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Systematic Methods in School Planning and Design. A Selected and Annotated Bibliography.

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A selection of technical reports, journal articles and books on various aspects of systematic methods for school planning and design, are presented in this bibliography. The subject areas include the design process in terms of--(1) practice, (2) theory, (3) methods, (4) decision systems, and (5) computer applications. Criteria for design with subsections include--(1) design research, (2) research studies, (3) design criteria, (4) human factors, and (5) modular construction. Each section contains a selection of sources related to school and general design applications, typical of the area they represent. Brief introductory material is presented with explanations and implications of each subsection. (Author)

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SYSTEMATIC METHODS IN SCHOOL PLANNING AND DESIGN

A selected and annotated bibliography

Prepared by
D. Michael Murtha
1968

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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INTRODUCTION

As school designers and administrators attempt to provide the best possible facilities for future generations of students and teachers, they are concerned with the most efficient and effective use of their physical and financial resources. In this regard many individuals are interested in the latest information and techniques which can be applied to current planning and design problems to produce the highest quality of end product. Design professionals have also recently shown a great surge of interest in the development of ways and means to arrive at better design solutions. The object in the preparation of this bibliography was to attempt to bring these two groups closer together by presenting an annotated listing of many of the references and resources describing the most recent thinking in design and some of the applications to problems of school planning and design. The selection is based upon a review of the current literature to discover references which might clearly show the directions in which the fields of design are moving in an attempt to identify and describe some of the specific approaches which are being taken to systematize the development of design solutions.

Systematization is the key to the present concern with the advancement of design. While designers have long relied on intuitive or subjective methods for the majority of their solutions, the need has been shown for an ordering and structuring of the design process in order to deal with the complexities of current problems. This has led to the development of a variety of methods and techniques which have been found to be applicable to a range of problems. In addition there has also been a concern with the quality of the information used as criteria in design problems, and the means by which it has been defined. The systematization of information generation has included a range of research methods and the redefinition of information fields and applications. These references are drawn from the body of literature which has been produced in the search for systematization of design, and as mentioned throughout, it is intended as a survey rather than an exhaustive listing of all relevant materials in the broad-reaching development within the profession. This should, however, include a listing of some of the most critical and applicable discussions, as well as including a broad range of pertinent general information related to these developments.

C O N T E N T S

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SECTION

1

THE DESIGN PROCESS

An area which is particularly important to the achievement of systematic design is the systematation of the design process, the steps and techniques which are used in the development of the design solution. Designers are continuously moving away from the earlier subjective approaches toward more structured and rigorously defined methodologies and more analytical or objective evaluation and decision-making techniques. This section covers some of these systematic processes in the areas of design theory and practice, methods and decision systems and computer applications. All of these contain information which may be applied to the solution of specific problems as well as providing a framework for further development of more refined methods and techniques. While this listing may not be exhaustive the materials do indicate much of the level of current thinking and the prime areas of movement or concern.

A

DESIGN PRACTICE

While the present and past methods of design practice may not have been very systematic, in the sense of a well-defined, structured methodology, there are numbers of factors which are indicated as components or criteria of a successful design solution. These are indicated in the following references on the professional practice of architecture and industrial design. This provides not only a comparison with the more systematic approaches, but also includes discussion of methods, techniques, design considerations which may be incorporated into the systematic structures.

1. Ashford, Frederick Charles. Designing for Industry. London: Pitman, 1955. 222 pp.

A review of professional product design practice in England in 1955 which includes discussion of aesthetics and design requirement development using the intuitive approach.

2. Bannister, Turpin C. (ed.). The Architect at Mid-Century and Evolution and Achievement. New York: Reinhold Publishing Corporation, 1954. 540 pp.

Presents a report resulting from a 1950 survey of architectural practice and education, includes discussion of methods and organization of practice, education and curriculum and registration. Also briefly mentioned is research in architecture.

3. Baynes, Ken. Industrial Design and the Community. London: Humphries, 1967. 96 pp.

Presents an overview and state-of-the-art of industrial design with a general discussion of criteria and methodology. Specific examples include the development of the Archer-Agnew hospital bed.

4. CowGill, Clinton H.: and Ben John Small. Architectural Practice. 3rd ed. New York: Reinhold, 1959. 272 pp.

Presents an overview of architectural method and practice, with a general discussion of design development, and an extensive design bibliography.

5. Danby, Miles. Grammar of Architectural Design with Special Reference to the Tropics. London: Oxford University Press, 1963. 244 pp.

Describes an overview of factors involved in architectural design; although fairly general there are extensive sections on space planning and analysis, perceptual variables and social and economic factors.

6. Dreyfus, Henry. Designing for People. New York: Simon and Schuster, 1955. 240 pp.

Provides a general overview to the field of industrial design as seen by an important practitioner, including general design

principles and requirements, early applications of human engineering, and testing and evaluation procedures.

7. Handbook of Architectural Practice. Washington, D.C.: American Institute of Architects, 1958.

   Provides an overview of architectural practice with an emphasis on business or office procedures, but includes project procedures for design, management, and specifications.

8. Hunt, William Dudley, Jr. Comprehensive Architectural Services--General Principles and Practice. New York: McGraw-Hill, 1965. 248 pp.

   A collection of articles from the AIA Journal dealing with many aspects of practice, including a description of services for colleges and universities, and research and development buildings, and techniques used in project analysis services.

