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Classroom Lighting

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CLASSROOM LIGHTING

by

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INTRODUCTION

Civilization is largely a world of seeing. Throughout its intricate pattern seeing is an intimately and universally important factor in the education, experience and performance of human beings. It is a powerful and universal influence in the efficiency, safety, comfort, behavior, health, life and happiness of human beings.

In the early stages of man's development, his life was essentially that of an outdoor creature. Because of this he was able to adapt himself to a wide range of lighting values; from the thousands of foot-candles of brilliant sunlight to less than one foot-candle of moonlight. However, most work was done outdoors in the daytime. By contrast, man of today spends a greater part of his living indoors doing many enterprises that are carried on under inefficient and poor-quality artificial light.

Our modern educational system has gone through a tremendous change, also. It involves much more seeing than ever before. No longer is education just confined to the reading of books, but involves the use of many other visual aids. This is found from the first grade through the university.

This change in man's use of his eyes has apparently led to many physical defects, not only of the eyes but of the entire body.

Luckiesh points out that:

> About one person in every five of our entire population wears glasses. Twenty-five million persons with eye-crutches. The eyes of another twenty-five million with eye defects are more or less limping along without crutches. A total of fifty million—forty percent of our entire population—has appreciable defects of vision of the refractive type. Worse still, an attitude of prevention is relatively nonexistent in an age in which preventive measures have made enormous strides in medicine, surgery and elsewhere.[1]

Certain statements made by Luckiesh, which are based on experiments and statistical evidence, indicate that many other physical defects may be avoidable.

> Nearly all our babies—approximately an average of ninety-five per cent—are born with nearly normal vision. Actually they are far-sighted, but this appears a matter of incomplete development of the eyes at birth. At least most of us still begin life with reasonable eye-sight.
>
> Eye-defects increase markedly with age. Only a few per cent of children entering school have eye-defects of the type for which eyeglasses are prescribed. Eye-defects, such as near-sightedness, increase rapidly from grade to grade. About one out of every four has measurable eye-defects at graduation from high school. This ratio increases to nearly one out of three when young people are graduating from college.
>
> Eye-defects vary markedly with occupation. The percentage of eye-defects is less for outdoor workers than for indoor workers. It is less among farmers than librarians. A typical investigation reveals that seventy-five per cent of garment workers had some defect of vision. The greater prevalence of eyestrain troubles and eye-defects in occupations where the task of seeing is obviously severe is a strong indication that the magnitude of eye-defects and possibly their number are preventable to some degree. This is emphatic evidence that

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[1] Matthew Luckiesh, Light, Vision and Seeing (New York: D. Van Nostrand Company, 1931), p. 15.

> they are partially the result of our use of the eyes and perhaps of poor seeing conditions which generally can be improved.[2]

Experiments performed under the direction of D. B. Harmon and his staff of the Texas State Department of Health and the Texas Commission on Child Development in the public schools of Texas seem to support these findings also.

> These studies showed . . . that in the Becker School, Austin, only 30.7 per cent of the children showed refractive eye problems in the low first grade, while 71.4 per cent showed them in low fifth grade. During the first four years, the number of visual cripples was being more than doubled. Among the entire group of 160,000 elementary children, 59 per cent had refractive eye problems, 39.5 per cent had eye problems other than refractive, 71 per cent had nutritional deficiencies, and there were similar high percentages of other troubles.[3]

Eyes are useless without light. Light is the most important partner of seeing. But, even though it is an essential partner of sight, it has been relatively ignored. Generally it has been taken for granted. Lighting, which involves the distribution of light—its direction and diffusion—has been ignored even more. The function of lighting in the school is to contribute to accurate, rapid, easy and comfortable seeing. "To the extent that it does this, it is as important as seeing, itself," says James.[4]

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[2] Ibid., p. 16-17.

[3] R. L. Biesele, Jr., "New Light on School Lighting," American School Board Journal, 113:28, July, 1946.

[4] Leonard W. James, "Good Seeing Conditions in Schools," The American School and University, 19:93, 1947-48.

He continues:

> Lighting might be considered, therefore, in a definitely preferred position relative to almost every other structural element and almost every other educational facility. This does not mean that these other details should be neglected in favor of lighting, but it does mean that those who would determine what lighting should be installed should study the extent and the manner in which lighting contributes to seeing.[5]

Change in Philosophy on Lighting

Until recently school lighting codes placed their greatest emphasis on tables showing how many foot-candles are needed for visual tasks in school rooms. A foot-candle is the quantity of light upon a printed page one foot from an ordinary candle. This has become the unit of intensity of illumination, just as a quart is a unit of liquid quantity. If what was found in the classroom measured up to the code table it was believed to be an acceptable visual environment for the students.

But now this narrow foot-candle concept of lighting is being vigorously challenged. "We are now concerned not only with the number of foot-candles, but also the kind of company the foot-candles keep," says Essex.[6] The thinking of informed illuminating engineers has advanced well past the concept that quantities of light make a good lighting job, to a broader concept that an adequate visual

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[5] James, loc. cit.

[6] Don L. Essex, "Lighting for School Buildings," The American School and University, 20:124, 1948-49.

environment depends upon many other factors. These factors are size of object being viewed, readability, time, brightness, brightness contrast and brightness ratio.

Factors That Influence Seeing

Size of object being viewed. The most obvious factor influencing seeing is the size of the object being viewed. Within certain limits increasing the size of an object increases its visibility and the ease of seeing. In some tasks the size of detail is controllable, but in others it is not and these tasks must be aided by other factors.

