DOCUMENT RESUME

ED 072 513	24	EA 004 800

AUTHOR	Baas, Alan M.
TITLE	Luminous Environments. Educational Facilities Review Series Number 15.
INSTITUTION	Oregon Univ., Eugene. ERIC Clearinghouse on Educational Management.
SPONS AGENCY	National Inst. of Education (DHEW), Washington, D.C.
BUREAU NO	BR-8-0353
PUB DATE	Mar 73
CONTRACT	OEC-0-8-080353-3514
NOTE	10p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Biological Influences; Classroom Design; Classroom Environment; *Controlled Environment; *Educational Facilities; Flexible Lighting Design; *Illumination Levels; Light; *Lighting; *Literature Reviews; Planning (Facilities); Windowless Rooms; Windows
IDENTIFIERS	Artificial Environments

ABSTRACT

The lighting of a school building should be considered an active element of the total educational environment. In addition to ensuring efficient performance of visual tasks, a good lighting system contributes significantly to the aesthetic and psychological character of the learning space. Recent literature on school illumination recommends a combination of natural and artificial lighting. Several documents cited in this review give evidence that reliance on artificial light sources alone may have adverse biological repercussions. Other documents describe lighting problems peculiar to open plan schools. The trend in luminous design provides for maximum lighting flexibility through use of both fluorescent and incandescent lamps. Thirteen of the documents cited are available from the ERIC Document Reproduction Service. (Author)

EDUCATIONAL RESOURCES INFORMATION CENTER • CLEARINGHOUSE ON EDUCATIONAL MANAGEMENT
EDUCATIONAL FACILITIES REVIEW SERIES

March 1973 Number 15

Luminous Environments

Alan M. Baas

> Classroom lighting design plays a particularly critical educational role because of the direct relationship between good lighting and a student's performance, between eye fatigue and eye health, and between eye health and general health. Both performance and health mark the adult for life since no one yet has managed to go back and re-do his early years.
>
> *Falk (1972)*

The lighting of a school building should be considered an active element of the total educational environment. In addition to ensuring efficient performance of visual tasks, a good lighting system contributes significantly to the aesthetic and psychological character of the learning space. Thus, lighting should be an integral part of the design of the entire educational facility, and the opinion of the lighting designer should be called for wherever there is to be an interplay between light and structure.

Research has shown that visibility depends on the quality of the entire visual environment, not just on the quantity of available light. It is through the contrast between a task (object) and its background that the eye sees. But excessive contrast, caused by glare from improperly placed light sources or reflected from nearby surfaces, reduces visibility and causes fatigue. Other forms of glare, called "veiling reflections," may also cause weariness by reducing the contrast between the task and its background. Optimum visibility, therefore, is achieved through proper placement of light sources and selection of surface textures and colors to control the effects of contrasting surface brightnesses and reflected glare.

Recent literature on school illumination recommends a combination of natural and artificial lighting. Several documents cited in this review give evidence that reliance on artificial light sources alone may have adverse biological repercussions. Other documents describe lighting problems peculiar to open plan schools. The trend in luminous design provides for maximum lighting flexibility through use of both fluorescent and incandescent lamps. The latter are more mobile and can be used especially where variable accents are desired.

Thirteen documents are available from the ERIC Document Reproduction Service. Complete instructions for ordering are given at the end of the review.

UNDERSTANDING LIGHT

In a report on the biological implications of artificial lighting, Wurtman (1968) encourages illuminating engineers to use natural light (or spectral facsimiles) sources whenever possible in modern artificial environments. He points out that in addition to providing visual stimulus, environmental lighting exerts profound biologic effects on humans and other mammals.

Light acts on the skin to stimulate synthesis of Vitamin D. It also acts, through the eyes, to control several glands and many metabolic processes. Light, or its absence, "induces" certain biologic functions and serves as synchronizer for basic body rhythms.

Wurtman reports that alterations in environmental lighting can produce marked, and sometimes pathological, changes in the body's metabolism. He recommends that as information accumulates about the mechanisms of the biologic effects of light, sources should be modified to become compatible with human needs.

A speech by Logan (1969) on the influences of the electromagnetic environment on life and man gives evidence that sea level solar radiation is biologically beneficial and necessary for man's physical and mental health. Logan observes that urban man has inadequate exposure to certain wavelengths of ultraviolet light normally received from sunlight, and that man has created an electromagnetically polluted environment potentially harmful to life.