9. Karger, Delmar W. The New Product. New York: The Industrial Press, 1960. 232 pp.

   Written from the viewpoint of general management in a manufacturing firm, this, nevertheless, gives a good overview in the problems and possibilities involved in product development and distribution.

10. McLaughlin, Robert W. Architect, Creating Man's Environment. New York: MacMillan Company, 1962. 204 pp.

    Written for individuals considering a career in architecture, this presents a broad overview of the field, methods, and practice, with an extensive section on research in architecture, the architect and science.

11. Nelson, George. Problems of Design. New York: Whitney Library of Design, 1965. 204 pp.

    While presenting a largely general overview of industrial design today, there is some discussion on approaches to design and development of requirements, and the future of the design profession.

12. Read, Herbert. The Practice of Design. London: Lund Humphries, 1946. 228 pp.

A series of articles by leading design practitioners in 1946, includes discussion of the design profession, education, and the future of product design.

13. Wallance, Don. Shaping America's Products. New York: Reinhold Publishing Corporation, 1956. 196 pp.

A series of case studies of designers and products, includes design criteria and general discussion of design methodology as employed in different situations.

B

DESIGN THEORY

Although this bibliography does not attempt to cover the range of design theories in depth, many of the systematic methods stem from new approaches to the theory of design. The references which are included cover some of the major trends and concerns in the consideration of design and design problems. These present examples of elements in design theory which suggest changes in methods and techniques, primarily directed toward increased responsibilities of the designer.

*1. Caudill, William W., and Cleon C. Bellamy. "Spatial Approach to Planning the Physical Environment," American School and University, 1954-55, (1954). EF 000 423

Architectural design is considered in terms of a spatial approach using horizontal and vertical screens rather than the traditional box. Examples related to secondary education describe screens to control sunlight, wind, sound, temperature, etc.

2. Doxiadis, Constantinos. Architecture in Transition. New York: Oxford University Press, 1963. 200 pp.

Concentrating on housing and urban design, this presents a review of the state of the art in architecture and suggests new methods and approaches, including ekistics, or the science of architecture.

3. Feiss, Carl. "Outerskins and Contact Environments," AIA Journal, 45 (June, 1966), 60-63.

Discusses problems in housing and design particularly related to public and mental health, with reference to new ways of approaching design problems and housing solutions.

4. Kepes, Gyorgy, (ed.). The Man-Made Object. New York: George Braziller, 1966. 232 pp.

While there is perhaps a more esthetic approach to this collection of writings, there are some points made about how to view the man-made object in society, and consequently how to understand the design variables involved.

5. Malone, Robert. "Essential Design," Industrial Design, 7 (February, 1960), 56-59.

Presents an approach or theory of essential design as a total solution relating man, environment, and tectonics, including implications for education and determination of design requirements.

6. Marks, Robert W. The Dymaxion World of Buckminster Fuller. Carbondale: Southern Illinois University Press, 1960. 232 pp.

An overview of Fuller's work and philosophy, related to his concept of design, industrialized housing, and geodesic and

other structures. Includes many examples and descriptions of product and architectural work.

7. Murtha, D. Michael. General Concepts in Human Engineering and Systems Theory as Applied to the Development of Knowledge and Method in Design. Unpublished M. S. Thesis. Ohio State University, 1967. 120 pp.

Prepared as a survey of the state of the art in systematic design methods, this paper covers the literature in architecture and product design, human engineering, and the systems fields of operations research and systems engineering. Discussion covers the relationships between these fields and the problems and requirements of the design profession, leading to the possibilities for integration and application of related methodologies and information in design practice.

8. Newton, Norman T. An Approach to Design. Cambridge, Mass.: Addison-Wesley Press, Inc., 1951. 144 pp.

This presents a general discussion of problems and considerations in the design process as related to architecture and industrial design.

9. Pye, David W. The Nature of Design. New York: Reinhold, 1964. 96 pp.

Discusses general principles of design which may include application to architecture and industrial design. It also includes the requirements for design, geometry, and relationships, and influences of production method and economy.

10. Thiry, Paul. "Total Design II," AIA Journal, (June, 1966), 75-78.

Identifies a present crisis in the state of design and calls for new approaches to the control of forces and the artificial and natural environments. This is particularly related to problems resulting from the misuse of technology.

C

DESIGN METHODS

While there are numerous new approaches suggested for design methods and strategies, there are relatively few formalized methodologies for systematic design. Some of the major reviews and developments are included in this set of references which cover design strategies and tactics as well as some specific techniques. Emphasis is placed upon the steps used by the designer in problem-solving rather than specific criteria or problems.

1. AIA Workshops. "Emerging Techniques," AIA Journal, 46 (November, 1966), 85-86.

A brief overview is given of topics discussed at a conference related to new techniques and methodologies currently being employed in architectural practice.

2. Alexander, Christopher. "A City Is Not a Tree," Design, 206 (February, 1966), 46-55.

A discussion of the nature of cities and of city planning is used in establishing the semi-lattice, diagramming overlapping sets, as contrasted to the more commonly used tree diagram as a tool for organizing or structuring information.

3. Alexander, Christopher. "Information and an Organized Process of Design," New Building Research, (Spring, 1961), 115-123.

Information storage and retrieval is related to the design process through a system of classifying and organizing reference materials. A research proposal to develop an ideal retrieval system is included in the report.