Readability. Readability means more than the symbols on a printed page. It is concerned with the seeing ability of the task under observation. Readability is affected by the visibility of the type, particular type face used, length of type and space between the type. In other words, material printed with Roman type possesses greater readability than does that printed with Old English, and expanded letters are easier to discern than condensed letters.

Time. It takes time to see. This is an important factor in seeing. Under some conditions it takes longer to see. Seeing is also influenced by time from the standpoint of the length of period to which the eyes are subjected to the crucial task.

Brightness. The brightness of an object or of its background is the primary factor upon which visibility depends. The primary purpose of light is to produce brightness. In fact, this is its overwhelmingly important contribution to seeing. "If light did not produce brightness," explains Luckiesh, "objects would remain invisible and our visual sense would be useless. We would have to see with our other senses as blind persons do."[7] Consideration of brightness involves details and a far more intimate knowledge of seeing and of factors which influence seeing. It is the function of the science of seeing to determine the relation of brightness to visibility and to the ease of seeing.

The importance of brightness is not confined to the visual task--objects, critical details and their backgrounds. Seeing conditions involve brightness of the immediate surroundings of the visual task and also brightnesses in the entire visual field. Luckiesh explains it by stating that:

> In addition to the task itself, good seeing involves the brightness of the immediate surroundings and of the entire visual field, for we cannot see with ease and comfort, for long periods, amid the dark surroundings due to stained walls and purely direct lighting. The annoyance of glaring light-sources is due not only to their inherent high brightnesses but also to their extreme contrast in brightness with their surroundings. Brackets containing bright lamps are more glaring against a dark stained wood panel than against a lighter background. The powerful headlights of an automobile are incomparably more glaring at night amid dark surroundings than in the daytime.[8]

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[7] Luckiesh, op. cit., p. 68.

[8] Luckiesh, op. cit., p. 70.

Excepting for self-luminous objects and the high lights reflected by shiny surfaces, brightness is due to light diffusely reflected from surfaces. Light in terms of foot-candle intensity falls upon a surface. The surface absorbs a portion of the light falling upon it and reflects the remainder. The percentage of the total amount of light falling upon the surface which is reflected by the surface is its reflection factor. The footlambert is used to measure the brightness of reflecting surfaces. Luckiesh points out that a surface may be perfectly diffusing without reflecting all the incident light. He gives as an example, a dark gray paper. If it reflects only ten per cent of the incident light, a foot-candle of illumination produces a brightness of only one-tenth footlambert. Therefore, multiplying the foot-candles by the diffused reflection factor gives the brightness in footlamberts of a diffusely reflecting surface.[9] In Figure 1, both of the perfectly diffusing surfaces are illuminated to a level of ten foot-candles. The former is four times as bright as the latter when viewed from any direction.

It is easy to talk about brightness values but not so easy to measure them. To measure brightnesses accurately an expensive photometric instrument is necessary of which comparatively few have been built. A trained photometrist is also required. Comparatively few illuminating engineers in the field have access to such an instrument, or are trained to use it. Until a simpler and less expensive

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[9] Luckiesh, op. cit., p. 73.

brightness meter is developed, such measurements are going to have to be made by specialists.[10]

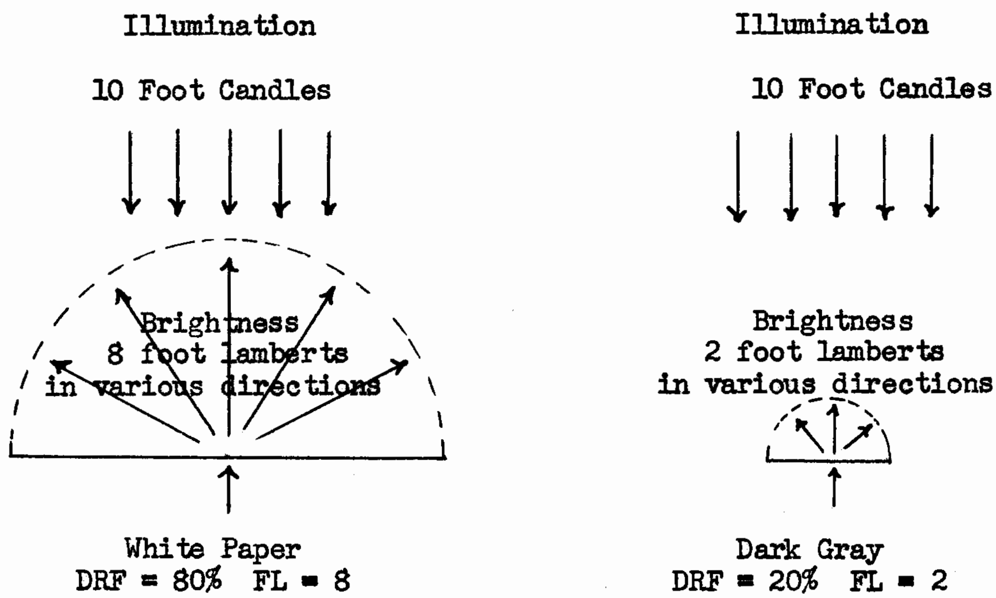

FIGURE 1

DIFFUSED REFLECTION FACTOR TIMES FOOT-CANDLES EQUALS FOOTLAMBERTS[11]