He emphasizes that man must concern himself with creating a biologically optimum electromagnetic environment. To achieve this, he recommends the creation of a new profession, "spectrum engineering," to deal with electromagnetic radiation and its biological effects on life. An important responsibility of this new profession should be the development of "bio-lighting" sources—artificial illumination with a light quality the approximate equivalent of sunlight found at sea level. Logan supplements his presentation with a listing of the effects of various wavelengths of solar radiation on life and includes references for further research.

A publication by the National Society for the Prevention of Blindness (1963) stresses the importance of illumination for the school child. Visual efficiency has a marked effect on many learning situations and is influenced by a number of factors. Physiological factors are the stage of growth and development of the child's eyes, and the presence of eye defects. Physical lighting factors include relative brightness of object and background (contrast), size and distance of object, amount of illumination, and glare. The document also discusses illumination quality and quantity in relation to brightness balance, reflection factors in the environment, natural lighting and its control, artificial lighting and its control, and lighting maintenance. In addition, the role of the teacher in the illumination program is described in terms of how he can improve seeing conditions in the classroom.

In an early report on coordinated classrooms, Harmon (1951) explicates the physical relationship of the student to classroom environment in terms of light control. He shows how shadows, glare, inadequate light distribution, desks, and desk positions affect the student's physiological and psychological well-being. The effects of light diffusion on desks, chalkboards, interior walls, and ceilings are examined in relation to vision and posture. Harmon also describes a study comparing learning achievement in light-controlled and non-light-controlled environments.

Larson and others (1965) suggest that natural lighting has no measurable effects on student learning. The authors report the results of a study to determine the effects of windowless classrooms on student achievement in grades K through 3. Observations made in two schools, one with windows and one without, indicate that windows have little effect on a child's performance. Teachers in the windowless classrooms noted fewer distractions from outside noise and weather conditions, though a few complained about drafts and stuffiness. Attitudes of parents and children ranged from curiosity to indifference. The authors conclude by reminding the planner of windowless rooms to provide for adequate artificial lighting and mechanical ventilating systems.

The research reported by Larson and his colleagues did not focus on physiological or psychological effects of light itself; rather the study sought to empirically test nonfenestrated learning environments against pupil achievement. Before investing in totally windowless schools, it would appear that educators should carefully consider comments made by both Logan and Wurtman (noted above) concerning the positive values of natural light. The most recent literature on school lighting (cited in the next section of this review) tends to prefer a combination of natural and artificial light sources.

Most of the literature on lighting emphasizes that improper illumination seriously reduces the ability to perform visual tasks. Levy's (1967) brief and informal summary of school lighting considerations points out that people tend to be unaware of their luminous environment. He urges early training of children to recognize the value of proper lighting.

SCHOOL LIGHTING

A recent article in *American School & University* (Corgan 1972) cautions against lighting mistakes that may limit the effectiveness of open plan schools. Because such schools accommodate many groupings and configurations of students and teachers, lights should not be arranged in long strips extending into several teaching areas and controlled by a single switch. Square or rectangular groups of fixtures provide far more flexibility. Aesthetic variation and cost savings can be achieved by lowering light levels in public areas.

Carpeting, a standard in most open plan schools, also plays an integrated role in the luminous environment. By providing uniform light absorption and reflectance, it avoids glare problems posed by vinyl tile. The glare factor requires various tradeoffs between lighting and maintenance design. Glossy surfaces are easier to clean but produce more glare; matte surfaces collect dust but transmit light evenly for a more harmonious effect.

Corgan proposes a general theory for maximizing flexibility while maintaining reasonable cost-effectiveness—limit the number of components (luminaires, types of lamp, and so forth) while increasing the