4. Alexander, Christopher. Notes on the Synthesis of Form. Cambridge, Mass.: Harvard University Press, 1964. 216 pp.

Describes an analytic process of design based on a systematic concept of design, using sets of design variables or misfits and structuring them into subsets using a computer decomposition program. This allows the designer to model and solve complex problems as illustrated in the design for an Indian village.

5. Alexander, Christopher. "The Theory and Invention of Form," Architectural Record, 137 (April, 1965), 177-186.

This article, related to Notes on the Synthesis of Form, presents brief descriptions of misfit variables, variable subsystems, and semi-lattices. Included is a list of 72 subsets of requirements for a condominium project.

6. Alexander, C., V. M. King, S. Ishakawa, M. Baker, and P. Hyslop. "Relational Complexes in Architecture," Architectural Record, 140 (September, 1966), 186-190.

   Discusses design requirements in terms of the concept of relational complexes, which are rigorously defined subsets of design variables based upon functional relationships. Examples are given from the Bay Area Rapid Transit Study.

7. Archer, L. Bruce. Systematic Method for Designers. Reprint from Design. London: 1965.

   Based on a series of articles presenting approaches to design and a detailed description of the design process, this provides a detailed sequential checklist for procedures and techniques used within the design process. Some case studies illustrating the method are included.

8. Asimow, Morris. Introduction to Design. Englewood Cliffs, N. J.: Prentice-Hall, 1966. 136 pp.

   A reference intended for students and instructors in engineering design, this book contains direct applications to product design, providing design methodologies and techniques, decision and optimization mathematical models, and examples of model building and the design process.

9. Bowen, Hugh M. "Rational Design 1: Human Engineering and Systems Concept," Industrial Design, 11 (February, 1964), 58-61.

   An attempt to provide industrial designers with new methods and approaches, including a discussion of human engineering and systems approach with system analysis, system design, and system test and evaluation.

10. Bowen, Hugh M. "Rational Design 2: Analytic Methods in Human Engineering Studies," Industrial Design, 11 (March, 1964), 38-45.

    Describes analytic methods in human engineering studies as an aid in systems design, including functional allocation, operational sequence diagrams, link analysis, and evaluation methods such as observation, checklists, interviews, and objective measurements.

11. Hall, Edward T. "A System for the Notation of Proxemic Behavior," American Anthropologist, 65 (October, 1963), 1003.

The study of proxemics, or the distance relationships between men and men or men and objects is discussed and extended in the development of a notational system for observation and recording, with an emphasis on cross-cultural comparisons.

12. Jones, J. Christopher. "Design Methods Compared 1: Strategies," Design, 212 (August, 1966), 32-35.

Describes a number of design strategies as sequences or stages which a designer follows, including such types as preplanned-branching, random, and traditional approaches. Demonstrates kinds of steps, order, and feedback loops.

13. Jones, J. Christopher. "Design Methods Compared 2: Tactics," Design, (September, 1966), 46-52.

Techniques or tools used by designers are discussed in this article, including computer-aided design, interaction matrices and nets, morphological charts, checklists, and brainstorming.

14. Jones J. Christopher and D. G. Thornley (eds.). Conference on Design Methods. New York: MacMillan Company, 1963.

This collection of articles presents a number of different approaches to the systematization of design methodology in the areas of architecture, product design, urban planning, and engineering design. Emphasis is on definitions and modeling techniques.

D

DECISION SYSTEMS

Since the essential nature of the design process lies in formulating and resolving sets of decisions, the application of existing decision models and techniques to design problems is an important aspect of systematic design. Problem definition or programming is also an important part of decision-making and may be considered within this context. The following references present a variety of approaches used in operations research and systems analysis as they might be applied to design, as well as unique methods developed for design problems. It should be noted that while this material presents a range of suggestions for techniques and methods, that there are other sources in design and related fields which expand upon many of these concepts in greater detail.

1. Bennett, Edward M. "Product and Design Evaluation through the Multiple Forced-Choice Ranking of Subjective Feelings." In Edward Bennett, James Degan, and Joseph Spiegel, eds. Human Factors in Technology. New York: McGraw-Hill, 1963. Pp. 521-555.

Describes research in psychophysical methodology related to responses toward product designs, based on the rating or ranking of response terms, usually adjectives. Techniques for testing and measurement are given as well as evaluation and interpretation of results.

2. Case Institute of Technology, Cleveland, Ohio, Operations Research Group. A Comprehensive Bibliography on Operations Research. New York: John Wiley and Sons, 1958.

Covers a general range of models and methods, including decision and value theory, materials testing and standards, and site location and layout.

3. Davidoff, Paul, and Thomas A. Reiner. "A Choice Theory of Planning," Journal of the American Institute of Planners, 28 (May, 1962), 103-115.

Develops a general theory of planning, based on value formation, means identification and effection; choice and evaluation procedures are identified for each phase.

4. Dyckman, J. W. "Planning and Decision Theory," AIP Journal, 27 (November, 1961), 335-347.

Discusses problems and criteria of planning in comparison with a detailed explanation of decision-making, and mathematical decision theory, leading toward a rational planning methodology. An extensive bibliography is included.

*5. Evans, Benjamin H. Architectural Programming State-of-the-Art. Gatlinburg, Tenn.: AIA Researchers' Conference, 1967. 17 pp. EF 001 578

This report describes briefly the present practice and implications of architectural programming and describes techniques used in programming, as well as details of programming as used by several different architectural offices.