Brightness contrast. Brightness contrast refers to the brightness difference between the object and its immediate background. White reflects more light than any color and black less. Hence, in practice, the highest brightness contrast found is that between such things as black printing and white paper. But black thread viewed on black cloth provides a very low brightness contrast. The

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[11] Luckiesh, op. cit., p. 73.

brightness contrast, then, should be high. Luckiesh believes:

> Brightness contrast is exceedingly important. This factor, generally ignored by eyesight specialists and inadequately considered in the science of vision, properly assumes its importance in the science of seeing. The minimum size of an object which is barely visible is many times greater when the brightness contrast is low than when it is high. For example, a 12-point type printed with black ink on a dark grey background may be only as barely readable by normal eyes as a 3-point type is when printed with black ink on white paper.[12]

Brightness ratio. The brightness ratio factor has been the most often neglected in the past. Brightness ratio refers to the brightness difference between the visual task and the surrounding field. A task which involves reading a book printed on white paper resting on a black desk top with adequate illumination provides a high brightness ratio. Likewise, a large area of bright sky viewed through a window surrounded by completely dark walls provides a high brightness ratio. The brightness ratio is low, as it should be, when the brightness of objects, surfaces and light sources approach equality. Brightness ratios are also of importance in determining how glaring a light source, or the bright area of any lighting equipment may be. "It is better to have surroundings darker rather than brighter than task," advises Luckiesh.[13] Table I indicates the practical and desirable ratios set by the Indiana Division of Research.

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[12] Luckiesh, op. cit., p. 58.

[13] Luckiesh, op. cit., p. 221.

TABLE I[14]

DESIRABLE BRIGHTNESS RATIOS

	Ratio
1. Between parts of the immediate central visual area, such as book and desk	3 to 1
2. Between the task and the more remote parts in the general field of view, such as between book and ceiling, walls, or out-of-door objects.	10 to 1
3. Between the luminaire, or the sky if visible, and the ceiling or wall adjacent to it in the visual field.	20 to 1
4. In no case should the combination of these ratios be interpreted so as to permit more than a 30 to 1 ratio of brightness in any normal field of view.	

[14] Bulletin of the School of Education, Indiana University, Planning School Building for Tomorrow's Educational Program: Proceedings (Indiana: Division of Research and Field Services, 1947), p. 25.

Since the size of the visual task in the classroom is usually predetermined, the time allotted for seeing usually held to a minimum and brightness contrast and background is fixed, it is believed by Darley, that the influence most easily and most universally applicable to increasing the visibility of the task is brightness.[15]

The Visual Field.

Inasmuch as the distribution of brightness in the visual field determines the seeing conditions, it is important to know what makes up this visual field. The brightness differences within these fields will determine to a great degree how comfortably, how easily and how quickly one sees. In Figure 2 the central field is considered the same as the visual task and its background such as this page of printed matter. The focal field is at the center of the total visual field. It is approximately one degree in extent and corresponds to the foveal area of the retina. The seeing of fine details is done in this field. The surrounding field covers about sixty degrees of the central part of the total visual field. The peripheral field is the remainder of the total visual field lying outside the surrounding field.[16]

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[15] William G. Darley, "Seeing in the Schoolhouse," American School Board Journal, 110:31, August, 1945.

[16] Charles D. Gibson and Foster K. Sampson, "Balanced Brightness VS. Footcandle Intensities as Related to Classroom Lighting," The American School and University, 18:220, 1946.

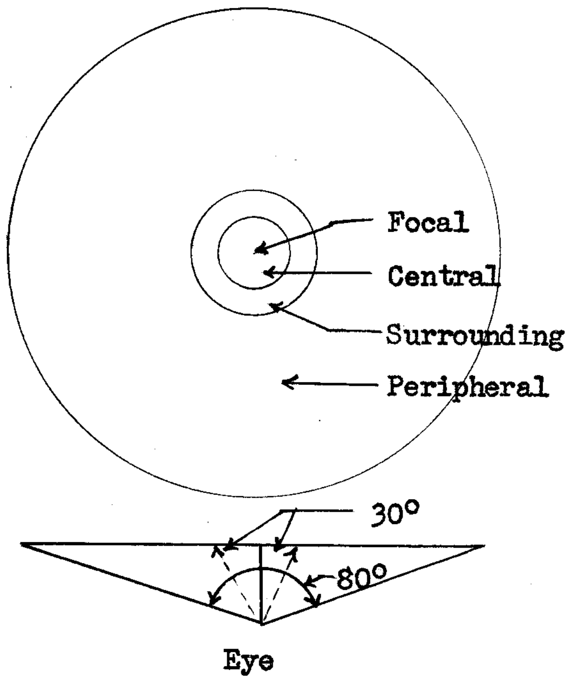

FIGURE 2

TOTAL VISUAL FIELD[17]

The principle of ideal brightness-difference for these visual fields has been stated by Gibson and Sampson in the very simple, but none-the-less accurate way as follows:

> The brightness-difference within the focal and central fields should be as great as possible while the brightness-differences between the visual task (central field) and the brightnesses found in the surrounding and peripheral fields should be as little as possible. In other words, in the task itself we want high brightness-differences, and beyond that area covered by the visual task, we want low brightness-differences. In the focal and central fields we would maintain the maximum possible brightness-differences. In the surrounding and peripheral fields

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[17] Ibid., p. 221.