SUMMARY OF GENERAL LIGHTING PRINCIPLES

- The quality of the light is more important than its quantity.
- The amount of light should be proportionate to the task performed.
- Task (object) brightness should be equal to or slightly greater than brightness of the entire visual environment. The brightness balance should be the dominant factor in lighting design.
- Excessive contrast (bright light, dark background) causes weariness and poor concentration. Shadows should be eliminated to improve performance and increase information retention
- Surroundings should not be less than one-fifth the brightness of the task and preferably one-third its brightness.
- Continuous overhead diffused light is the most efficient and economical form of artificial lighting. It also produces minimum glare.
- Glare from nearby surfaces should be reduced as much as possible through use of matte finishes and avoidance of glossy paints, varnishes, and plastics.
- The angle at which materials are held to the light source is critical. Because of the reflected glare, work areas should never be directly under light sources.
- Use of polarizing panels is one of the most effective ways of reducing glare.
- Uniform light is not always best
- White light gives maximum visibility, but other colors may be introduced for psychological and aesthetic reasons.
- Colors of surrounding areas should be considered in a balanced luminous environment.
- Lighting should be well integrated with other building design factors (spatial, thermal, visual, acoustic, and aesthetic).
- The footcandle is not the best criterion for determining proper illumination.
- An objective method should be used to determine the effectiveness of any given lighting system Methods are described in many of the technical manuals.

These general observations about lighting and its relation to visual task performance are drawn from Levy (1967), Gibson (1965), and Crouch (1966).

range of applications (switching configurations, surface treatments, and so forth). He also discusses major alternatives for mounting light fixtures and gives two examples of open plan schools that demonstrate good lighting design.

In another *American School & University* article, Falk (1972) offers a detailed summary of basic lighting considerations for school design. In addition to maintaining a minimum brightness level, the effective learning environment must control both direct and indirect glare. After explaining the effects of glare on visual performance, Falk identifies several methods of glare reduction that have become standard in the well-planned classroom. Glossy paints on walls, glossy varnishes on furniture, and modernistic chrome trim should be avoided. He also advises educators to guard against the glare caused by plastic surfaces on visual aids, teaching machines, and translucent covers for books. Manufacturers should be urged to provide matte finishes wherever possible.

Falk also describes recent developments in fluorescent and incandescent lighting, the most significant of which is the twin-beam fluorescent fixture. The twin beams minimize glare and control reflections. Better texture is created by their sharply defined directional quality. For technical advice and standards, Falk recommends use of the 1972 fifth edition of the *IES Lighting Handbook* (available from the Illuminating Engineering Society, 345 East 47th Street, New York, New York 10017) and the *American Standard Guide for School Lighting*, published by the American Institute of Architects in 1962. Standards shown in this guide were reaffirmed by the American National Standards Institute in 1970.

In an article in *School Management*, Shemitz (1972) gives a profile of an elementary school where the lighting designer participated in every decision affecting the interplay of light and structure. Monotony of uniform high intensity light is avoided throughout the building by providing accents, interest, and variety in lighting and architectural effects. A combination of fluorescent and incandescent lights, together with ample provisions for natural lighting, helps to achieve an optimum open plan learning environment.

Results of a study by Sampson (1970) show that many lighting systems now in common use are less than 20 percent effective in terms of adequate "glare-free" illumination. To determine how contrasts from different light sources affect the ability to see visual tasks in the school room, Sampson measured and analyzed eighteen significantly different classroom lighting systems. Using criteria and techniques from previous lighting research, he evaluated the lighting systems according to degrees of visual contrast provided.

One significance of Sampson's examination is that it considers the many potentially negative effects of lighting fixtures and their arrangements. His detailed report includes comparative data and specific conclusions regarding the effectiveness of various systems and provides valuable recommendations regarding the design of new or remodeled luminous environments.

The application of good lighting principles to school lighting receives attention in a bulletin by England's Department of Education and Science (1967). The study also considers circumstances in which daylighting and artificial sources may be designed together. Appendixes treat in greater detail some of the problems that arise in lighting specific areas of the school, in lighting for the partially sighted, and in remodeling old schools.

Gibson (1965), the June 1965 issue of *American School Board Journal*, and Crouch (1966) provide dated but still useful perspectives on school lighting concepts. Many of the observations made by Gibson and Crouch appear in the "Summary of General Lighting Principles" (page 4 of this review). Gibson also points out that beauty, comfort, safety, security, and full use of space should accompany speed and accuracy of task performance as criteria for adequate luminous environments. To improve general visibility conditions, he recommends avoiding high glare surfaces in purchasing instructional materials and equipment.

In addition to discussions of concepts and challenges relating to lighting design, the *American School Board Journal* contains articles on maintenance evaluation, use of glass, effects of illumination on learning, auditorium lighting, remodeling school lighting, and relevant new products for school illumination.