*6. Green, Meg. Decision-Making Theory Applied to Architectural Programming: Some Research Applications. Gatlinburg, Tenn.: AIA Researchers' Conference, 1967. 6 pp. EF 001 577

Presents a general discussion of architectural programming and decision-making, including suggested research in the areas of decision sequences, information needs and classification systems, role responsibilities, and specific tools such as decision tables, etc.

7. Hassid, Sami. "Systems of Judgment of Architectural Design," New Building Research, (Spring, 1961). Washington, D.C.: National Academy of Sciences - National Research Council, 1961. Pp. 92-106.

Proposes a research project on the relation of design criteria to the critical evaluation of architectural works, including criteria used by the designer as compared with that used by the evaluator, developed from literature and interviews in a variety of sources.

8. Herrick, John H., Ralph D. McLeary, Wilfred P. Clapp, and Walter F. Bogner. From School Program to School Plant. New York: Henry Holt and Company, 1956. 484 pp.

Directed toward giving educational administrators an understanding of the goals and problems in school planning, including the preparation of an educational program or specifications, and design requirements for different instructional spaces.

*9. Horowitz, Harold. "The Program's the Thing," AIA Journal, (May, 1967), 94-100. EF 001 462

Presents in detail the types of information to be included in a program, some of the techniques used in organizing information, as well as some of the contributions of the behavioral sciences to the architect's program.

10. Litchfield, N. "Cost Benefit Analysis in City Planning," Journal of the American Institute of Planners, 24 (November, 1960), 273-279.

Outlines a proposed method of approach for city planning decision-making, based on an analysis of social and economic costs and benefits, with emphasis on developing measures of community welfare.

11. MacConnell, James D. Planning for School Buildings. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1957. 348 pp.

Provides administrators and planners with basic information in the planning and design of school buildings, with particular emphasis on educational specifications.

12. Ronayne, Maurice F. "An Annotated Bibliography for the Systems Professional." Systems and Procedures Association, 1962.

References cover general systems areas, including survey analysis techniques space and facility planning, equipment evaluation, and graphic presentation and statistics.

13. Rossetti, Louis. "Comprehensive Architectural Practice: Building Programming," AIA Journal, 41 (January, 1964) 62-66.

Building programming is described as a function make-up of planning, scheduling and layout, using where needed critical path methods. While there is no clear definition of the author's topic, general consideration, which is mentioned, may be relevant.

14. Starr, Martin K. Product Design and Decision Theory. Englewood Cliffs, N. J.: Prentice-Hall, 1963.

A mathematical concept of decision theory is discussed in terms of problems associated with product design. Although most of the discussion is directed toward production and marketing problems, the basic approach may be applied to other design variables.

E

COMPUTER APPLICATIONS

A recent development in design method with far-reaching implications is the introduction of the computer into the design process. While the initial developments are generally quite tentative, there are many cases in which even simple programs can be highly useful. These references provide a broad overview of computer based techniques and applications ranging from scheduling in universities as related to space allocation to sketching or simulating visual aspects on computer displays. Again, these materials are suggestive of a much broader body of literature, as in the November/December 1966 issue of Print, and the 66/67 issue of Design Quarterly.

1. "Architecture and the Computer." In Boston Architectural Center Conference Proceedings. Boston Architectural Center, 1964. 60 pp.

   Includes a series of articles on computer graphics and computer-aided design for architecture and planning, with a major emphasis on methods and applications in the design process.

2. Campion, David. "Design Simulation by Computer," Architectural Review, 140 (December, 1966), 460-462.

   The application of computer techniques, particularly simulation, to problems in space planning and organization, describes data preparation, programming, and limitations. An example is given based on dining hall queues.

3. Cosand, Joseph P., and John E. Tirrell. Flying a College on the Computer (The Use of the Computer in Planning Buildings). St. Louis County: The Junior College District, St. Louis, Mo., 1964. 7 pp.

   Describes the development of a computer simulation program, adapted from the General Academic Simulation Program, used to determine scheduling and space requirements as an aid in planning junior college facilities. A master plan for a proposed facility was developed based on optimizing both room and seat utilization. Staffing patterns were also indicated.

4. Dawson, John W. "Use of Small Digital Computers in Building Design," New Building Research (Spring, 1961). Washington, D. C.: National Academy of Sciences - National Research Council, 1961. Pp. 108-114.

   Use of the computer is demonstrated for mathematical calculations related primarily to structural and engineering considerations, but with some reference to architectural design.

*5. Haviland, David S. The Computer and the Architectural Profession. Troy, N. Y.: Rensselaer Polytechnic Institute, 1966. 55 pp. EF 000 422

   Provides an overview of present and future implications of the computer and design, for architectural planning and management, including technical considerations in computer programming and hardware.

6. Krampen, Martin (ed.). Design and Planning II. New York: Hastings House, 1967.

A collection of conference papers in the general area of design research, with a major emphasis on papers dealing with design and the computer and computer graphics, including computer-aided design, simulation, and visual forms.

*7. Krauss, Richard. Design: A Case History. Designer's Specifications for a Computer System. An unpublished paper, 1967. 8 pp. EF 001 581

This describes the efforts by a firm of architects to develop a computer model of the design decisions in a previously completed school building design project. Possibilities and limitations were shown in areas such as space allocation, room location, dimensional checks, and information search.