> we would strive to maintain brightnesses which would be as near as possible to the brightness of the task itself. However, under most circumstances, this is not economically feasible. A practical ideal goal would allow a maximum brightness-difference of 10 to 1 between the brightest and darkest objects in the surrounding and peripheral fields. If the story of seeing were told in a nutshell, it might well be said this way—brightness-differences in the total visual environment determine how well we see.[18]

Probably the most encouraging example of this change of emphasis is the results of the twenty-third annual meeting of the National Council on Schoolhouse Construction held in Jackson, Mississippi, in October of 1946. At this meeting the standards committee of the council was authorized to issue a first edition of a new version of the Council Standards.[19] The standards, since 1930, have been revised and enlarged from year to year. But until the 1946 revision the standards had not deviated greatly from a series of positive statements or directives which gave little leeway for school designers to change their plans to fit local requirements and conditions. "It was found that the minimum standards given tended to become maximum practice," reports Darley. "Hence a designer could comply with the letters of the standards and miss the spirit of functional planning to house comprehensive programs of school and community service."[20]

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[18] Ibid., pp. 221-222.

[19] National Council on Schoolhouse Construction, Part II Guide For Planning School Plants (Nashville, Tennessee: State Department of Education, 1947), p. 37.

[20] William Darley, "Conditioning School Rooms for Visual Comfort and Efficiency," American School Board Journal, 114:47, September, 1947.

The National Council on Schoolhouse Construction published this guide, not as standards, but as principles and objectives for planning school facilities. They had hopes that it would induce school administrators and architects to some comprehensive and creative thinking. They hoped they might find new, ingenious and economical ways of complying with the objectives of good planning.

The subsection of the guide dealing with lighting is appropriately titled, "Conditioning Schoolrooms for Visual Comfort and Efficiency." The introduction of this section gives one an idea of the newness of viewpoint and points out the new emphasis in the field of school lighting. It says,

> More recent emphasis advanced by students of the seeing-in-the-schoolroom problem has broadened considerably from the narrow foot-candle concept. The relationships of brightness, brightness difference, and total visual fields have supplanted the elementary discussions of foot-candle standards. The problem has shifted from "How much light should we have" to "how well can we see?" The relative importance of the factors which constitute a good visual environment in schools has been modified from the realm of opinion centering about light quantity recommended to the more educationally accepted concern about the positive correlation between good seeing conditions and the conservation of human resources. The philosophy of those who would attempt to claim material educational growth based solely on increased quantities of light at desk-top level has been abandoned for a more acceptable approach which takes into consideration the entire visual environment as it affects the physical, mental, and emotional welfare of students.
>
> The remainder of this subsection will be devoted to a presentation of the basic elements which must be understood in order to evaluate objectively the environment as it is related to visual comfort and efficiency. Following the presentation of these basic elements, practical procedures for the conditioning of the environment for visual comfort and efficiency will be suggested.[21]

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[21] National Council on Schoolhouse Construction, op. cit., pp. 58-59.

From the introduction it is evident that the Council has stepped into a position of dominant leadership in this field. "It has made available," says Darley, "the first guide to the attainment of a desirable visual environment in the classroom which is based upon the over-all brightness environment rather than solely upon the narrower concept of visibility."[22]

The Council's intent to maintain a position of dominant leadership is made plain by the following quotation:

> Practical versus optimum conditions dictate that this guide should make specific recommendations which are educationally acceptable and practically feasible at this time. As research and science progress, conditions more nearly approaching the optimum will be available. At that time present recommendations can be revised in terms of new development.[23]

This approach, then, should have a profound influence on the planning for visual environments in American schools.

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22 Darley, op. cit., p. 47.

23 National Council on Schoolhouse Construction, op. cit., p. 63.

CHAPTER II

THE EFFECT OF LIGHT ON THE GROWING CHILD

Measuring the human being as a whole in relation to his visual environment has been the work of Harmon, an educator and a psycho-physiologist. To apply his classroom research he went directly to industry. Six manufacturers of schoolhouse equipment and materials set up a fund so he could conduct independent studies and at the same time use the facilities of their industries for experimentation and testing. In his writing concerning the effect of light on growing children he writes, "Children do not see to see--they see to act."[1] Seeing, then, involves more than the eye. It is only one of the body processes set into action by light entering the eye. According to Biesele, light actually has five physiological functions.

> 1. It prepares the mind and body to respond to any external stimulus. In this respect, it is similar to the switch on a radio set.
>
> 2. It helps an individual orient himself in space. It tells him where he is with respect to all the other things in his field of view.
>
> 3. It causes him to adjust his eyes, his head, and his body, almost automatically, to face anything which has caught his attention.

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[1] Darell B. Harmon, "Light on Growing Children," <u>Architectural Record</u>, 99:79, February, 1946.

4. It permits him to see, or recognize the object or visual task which has caught his attention. This is what is usually thought of as seeing, although actually all five functions of light mentioned here are various aspects of the seeing process.

5. It assists the body and mind in performance of the task called for by what is seen.[2]

One can readily see, then, that light affects more than the eye. Light does more than aid a child in the recognition of words and objects. It is an important force in his environment that can shape or distort the total child, his eyes, his muscles, his well-being, currently or permanently.[3]

Physical Effects

In designing the lighting for a classroom, it is necessary first to look at the child as a whole. The first and primary function of every child is to grow and develop. How well he does this will depend on his environment. "Organic life consists of a continuous process of balancing," says Harmon.[4] He goes on to say:

> Within limits the human body is an organic mechanism fitted to survive by its capacity to adjust its relationship to the environment in which it finds itself. This is accomplished by shifting the internal balance between various bodily systems and parts, and by modifying or adapting many of its structures to fit the specific environmental factors which it encounters through a period of time. This adjustment of internal balances,

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[2] R. L. Biesele, "New Light on School Lighting," American School Board Journal, 113:28, July, 1946.