Crouch's discussion of modern school flexible lighting requirements stresses integration of the luminous environment with visual and acoustic aspects of school building design. After presenting a table of acceptable illumination levels and surface reflectances, he provides a sketch showing potential sources of specularly reflected glare and a simple test for determining discomfort glare.

TECHNOLOGY AND ITS APPLICATIONS

Implications of the total energy concept (integrated central lighting, heating, cooling, and power systems) for schools and colleges are reported in an Educational Facilities Laboratories (1967) document. The concept entails higher initial investments for onsite power generation, but promises greater long-range operating economies. EFL's examination of design alternatives measured against long-term engineering costs suggests that total energy systems may be the best solution for modern school energy needs. Case studies and discussions of future trends are included in the report, together with guidelines for feasibility studies and plant and equipment design.

A publication by the General Electric Company (1966) discusses design implications and methods for the evaluation and control of integrated systems utilizing the heating potential of lighting equipment. Its treatment of general principles includes heat transfer, heat from lamps and luminaires, and control of lighting heat. Suggested systems include total control systems, bleed-off systems, separate systems, and water and air systems. The document also explains all-electric systems components such as heat pumps and electric supplementary heating. Extensive use of photos, schematic drawings, and charts show heat and light outputs of different lamps, and heat transfer with different exhaust methods.

A "Lite-Therm System" for providing occupant comfort in glass façade buildings is presented in a publication by the Environmental Systems Corporation (1967). The system intercepts radiant heat before it enters the room and integrates the building's lighting, heating, and cooling systems through a combination of luminaires, induction boxes, and louvers.

The twin-beam fixture described by Falk also receives detailed attention in an *American School & University* article by Gardner (1971). He affirms that the twin-beam design provides cost-effective, optimum visibility with a minimum of glare. He also describes a new lighting evaluation technique that measures reflected glare as well as footcandles.

Allphin (1965) discusses basic principles and circuitry of the most commonly used lamp types. In addition to identifying troubleshooting and cleaning techniques, his guide examines lighting fundamentals, economical lighting systems, and incandescent, fluorescent, and mercury lamps.

The *American Standard Guide for School Lighting* (American Institute of Architects 1962) is designed for educators as well as architects. The guide surveys changing goals and needs of school lighting and discusses techniques for evaluating the lighting requirements of various tasks. Visibility variables such as size, contrasts, reflectance, glare, and illumination quality receive attention together with the relative merits and characteristics of artificial and natural lighting. Information is also given on illumination design and maintenance procedures. The guide concludes with special applications of lighting principles, using examples ranging from art rooms to swimming pools. Appendixes list technical data, instruments used in the lighting survey, and definitions of relevant terms.

Hopkinson (1963) discusses lighting principles in terms of physiology, psychology, engineering, physics, and architectural design. The first part of his substantive treatment describes elements of architectural physics and includes information on physiological aspects of lighting, visual performance, lighting design, calculation and measurement of illumination levels, daylighting, glare and visual comfort, reflectance, and color. Edited reprints of papers previously published by Hopkinson and his colleagues complete his book.

In his 1964 book on lighting and architectural design, Phillips writes to bridge the gap between architects and illuminating engineers. He offers information and analysis of how natural and artificial lighting affect building design, illumination levels affect vision, and lighting relates to safety. In addition to the nature of light and various relevant economic factors, Phillips discusses lighting control and the interaction between lighting and other building systems (heating, electrical, and structural). A section on computations presents methods of daylight and artificial light calculation, details of the lumen calculation method, and explanations of combatting glare from light sources. Photographs and drawings illustrate good and bad practices in lighting.

Pena (1957) reports that natural lighting effects can be predicted early in the design of a building through use of a model testing method. He describes a method in operation at the Texas Engineering Station that enables rapid and economic testing of a variety of architectural and landscape combinations. He also gives a detailed example of the test model procedure used in conjunction with the design of a school in Georgetown, Texas. Tests on the completed building indicated that initial model predictions were reasonably accurate.

An illustrated handbook on light shows (Edmund Scientific Company 1969) gives facts, ideas, techniques, suggestions, and sources for many hard-to-get materials and products. The guide discusses black light, flashing light, musicvision, and lumia (antishapes). In addition to instructions for creating special effects with overhead, 35mm, and kaleidoscope projectors, the document describes uses of slides, color wheels, color organs, mirrors, movies, screens, and light boxes. Information is also given on various electrical requirements for light shows.