**8. Milne, Murray. Architectural Applications of Computer Based Network Analysis Models. Gatlinburg, Tenn.: AIA Researchers Conference, 1961.

A discussion of network analysis as applied to the architectural process for the grouping of complex systems of design elements into subsets or clusters. The Hidec program is examined and an alternate approach is suggested based on cluster growing algorithms.

9. Siders, R. A., and others. Computer Graphics, A Revolution in Design. New York: American Management Association, 1966. 160 pp.

Primarily directed toward engineering design applications, this presents an overview of the methods and systems available, and how they might be integrated into the design process. Extensive bibliography.

SECTION

2

CRITERIA FOR DESIGN

Although systematic methods are very important to the design process and may be essential factors in organizing and identifying the necessary information, the design method is still only as systematic as the data or criteria which are used in determining the solution. This section covers some of the factors involved in systematic generation of criteria, from the ways in which information may be derived to the types of information which may be relevant in design. The references which are included are not intended to provide an exhaustive set of data, but they may aid in determining where to look, and some of the methods which are presently being used to define the data.

A

DESIGN RESEARCH

One of the sources for design information and criteria which is drawing increased attention and application is research into the relationships between the environment and human behavior and well-being. These references present some of the recent thinking concerning research and design including relevant studies, contributions from other fields, and areas where research is needed. The materials are important in raising questions about where research is possible and in identifying variables which deserve critical consideration. Specific areas and methods for research are also mentioned in the following sections.

1. AIA-NSF Conference on Research for Architecture. Research for Architecture. Washington, D. C.: AIA Document Division, 1959. 127 pp.

   Presents papers from a conference on architectural research related to the relationships of the physical, biological, and social sciences in the problems of optimum created environment for human activities. Special topics include an architectural research network and sociological aspects of environmental design.

2. Building Research Institute. School Building Research. Washington, D. C.: Building Research Institute, National Research Council, 1963. 200 pp.

   A series of conference reports include school building needs, campus planning, research in school facility design, equipment and services. Some mention of design principles and research in thermal control and school windows.

3. Dyckman, J. W. "Of Men, Mice, and Moles: Notes on Physical Planning, Environment, and Community," Journal of the American Institute of Planners, 27 (February, 1961), 102-104.

   Discusses the impact of social science research on Urban Design and architectural decision-making, including a listing of social interactions of man and environment in an urban setting.

4. Evans, Benjamin H. "What is Research for Architecture?" AIA Journal, 41 (May, 1964), 87-89.

   Presents a review of current basic and applied research related to architectural design, including several examples of factors in school building design.

**5. Fitch, James M. "The Aesthetics of Function," Annals of the New York Academy of Sciences, 128 (September, 1965), 706-714. EF 000 080

   Human requirements in architecture are discussed in terms of the relationship between man and his environment, with emphasis on psychosomatic responses and the experiential spectrum of stress.

6. Handler, B. "Needed Research on the Effects of Buildings on Human Behavior." New Building Research Institute, Fall 1960. Washington, D. C.: National Academy of Sciences, National Research Council, 1960.

Describes the major variables in the environment and in human behavior which relate to building, and indicates the areas of appropriate research on the different variables and relationships.

7. Horowitz, Harold. "An Introduction to Research Methods for Architecture," AIA Journal, 41 (January, 1964), 62-66.

Describes an introductory college course in research methods for architects, including topics for discussion, class projects, and a large listing of references related to architectural research.

*8. Horowitz, Harold. Can the Behavioral Sciences Assist Planning? Ann Arbor, Mich.: Society for College and University Planning, 1967. 14 pp. EF 001 459

Using examples from higher education facilities, indications are given of some techniques which have been developed by behavioral scientists as applied to specific problems in the development of planning criteria. Implications are given for areas of further research.

9. International Council for Building Research, Studies and Documentation - CIB. Building Research and Documentation. New York: Elsevier Publishing Company, 1961. 500 pp.

This collection of papers from an international conference includes a number of papers describing research in the sociological and functional aspects of housing design, as well as details for operations research in building design decision making.

*10. Kiyoshi, Izumi. "Psychosocial Phenomena and Building Design," Building Research, (July-August, 1965), 9-11. EF 000 093

Psychological and social phenomena are discussed in terms of examples found in existing architecture and their evoked responses. Attention is drawn to the areas of visual ambiguity and illusion, privacy, and safety and welfare factors, as examples of areas to be studied and accounted for in building design.

11. Llewelyn-Davies, Richard, and Peter Cowan. "The Future of Research," Architectural Record, 136 (September, 1964) 105-112.

Introduces the basic question of architectural research in terms of needs for research, general approaches and methodologies, and requirements for practice and education.

12. Logan, Henry L. "Human Behavior and Building," Building Research, (July-August, 1965), 4-5.

Discusses human variables in buildings and various research approaches and needs. Includes a description of the state-of-the-art in research and information.

13. Myrick, R., B. S. Marx, and S. L. Cohen. "Is What is Good for General Motors Good for Architecture?" AIA Journal, 45 (March, 1966), 62-66.

Contrasts the utilization by management and architecture of social psychological data and expertise in the design and management of space. Includes reports of research and outline of critical psychological variables.

14. Neutra, Richard. Survival through Design. New York: Oxford University Press, 1954. 384 pp.

Although this is a rather general treatise on architecture and design today, the discussion spends a lot of time on the physiological, psychological, and social requirements, and suggests areas for possible research.