[3] Harmon, op. cit., p. 79.

[4] Loc. cit.

> and modification or adaption of certain structures (eyes, muscles, bones, body chemistry, etc.) can be beneficial to the individual, or it can be harmful. The harm done, in turn, can be merely a temporary functional change, or it might be a handicapping chronic affliction.[5]

Harmon believes that lighting affects growth, both as to rate and as to pattern because virtually all the educational tasks of children are either introduced or carried on through critical seeing, involving the bodily balancing mentioned above.[6]

Seeing requires the expenditure of nervous energy. It is estimated that a person with normal vision consumes, under adequate lighting, one quarter of his bodily energy in seeing. Consumption of bodily energy would be increased considerably, then, if vision were poor or illumination improper.[7]

A child has available just so much energy to expend, depending on his nutrition, that must be spread over a number of demands. The first demand is that required to keep himself alive, such as breathing. Doing what he is called upon to do by all the influences of his environment is the second demand. If there is any energy left after these demands are met it goes to fighting infection and then the remainder goes to growth.[8] Harmon reports that "Activity takes

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[5] Harmon, loc. cit.

[6] Ibid., p. 80.

[7] John J. Neidhart, "Protect Their Eyesight by Adequate Lighting," The Nation's Schools, 34:34, October, 1944.

[8] Biesele, op. cit., p. 29.

precedence over growth in the use of nutrients."[9] It must be remembered also that of the total energy required for most actions 80 per cent of it is used up in merely getting ready to act, and only 20 per cent in the actual performance. Thus it is possible for large demands to be made on the energy of the school child even though there may be no overt action at all.[10] Harmon warns that "continued stresses induced by poor distribution of light, by bad contrast, glare, and other bad practice, might readily use energy needed for growth, for body function, for protection against infection, and for defense."[11]

To see properly, the child adjusts not only with his eyes but his head, his trunk and his entire body. The whole body tries to center itself on the brightest area affecting the eye. A child will always adjust automatically to the best position. If that adjustment puts him into a one-sided position regularly he will grow one-sided. Sometimes if a disturbing light source is in the field of view, the child will shield his eyes with his hands, or shift his head. Such shifts may produce distorted vision and in time refractive eye defects.[12] And as Harmon puts it:

> The child's body grows along the lines of stresses induced in it by various activities, in order to reduce those stresses.

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[9] Harmon, op. cit., p. 80.

[10] Biesele, op. cit., p. 29.

[11] Harmon, op. cit., p. 80.

[12] Biesele, op. cit., p. 28.

> If the environment sets up lines of body stress that are not normal, that do not fit the alignment of inherent and normal growth, the result is structural warping. As the child continues to grow and function in such surroundings, the final result is asymmetrical or unbalanced body structure, deviating performances, and physical or psychological lesions and disabilities.[13]

In 1939 the state department of Texas, under the direction of Harmon, started to study the health and growth of 160,000 elementary school children. An inventory was made during the first three years of the physical and psychological difficulties affecting the children. At the same time a check was made of the classroom factors which might be related to these difficulties. The initial data indicated that the difficulties they were having were probably more related to the bodily activities aroused when the eye was stimulated by light, than to the intensity of the light on their work. Thus bodily activity in close visually centered tasks, and the total distribution of light were singled out for further study.[14] In this study Harmon discovered that the whole body was involved in the process of seeing. He explained it this way:

> If a visual task requires adjustment of the eyes to function at a certain focal distance for efficient resolution, then it follows that the supporting structures of the eyes (the head and body) must adjust to support the eyes at a distance from the task determined by that focal distance, and hold them there as long as the task is being performed. If the task is one also requiring manual manipulation (i.e., writing, or holding a book), then these supporting structures must not only maintain the eyes

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[13] Harmon, _op. cit._, p. 81.

[14] Darell B. Harmon, _The Co-ordinated Classroom_, (Grand Rapids, Michigan: American Seating Company, 1949), p. 3.

> at the appropriate distance from the task, but must also support the arms and hands at distances permitting both successful eye-hand coordination and maximum efficiency in continued manual manipulation. These activities must go on simultaneously with the other activities which support the body against gravity, and balance it with all the other demands of the task and in the environment. The common elements in body proportions, optical laws, and body function should reveal basic formulae for such light-and-task-stimulated activities, applicable to all children, that could be used in planning classroom surroundings and for evaluating the efficiency of children in them.[15]

From these studies and observations which were presented in detail in his brochure "The Co-ordinated Classroom"[16] he set about to develop experimental classrooms in which the environment would be conducive to good seeing. His method was based on distribution of brightness. He believed that if the child's field of vision was more than three times brighter than the brightness of any other visible area, the child was in trouble.[17] According to his technique there are four main factors in the classroom that need re-doing. They are (1) fenestration; (2) decoration of floors, ceilings and walls, including chalkboard and draperies; (3) furniture; (4) artificial lighting. These factors will be discussed in a later chapter.

Twenty-four classrooms were set up in Texas to test the effects of the improvements of classroom lighting. Health examinations were

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[15] Darell B. Harmon, "Light on Growing Children," Architectural Record (Reprint), February, 1946, p. 81.