BIBLIOGRAPHIES AND RELATED RESOURCES

An annotated reference source for architects and engineers is provided by Hartman (1968). His bibliography includes nineteen short overview articles and forty-three documents with an implicit orientation toward classroom lighting. Major document content areas are as follows: general specification guides with some psycho-physiological background, evaluation of human responses to various environmental aspects, mechanical system evaluations, control of specific aspects of the luminous environment, and environmental rating systems.

A selected bibliography by the ERIC Clearinghouse on Educational Facilities (1970) is intended to give an overview of lighting design while maintaining a technical level comprehensible to the layman concerned with school planning. Subject areas include visual and lighted environments relating to school facilities; man's biological, physiological, and psychological needs for light in the school environment; electric lights for educational facilities; lighting of audiovideo facilities and auditoriums; provision of daylight for the school environment; and applications of lighting design to educational facilities.

Larson (1965) presents a collection of annotated abstracts on various aspects of the school environment. The abstracts review existing literature describing various relationships linking environment with human behavior. Sections deal with environment and the human senses, as well as with behavior in relation to the atmospheric, luminous, sonic, and social environments.

REFERENCES

Abstracts of the following documents can be located in *Research in Education*. The complete texts are available from the ERIC Document Reproduction Service (EDRS), commercial channels, or both. Publications can be ordered in either Xerox copy form (HC) or microfiche (MF).

For each order, indicate the ED numbers of the desired publications, the type of reproduction desired (paper or microfiche), and the number of copies being ordered.

Payment must accompany orders under $10.00. Postage, at book rate or library rate, is included in the price of the document. If first class mailing is desired or if shipment is outside the continental United States, the difference between book rate or library rate and first class or foreign postage will be billed at cost. All orders must be in writing.

Journal articles cited with EJ numbers are indexed in *Current Index to Journals in Education*, a monthly companion index to *Research in Education*. Reproductions of the journal articles are not available from EDRS.

Address requests to ERIC Document Reproduction Service, P.O. Drawer O, Bethesda, Maryland 20014.

Allphin, Willard. *Primer of School Lighting Lamps and Maintenance*. New York: Sylvania Electric Products, Inc., 1965. 70 pages. ED 027 711 MF $0.65 HC $3.29.

American Institute of Architects. *American Standard Guide for School Lighting*. Washington, D.C.: 1962. (Reaffirmed in 1970 by the American National Standards Institute.) 40 pages. ED 019 868 Document not available from EDRS. (Available from the Illuminating Engineering Society, 345 East 47th Street, New York, New York 10017, $1.50.)

Corgan, C. Jack. "Overhead Planning for Open-Plan Schools." *American School & University*, 45, 3 (November 1972), pp. 48-50. EJ number not yet assigned.

Crouch, C. L. "Better Lighting through Research." *American School & University* (May 1966). ED 015 618 Document not available from EDRS.

Department of Education and Science. *Lighting in Schools*. London, England: 1967. 72 pages. ED 035 240 Document not available from EDRS. (Available from Pendragon House, Inc., 899 Broadway Avenue, Redwood City, California 94063.)

Edmund Scientific Company. *Unique Lighting Handbook*. Barrington, New Jersey: 1969. 112 pages. ED 047 492 Document not available from EDRS. (Available from Edmund Scientific Company, Barrington, New Jersey 08007. Stock No. 9100, $3.00.)

Educational Facilities Laboratories, Inc. *Total Energy, A Technical Report from Educational Facilities Laboratories*. New York: 1967. 52 pages. ED 031 073 MF $0.65 HC $3.29.

Environmental Systems Corporation. *Lite-therm Design Manual. Second Edition*. Atlanta: 1967. 28 pages. ED 024 238 MF $0.65 HC $3.29.

ERIC Clearinghouse on Educational Facilities. *The Luminous Environment for Education. A Selected Bibliography*. Madison: University of Wisconsin, 1970. 49 pages. ED 037 993 MF $0.65 HC $3.29.

Falk, Norman. "New Standards for Classroom Lighting." *American School & University*, 44, 7 (March 1972). pp. 21-23. EJ 055 340.

Gardner, John C. "How Much Light Is Enough?" *American School & University*, 43, 5 (January 1971), pp. 14-16. EJ 033 332.

General Electric Company. *Electrical Space Conditioning*. Cleveland: Large Lamp Department, 1966. 24 pages. ED 026 825 MF $0.65 HC $3.29.