B

RESEARCH STUDIES

Although the field of design research is only in the very earliest stages, there have been some studies made which illustrate some of the problems and potentials of research. The references which are given refer for the most part to research related to school facilities design, and indicate some of the factors in this area which are subject to research. While there were some significant data generated in these studies, their importance is primarily in indicating what can be done with research, and some of the methods and approaches which can be used. The research which is described, ranges from social interactions through systems analysis and human engineering, indicating the breadth of the areas open to study. Again, these examples are only illustrative and more complete listings of research can probably be identified for these and other areas.

1. Blake, Robert, and others. "Housing Architecture and Social Interaction," Sociometry, 19 (July, 1956), 133-193.

Investigates social interactions based on group living situations with either closed or open living arrangements, in a study of Air Force barracks, with implications for more general living and working arrangements.

2. Eisenhart, Churchill. "Operational Aspects of Instrument Design," Science, 110 (October, 1949), 343-346.

In describing the state-of-the-art, requirements and difficulties in the design of scientific laboratory instruments and fundamental principles of design are discussed which may be related to more general problems.

3. Kira, Alexander. The Bathroom, Criteria for Design. Ithaca: Center for Housing and Environmental Studies, Cornell University, 1966. 120 pp.

A rigorous research study of design requirements for bathroom facilities, including the psychological, physiological, and functional aspects of the major personal hygiene activities. Includes anatomical and photographic studies and mockups. Typical ideal solutions are presented.

4. Lindheim, Roslyn. "Putting Research to Work," AIA Journal, 45 (February, 1966), 46-53.

Reports a project on the design of a hospital radiology laboratory based on systematic design principles, including information forms, flow diagrams, graphic models, and link analysis.

5. Llewelyn-Davies, Richard, J. W. Nightingale, and T. J. Bailey. "Laboratory Design: Survey of Space and Services Requirements in Two Agricultural Research Laboratories," Nature, 176 (November, 1966), 999-1001.

Describes an early study to determine design requirements in two research laboratories, covering variables such as bench length and group requirements, provision of services to benches, illumination, and work contrasts.

*6. Montgomery, James R. Some Questions and Answers Concerning Housing for Graduate Students. Knoxville: University of Tennessee, 1963. 27 pp. EF 000 050

Describes a survey made of married and single graduate students to determine preferences for types of housing and facilities. Results are tabulated and compared with other institutions.

*7. Myrick, Richard. Behavioral Factors in Dental School Design Summary Progress Report on the Planning Study. Washington, D. C.: George Washington University, 1965. 28 pp. EF 000 088

Describes a study to integrate social and psychological needs with physical needs in the design of a new dental school, including details of three research studies on attitudes and social interactions.

*8. Stoke, Stuart M., and others. Student Reactions to Study Facilities. Amherst, Mass.: Amherst College, 1960. 60 pp. EF 000 078

An extensive survey of student study habits and needs was conducted. Results showed where studying occurred, and student preferences, attitudes, and design requirements. Questionnaires and student diaries were used.

**9. Wells, Brian. "A Psychological Study with Office Design Implications," The Architects Journal Information Library, (October 14, 1964), 877-888. EF 000 083

A comparison is made between two building types, the relatively shallow slab building, and the relatively deep block type based on practical and psychological considerations, demonstrating how human needs may determine the type of building, and the advantages of extensive psychological studies.

10. Whitfield, D. "Validating the Application of Ergonomics to Equipment Design: A Case Study," Ergonomics, 7 (April, 1964), 165-174.

While there is much design work based on ergonomic's studies, this report describes research done to validate an ergonomically designed computer console. The results showed that the console could be operated significantly faster than the previous model.

**11. Ward, Joan S. "Optimum Dimensions for Domestic Stairways: A Preliminary Study." The Architect's Journal Information Library, (July 5, 1967), 29-40. EF 000 082

An ergonomic study was conducted to determine the optimum relationship between tread and riser dimensions, using physiological, physical, and psychological measures. Techniques include measures of heart rate, photography, and preference ratings.

C

DESIGN CRITERIA

Another approach to systematic design lies in the collection and application of data which has established relevance to a given problem. This gives some indication of factors which should be further defined for a specific problem as well as providing factors which are established for general conditions. The resources in this section provide some of the criteria which has been generated for school facility design. The material includes some general discussion of criteria but the emphasis is upon defined criteria in charts and checklists, and upon the criteria related to specific design problems. Additional criteria for specific problem areas may be found in similar sources.

*1. A Guide for Planning Physical Education and Athletic Facilities. State of New Jersey, 1964. 44 pp. EF 000 055

While concentrating on one curriculum area, this provides examples of different combinations of facilities for different needs, checklists, and graded recommendations.

**2. Bard, Bernard. A College Health Center. New York: Educational Facilities Laboratories. 32 pp. EF 000 069

A particular problem, the design of a small college health center, is discussed at length and a typical solution is presented, supported by a graphic analysis of the design factors. The relationship is given between design analysis, design method, and solution.

*3. Bartnick, Lawrence R. Designing the Mathematics Classroom. Washington, D. C.: National Council of Teachers of Mathematics, 1957. 40 pp. EF 000 404

In addition to general discussion of design requirements, this includes extensive checklists for tools and equipment, etc., graded into ranges of essential desirable and possible, providing limits for selection.

4. Engelhardt, F. L., N. L. Engelhardt, Jr., and Stanton Leggett. School Planning and Building Handbook. New York: F. L. Dodge Corporation, 1956. 628 pp.