[16] Darell B. Harmon, The Co-Ordinated Classroom, (Grand Rapids, Michigan: American Seating Company, 1949).

[17] Mildred Whitcomb, "Classroom Lighting: The Harmon Technique," The Nation's Schools, 39:36, May, 1946.

given in all the demonstration schools at the beginning of the tests and regularly thereafter. For example, in one school of 306 children given thorough pedriatic examinations and nutritional, visual, psychological, educational and other similar tests, the examinations showed that 53.3 per cent had functional and organic visual difficulties; 70 per cent had signs accepted by medical nutritionists as indicative of nutritional difficulties. Six months later only 22.8 per cent of the children showed refractive eye difficulties, a reduction of 57.1 per cent; in addition, nutrition problems had dropped 44.5 per cent below those recorded at the beginning of the experiment, and the signs of chronic infection had been reduced 30.9 per cent. At the same time that their health difficulties went down, their performance records went up. Harmon reported a mean educational growth of 10.2 months, a median growth of ten months and a modal growth of ten months in the experimental school. In the controlled school the mean educational growth was 6.8 months of educational age, the median six months, and the modal growth six months.[18]

Harmon's studies showing the effect of poor lighting and poor posture have been vigorously opposed and his motives and methods have been questioned. He asks no words of defense. He believes there is sufficient evidence now in the hundreds of new and remodeled schoolrooms throughout the nation where his principles have been put into practice.

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18 Darell B. Harmon, "Light on Growing Children," Architectural Record, (Reprint), February, 1946, p. 83.

The American Association of School Administrators follow the same trend of thought. They say that:

> The aim of school lighting is to produce the condition under which the visual tasks of the school day can be done efficiently, in comfort, and with the least output of strain and effort. Children should use their physical energy and vitality, so far as possible, for growth and nutritional processes and for the development of sturdy and vigorous bodies—not for overcoming the handicaps of defective lighting.[19]

Physiological Effects

Seeing is not an instantaneous process. In the case of studying, many countless impressions are made on the retina of the eye and in turn transmitted to the brain. Seven muscles operate the movements of the eyeball and are exercised every time the eye moves from side to side or up and down. These muscles get tired just like any other set of muscles, but the tiredness is seldom felt in the eye itself. It is usually communicated to some other part of the body.

Science has found that eyestrain affects the whole body. Because there is such an intimate connection of the eyes with the brain and the nerves, the ill effects of difficulty in seeing are transmitted throughout the system.

Significant experiments have shown that lighting affects parts of the body remote from the eye. One experiment[20] showed that a

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[19] American Association of Administrators, American School Building; Twenty-seventh Yearbook, (Washington, D. C.: the Department, 1949), pp. 217-18.

[20] Matthew Luckiesh, Seeing and Human Welfare (Baltimore: Williams and Wilkins Company, 1934), pp. 34-40.

nervous muscular tension was exerted throughout the body when the eyes were used under poor lighting facilities. Measured at the fingertips, it was found to decrease markedly with the increase of illumination.

Results of another research[21] showed that reading under one foot-candle of light caused a 23 per cent decrease in convergence reserve of the ocular muscles after one hour, while the same hours reading under one hundred foot-candles of illumination caused only a 7 per cent decrease in convergence reserve of the ocular muscle. That was less than a third of the amount of fatigue.

Following the theory that involuntary blinking was related to the degrees of tension or strain of the individual during the performance of a critical visual task, a number of researches were carried on by Luckiesh and Moss.[22] The results showed that for all subjects the rate of blinking increased with the duration of the test and decreased as illuminations was increased.

Another experiment[23] showed that there was a lesser effect on the rate of heart beat of subjects using good lighting facilities than those using poor facilities. From Luckiesh and Moss's viewpoint:

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[21] Matthew Luckiesh and Frank K. Moss, Reading As A Visual Task (New York: D. Van Nostrand Company, 1942), pp. 359-62.

[22] Ibid., pp. 356-59.

[23] Ibid., pp. 350-55.

> A depression of the "normal" heart-rate due to the task of critical near-vision for prolonged periods under conditions unfavorable for seeing, may produce significantly deleterious effects upon other bodily functions. For example, such reflect effects might inhibit the processes of indigestion and defense to some extent; and the integrated effects of such inhibitions over a period of years might be a factor of no little importance.[24]

It is emphasized by Luckiesh and Moss, however, that these effects are not necessarily harmful upon the reader performing the critical task if not of extreme nature. But they do think these researches are of great importance in practical consideration of conditions for easier seeing. They point out that these observations were made after relatively short periods of reading and they are not prepared to estimate their importance if continued day after day for years. They think it is a subject for clinical research.[25] Figure 3 gives a summary of the results made by Luckiesh and Moss. This summary reveals the influence of illumination on important aspects of visual function and upon even more important effects of seeing.

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[24] Ibid., p. 354.

[25] Matthew Luckiesh and Frank Moss, Science of Seeing (New York: D. Van Nostrand Company, 1937), p. 242.