Gibson, Charles D. "Today's Concepts in School Lighting." *American School Board Journal* (June 1965). ED 015 619 Document not available from EDRS.

Harmon, Darell Boyd. *The Co-ordinated Classroom* Grand Rapids, Michigan: American Seating Company, 1951. 52 pages. ED 020 621 MF $0.65 HC $3.29.

Hartman, Michael. *The Luminous Environment of the Classroom. A Selected and Annotated Bibliography*. Madison: ERIC Clearinghouse on Educational Facilities, University of Wisconsin, 1968. 17 pages. ED 024 250 MF $0.65 HC $3.29.

Hopkinson, R. G. *Architectural Physics: Lighting*. London, England: Building Research Station, Department of Scientific and Industrial Research, 1963. 370 pages. ED 035 236 Document not available from EDRS. (Available from Pendragon House, Inc., 899 Broadway Avenue, Redwood City, California 94063.)

Larson, C. Theodore. *Environmental Abstracts. School Environments Research Publication No. 1*. Ann Arbor: College of Architecture and Design, University of Michigan, 1965. ED 020 629 Document not available from EDRS. (Available from Publications Distribution Service, University of Michigan, 615 East University, Ann Arbor, Michigan 48106. $15.00.)

Larson, C. Theodore, and others. *The Effect of Windowless Classrooms on Elementary School Children*. Ann Arbor: College of Architecture and Design, University of Michigan, 1965. 101 pages. ED 014 847 MF $0.65 HC $6.58.

Levy, Charles, and Howe, William. *Brighten Your Corner, Broadcast No. 7464. University Explorer*. Los Angeles: University of California, 1967. 4 pages. ED 019 821 MF $0.65 HC $3.29.

Logan, H. L. "Bio-Lighting." *Lighting Techniques in Architecture (Madison. December 9-10, 1969)*. Speech, presented at conference on Lighting Techniques in Architecture, Madison, December 1969. 25 pages. ED 037 931 MF $0.65 HC $3.29.

McVey, G. F. *Environment for Learning: The Application of Selected Research to Classroom Design and Utilization*. 1969. 38 pages. ED 030 292 MF $0.65 HC not available from EDRS.

To gather the documents in this review, *Research in Education* and *Current Index to Journals in Education* monthly catalogs were searched from January 1968 through December 1972, using as search terms these descriptors: Controlled Environment, Light, Lighting, Illumination Levels, and Windows.

National Society for the Prevention of Blindness. *Classroom Lighting.* 1963. 15 pages. ED 019 822 MF $0.65 HC $3.29.

Pena, William A. *Predetermination of Natural Illumination by the Model Testing Method.* Bryan, Texas. Caudill, Rowlett, Scott and Associates, 1957. 4 pages. ED 018 929 MF $0.65 HC $3.29.

Phillips, Derek. *Lighting in Architectural Design.* New York: McGraw-Hill Book Company, 1964. 310 pages. ED 036 128 Document not available from EDRS. (Available from McGraw-Hill Book Company, 330 West 42nd Street, New York, New York 10017, or 8171 Redwood Highway, Novato, California 94947. $18.50.)

Sampson, Foster K. *Contrast Rendition in School Lighting.* New York: Educational Facilities Laboratories, Inc., 1970. 103 pages. ED 037 943 MF $0.65 HC $6.58. (Also available from Educational Facilities Laboratories, Inc., 477 Madison Avenue, New York, New York.)

"School Lighting." *American School Board Journal* (June 1965). ED 020 628 Document not available from EDRS.

Shemitz, Sylvan R. "Lighting an Open Plan School." *School Management,* 16, 2 (February 1972), pp. 22-25. EJ 051 789.

Wurtman, Richard J. "Biological Implications of Artificial Illumination." *Illuminating Engineering,* 63, 10 (October 1968), pp. 523-529. ED 025 929 Document not available from EDRS. (Available from Illuminating Engineering, Illuminating Engineering Society, 345 East 47th Street, New York, New York 10017.)

Clearinghouse Accession Number: EA 004 800

The ERIC Clearinghouse on Educational Management operates under contract with the National Institute of Education of the United States Department of Health, Education, and Welfare. This review was prepared pursuant to that contract. Contractors undertaking such projects under government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official Institute of Education position or policy.