Provides information on school planning and construction for educational administrators, including checklists and charts related to school design variables and requirements for drawings, details, and specifications.

*5. Gibson, Charles D., and Clair L. Eatough. School Site Analysis and Development. Sacramento: California State Department of Education, 1966. 40 pp. EF 000 066

As a guide in determining site area requirements for elementary and secondary schools, this report provides tables of area requirements, layouts of physical education requirements, and an outline of the site planning process.

*6. Guide for Schoolhouse Planning and Construction. Trenton, New Jersey: Department of Education, 1967. 82 pp. EF 001 141

A guide for schoolhouse construction provided by the state board of education, which contains, in addition to minimum requirements, a more general series of charts and tables for determining different variables in a variety of situations.

*7. Guide for the Evaluation of School Facilities. California Association of Public School Business Officials, 1966. 59 pp. EF 000 471

Designed as a guide for the evaluation of school facilities, this document contains detailed checklists for design variables, including equipment, controlled environments, safety, maintenance, and aesthetics. This also includes rating scales for specific variables.

*8. Johannis, Norma and Mildred Doster. Providing a Healthful School Environment. Denver: Colorado State Department of Education, 1962. 12 pp. EF 000 073

A checklist has been developed to assist school personnel in the evaluation of present and planned facilities on factors related to school environmental health in the areas of school grounds, school buildings, illumination, heating, toilets, fire and safety, etc.

9. McQuade, Walter (ed.). Schoolhouse. New York: Simon and Schuster, 1958. 272 pp.

General overview includes extensive discussion of school environment with charts for design specifications and discussion of design requirements.

10. Perkins, Lawrence B. Work Place for Learning. New York: Reinhold Publishing Corporation, 1957. 64 pp.

Provides a general overview of school building design, including a discussion of various design requirements and examples of alternative solutions.

*11. Pilkington Research Unit. The Primary School: An Environment for Education. Liverpool: University of Liverpool, England, 1967. 164 pp. EF 000 079

A collection of essays related to design requirements for elementary education facilities, including discussion of the external, spatial, visual, thermal, and aural environments and extensive checklists of environmental factors.

12. Roth, Alfred. The New Schoolhouse. New York: Praeger, 1966. 304 pp.

This comparison of school design solutions from a number of different countries provides implications for different methods and approaches. Also included is a general review of design requirements and methodology.

13. "Schools for the New Needs," Architectural Record, (1956) 312.

Although this is essentially a series of case studies of individual design solutions as appeared in the magazines, this does allow a comparison of different approaches and definition of requirements.

*14. Sherrill, Frank O., and others. Campus Design Study, Duke University. Houston: Caudill, Rowlett and Scott, Architects, 1963. 54 pp. EF 001 009

A method for analyzing existing architecture on a university campus as a guide to construction of future buildings was developed with the three major factors as character, components, and compositions. A case study illustrates the design method as program, analysis, design, and critique.

15. Sleeper, Harold R. Building Planning and Design Standards. New York: John Wiley and Sons, Inc., 1955. 331 pp.

This is a companion to Architectural Graphic Standards with an emphasis on commercial buildings, including schools. Graphs, charts, and tables related to dimensions and guidelines for sites and architectural details and equipment are provided to aid in developing design solutions.

D

HUMAN FACTORS

Human Factors or Human Engineering as a field with primarily military and industrial applications, has recently been adopted as a source of criteria for design problems. The emphasis of this field is upon factors such as temperature, lighting, sound, as well as body dimensions, controls and displays, many of which have been assumed in the field of architectural engineering. Although there are numerous human factors references containing information of interest to designers, the materials which are listed are concerned primarily with the application of human engineering or ergonomics to design problems. The attempt has been to show how this data may be used, with the choice of data sources left to the individual. The references do, however, contain some listings of data which may be useful in design problems.

1. Architectural Record. Architectural Engineering: New Concepts, New Methods, New Materials, New Applications. New York: F. W. Dodge Corporation, 1955. 494 pp.

A series of articles from Architectural Record, related to technical developments in architectural engineering, including areas of construction, environmental control, utilities, site, materials, and safety. Specific references are given for school design.

2. Birren, Faber, and Henry L. Logan. "The Agreeable Environment," Progressive Architecture, (August, 1960), 174-177.

A color consultant and an illuminating engineer review progress in the visual and physiological study of light and color as related to the problems of the architect and interior designer.

3. "Design and People 1," Design, 136 (April, 1960), 50-54.

Describes Henry Dreyfus' applications of human factors data to the design of industrial machines and earth moving equipment.

4. "Design for People 2," Design, 139 (April, 1960), 53-55.

Details other Dreyfus' human engineering projects for equipment design and aircraft seating, with particular emphasis on anthropometrics.

5. Dreyfus, Henry. The Measure of Man. New York: Whitney Library of Design, 1960.

Human factors data with an emphasis on anthropometric measurements is presented in graphic and checklist form as an aid to industrial designers. In addition to anthropometric standards for male, female, and children, factors of controls and displays, illumination and environment are included.

6. Fischer, Robert E. (ed.). Architectural Engineering: Environmental Control. New York. McGraw-Hill, 1965. 212 pp.

This collection of articles presents quantitative and qualitative design requirements and specifications in

the areas of heating and air conditioning, lighting, and acoustics. Examples include applications in school design.