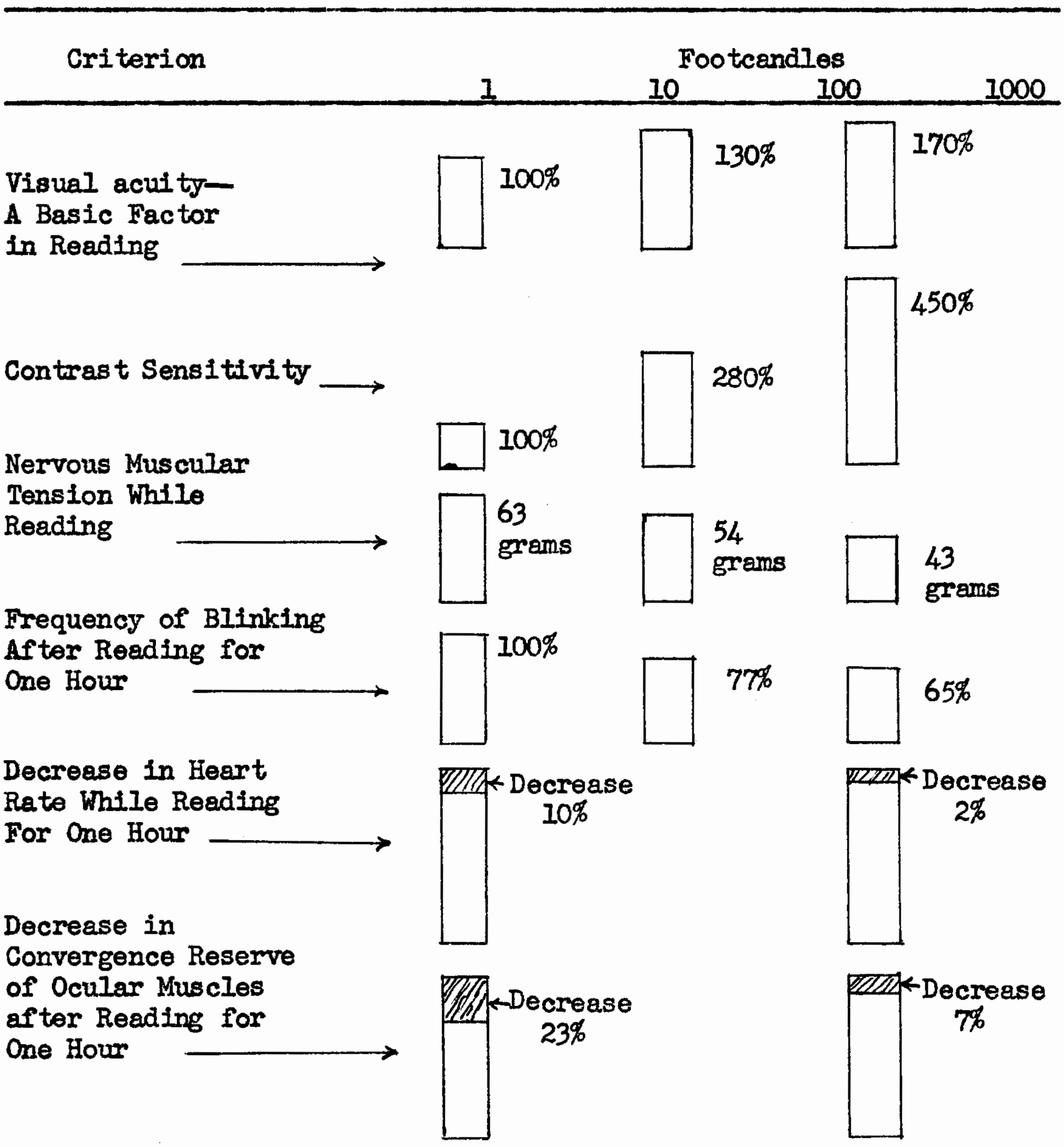

FIGURE 3

SUMMARY OF RESEARCHES[26]

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[26] *Ibid.*, p. 49.

Psychological Effects

Under certain seeing conditions, not necessarily described as extreme, it is not unusual to experience harmful effects. In such cases these influences may be of a psychological character. Attention and distraction are two factors that are of fundamental significance in this respect and should be recognized as powerful forces in the comfort and efficiency of human beings and in their eventual reactions toward lighting.[27]

Brightnesses within the peripheral field which might not seem extreme during casual seeing may be very annoying when doing critical seeing. For example, it would not be annoying viewing a landscape during the daytime, but if one were to try to read, the brightness would be annoying.[28] This same principle would apply in the classroom. The brightness of the task should be as great as, or greater than, its surroundings.

Stimulation and impression are also psychological factors which are influenced by lighting. Everyone has been influenced by natural environment. The cheerfulness of a sunny day enlivens the step and the attitude. Very often an overcast sky leaves one with a very depressed feeling. It is true that many times it is the association of these weather conditions that are responsible for their

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[27] Ibid., p. 381.

[28] Ibid., p. 382.

effects, but this does not alter the fact that they are psychologically effective. Colors, too, have a great influence over people's lives in creating in them certain mental states, and stimulating or depressing physical and mental activity.[29] These same principles should apply to classroom lighting. Many times through neglect, indifference and ignorance, indoor environments are often depressing and distracting.

As for the psychological effects of lighting, Neidhart wrote:

> We can hardly blame them for not liking school if their classrooms are dingy with dark woodwork and drab walls. Bright, cheerful surroundings will do much to create a pleasant atmosphere that will take some of the drudgery out of school work. With the dissatisfaction caused by unpleasant surroundings eliminated, the children will like school better and will take more interest in studies.[30]

Luckiesh believes that lighting and the proper use of color can do much to conserve the resources of human beings and foster their happiness.[31]

Motto, an opthalmologist, feels that school children are a special group and should be given every aid to adequate vision, including proper illumination. He considers lighting an extremely important part of a combination to give the optimum vision to children

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[29] John Sharpe Warren, "Crusade for Color," American School Board Journal, 110:41, January, 1945.

