 1998).

theories of design are popular subjects for discussion. Foundations and methods of design research are being reevaluated. The form and structure for the doctorate in design still is under development. The relationship between practice and research in design has become an important focusing topic among the academic as well as the professional communities.

Conclusion

The history of design research with reference to design methodologies, as well as design science, is a wide and comprehensive subject that needs additional extensive research. Only a brief review of research history on this relatively new discipline of design has been covered here. Generally, articles and book chapters concerning state-of-the-art reviews, the history of the discipline, or original conference proceedings and other documents were used in this paper.

Design research and its relevance to design methodology, as well as scientific research, are reviewed. Most design research studies were made in architecture because of the requirements of the societies after World War II. Scientific developments during the war, and the shortage of resources in postwar societies obviously necessitated and gave impetus to the creation of new ways to solve existing problems. Future studies in various design disciplines may benefit from the experience and progress in disciplines concerned with building as well as engineering.

Here, I tried to look at design research and its relevance to design methods and design science from a Turkish perspective. Mutual influences of information technologies and design research were the requirements of the era, although that is not mentioned in many relevant publications. Another area of studying design research is the utilization of the methods of disciplines in such areas as psychology, social psychology, management, economics, semantics, and ergonomics. Here, only main starting points have been indicated concerning the various disciplines.

107 N. Bayazit, *Abstracts: Architectural Design: Interrelations among Theory, Research, and Practice* (1978).

108 N. Bayazit, *Papers: Architectural Design: Interrelations among Theory, Research, and Practice* (1979).

109 N. Bayazit , M. Tapan, N. Ayiran, and N. Esin, *Tasarlama (Dizayn) I. Ulusal Kongresi Bildirileri* (Istanbul: Istanbul Teknik Universitesi Mimarlik Fakultesi, 1982).

Epilog

Academics in Turkey were following the developments in the UK and U.S. on design methodology and the scientific approaches to design because the Ph.D. was an obligatory stage of academic life by law in every field—even in architectural design. Consequently, the Architectural Design Methods Chair was established in the ITU Faculty of Architecture in 1973. In Turkey, architectural design methods was recognized by the National Central Authority of Universities as an academic discipline that same year. The first international conference on design in Turkey, "Architectural Design: Interrelations among Theory, Research, and Practice," was held at ITU in 1978 in collaboration with DRS from the UK. Selected abstracts[107] and papers[108] of this conference were published in the U.S. journal *Design Methods and Theories.* Even though it must be confessed that the idea and the intention were very good, the conference received few papers concerned with design research and its relevance to design practice; but it gave an impetus to further Ph.D. studies in architecture.

In 1982 in Turkey, the First National Design Conference also was organized in the ITU Faculty of Architecture.[109] It was the first national design conference in Turkey covering the disciplines of architectural design, engineering design, and industrial design.