**7. Fitzroy, Dariel. Acoustical Environment of School Buildings. New York: Educational Facilities Laboratories, 1963. 128 pp. EF 000 094

This describes an extensive study made of school acoustics, primarily in the areas of sound levels and noise reduction. It includes details of recommendations and survey methodology, as well as the details from a large number of case studies.

8. Kinzey, Bertram Y., Jr., and Howard M. Sharp. Environmental Technologies in Architecture. Englewood Cliffs: Prentice Hall, Inc., 1963. 788 pp.

Provides human factors data and design and performance specifications for mechanical systems. Graphs, charts, and mathematical formulas are used to determine requirements in the areas of thermal atmosphere, acoustics, sanitation, lighting, and electricity.

9. Larson, C. Theodore (ed.). School Environments Research 1, 2, 3. Ann Arbor: University of Michigan, 1965.

A series of publications related to the description of links between the environment and human behavior, including abstracts of 600 reference documents, evaluations, or summaries of major environmental factors such as space, thermal, luminous, sonic, and social environments, and analysis providing a framework for relating total environment effects to the learning process.

10. Murrell, K. F. H. Ergonomics, Man in His Working Environment. London: Chapman and Hall, 1965. 496 pp.

Describes human engineering aspects with emphasis on non-military applications in product and equipment design, including basic human factors data, and may be generalized to domestic or educational problems.

11. Olgyay, Victor. Design with Climate. Princeton, New Jersey: Princeton University Press, 1963. 196 pp.

A demonstration of the influence of climate on building principles, and a description of techniques of analytical reasoning used in determining solutions. Topics include site selection, sol-air orientation, solar control, environment and building forms, and wind effects.

12. Page, J. K. "Some Ergonomic Problems Confronting the Building Designer," Ergonomics, 3 (1960), 133-140.

Defines ergonomic considerations in building design, including anthropometric and postural factors, energy expenditure, temperature, noise, and lighting. A bibliography of related references is given.

13. Progressive Architecture. Materials and Methods in Architecture. New York: Reinhold Publishing Corporation, 1954. 412 pp.

A series of articles from Progressive Architecture related to developments and improvements in architectural engineering techniques. Includes areas of construction methods and materials, environmental control, and equipment. Specific references made to school design.

14. Wheeler, Lawrence, and E. E. Miller. "Comprehensive Architectural Practice: Human Factors Analysis," AIA Journal, 40 (December, 1963), 43-49.

Describes adaptation of human factors analysis to architectural problems in terms of information flows and interactions, link valves and matrices, and vector analysis used in optimizing relationships. These are then related to applications in space planning and layout.

E

MODULAR CONSTRUCTION

Another form of systematizing design criteria is provided in the systematizing of the solution framework through the use of modular coordination for building structures and materials. This can be an important standardization for mass-production or industrialized building, and can also be a factor in achieving flexibility and interchangeability. Modular coordination may also be useful in providing designers with a given set of modules as a standard or matrix for design decision-making. These references cover a range of topics within a general area of modular building, including outlines of modular systems and human responses to scale and proportion. While this is only one approach to systematizing the construction or structural processes, it does indicate some of the factors in the layout and coordination of materials and components, and opens the way to systematic consideration of construction and production methods.

1. Alexander, Christopher. "Perception and Modular Coordination," Royal Institute of British Architects Journal, (October, 1959).

The concept of proportion in design as a theory of visual order based on perception is discussed in an overview of historical concepts and is related to the systems of modular coordination based on technological disciplines.

2. European Productivity Agency. Modular Coordination in Building. Paris: The Organization for European Economic Cooperation, 1957. 168 pp.

Describes the European approaches to modular coordination of materials and components in buildings, with sections on design, manufacture, and construction.

3. Honey, C. R. "Disciplines in System Building," Architectural Record, 140 (September, 1966), 224-228.

Describes design problems and considerations related to system building, using prefabricated components and suggests the adoption of a working discipline based on an appreciation of operational factors.

4. Jeanneret-Gris, Charles Edovard. Modular 2, 1955. Cambridge, Mass.: Harvard University Press, 1958. 336 pp.

Expands upon the concept of the Modular, a system of modular or proportional coordination of design and construction, including discussions of development, theory, and applications.

5. Jeanneret-Gris, Charles Edovard. The Modular. Cambridge, Mass.: Harvard University Press. 243 pp.

The modular, a harmonious measure to the human scale, universally applicable to architecture and mechanics, extends the concept of modular construction and proportional scaling systems into a specific mathematical system based on human proportions.

*6. Koppes, Wayne F., and Alan C. Green. Modular Coordination and School Design. Troy, New York: Rensselaer Polytechnic Institute, 1967. 99 pp. EF 001 287

An orientation and overview to modular planning and design are presented in this report, with emphasis on applications

in school building design. This includes some checklists and tables related to modular design methodology.

7. Licklider, Heath. Architectural Scale. London: Architectural Press, 1964. 232 pp.

Scale is discussed primarily in terms of aesthetics, but some reference is made to proportional or modular systems and to design relationships with human scale, both functional and subjective.

8. Modular Building Standards Association. Modular Practice: The Schoolhouse and the Building Industry. New York: John Wiley and Sons, Inc., 1962. 198 pp.

Describes the modular coordination of materials and components in building design, with emphasis on school buildings. Specific guides are provided for architects in the areas of design, working drawings, plans, elevations, and details.