[30] Neidhart, op. cit., p. 33.

[31] Matthew Luckiesh, Seeing and Human Welfare (Baltimore: The Williams and Wilkins Company, 1934), p. 13.

who must recognize minute differences in form, structure or even texture and do it quickly. He stated that:

> The eyes of the school child are not fully developed and are less resistant to the varied influences of the schoolroom than they will be in adult life. Some of these childhood conditions may be responsible for serious eye afflictions that will carry through life. In qualifying a child for school, a prime need is mental and physical fitness with special stress upon those organs of sight which will be the most important vehicle toward attainment of an education.[32]

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[32] F. I. Wilson, "Through the Ophthalmologist's Eyes," American School Board Journal, 108:30, May 1944.

CHAPTER III

COLOR AND ITS RELATION TO LIGHT

"Lighting is of great importance," says Luckiesh, "because it is essential to our most important and educative sense—vision—and color is intimately associated with lighting and vision."[1] Color is part of the universe of light. The color of nearly everything looked at is determined by the way the light rays are absorbed or reflected. It may be said, then, that color comes from light and is a property of it. Color is a quality of the light by which the form and nature of an object is recognized.[2] It is evident that there must be a close relationship between the treatment of school interiors and the visual comfort of school children. Says Pleason:

> It is important to recognize that the amount and distribution of light in the schoolroom, as well as light relationships within the child's field of vision, will be greatly affected by the paint colors and finishes used on the walls, the ceiling, the floor, the equipment, the woodwork and trim, and other surfaces of the schoolroom.[3]

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[1] Matthew Luckiesh, Color and Its Application (New York: D. Van Nostrand Company, 1921), p. 224.

[2] M. Pleason, editor, Color Planning for School Interiors (prepared for use in St. Paul Public Schools by the Department of Education; St. Paul: Ramaley Printing Company, 1948), p. 26.

[3] Ibid., p. 9.

Interior decorations for school rooms should be approached as a problem in the use of color to create the most efficient and attractive school environment possible under the given condition of light, structure and purpose of interiors. "As to cost," says Pleason, "it would cost no more in dollars and cents to apply paint in accordance with the best and latest knowledge obtainable from the field of science, art, and industrial research than to repeat blindly the patterns of the past."[4]

Providing such school environment involves, of course, more than just the use of paint colors. Pleason gives the four guiding principles used in the planning of the interior decorating for the St. Paul schools.[5]

1. It was approached as a problem in the use of colors to create the most efficient and attractive environment possible.

2. A variety of colors were to be used. Light reflection factors in paint colors and human reactions to color were not to be disregarded. St. Paul used a variety of hues and values.

3. A range of colors was to be used. These should vary from medium to light, but darker colors were not to be ruled out. Sometimes they are useful.

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[4] Ibid., p. 13.

[5] M. Pleason, "Color Planning for School Interiors," American School Board Journal, 116:29, January, 1948.

4. The color scheme was to be planned. The environmental factors of each interior was to be studied and the selection of colors and color combinations were to be made in accordance to this study. This study led to the stressing of several factors:

(a) The physics of color. The colors used are a part of the lighting system. They will determine how much of the available light is absorbed by the painted surfaces, how much is reflected or turned back into the room, and, in part, how the light is distributed.

(b) Physiology and psychology of color. The physical energies and mental states of the person using the room is continuously affected by the colors used.

(c) Color and structure. The interior must be thought of as a shape and not merely flat surfaces.

(d) Color adaption to human activities and educational purpose. When planning the color scheme the activities for which the room is used, the equipment must be considered.[6]

"Well planned color schemes for school interiors involve the use of color as an ally of the lighting, both natural and artificial,"

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[6] _Ibid._, pp. 29-30.

states Pleason.[7] He names four ways that paint colors may be used as aids in a lighting system:[8]

First, to achieve a fuller utilization of light. Different colors reflect different percentages of light falling upon them. Anytime a surface of the school interior is painted a very dark color, much of the light provided by means of windows or artificial lighting is wasted because it is absorbed by the dark surface. If the surface is of a light color, much of the light falling on it will be reflected, thus providing more light in the nearby area.

Second, to improve the distribution of light. Uneven distribution of light is quite common in classrooms. On the window side there is a great deal of light but much less on the opposite side. Artificial illumination aids this condition, somewhat, but painting of the interior may also be an aid. If there is a blackboard on the side of the wall 80 to 95 per cent of the light falling on it is absorbed. This should be painted to match the wall or replaced with tackboard and painted. The color of the woodwork will also help or hinder.

Third, to prevent glare. When used in connection with color it applies to glossy or highly polished surfaces that act as mirrors

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[7] M. Pleason, editor, Color Planning for School Interiors (prepared for use in St. Paul Public Schools by Department of Education, St. Paul: Ramalay Printing Company, 1948), p. 61.

[8] *Ibid*., pp. 61-63.

rather than as diffusing reflecting surfaces such as are provided by flat wall paints and mat finish. Non-glossy finishes should be used on all surfaces to eliminate glare and reflections. This glare can become uncomfortable, distract attention and reduce visibility.

Fourth, to regulate some of the brightness differences within the school child's field of view. Value is the amount of light or dark in a color. The value refers to the percentage of light that will be reflected from the area to which a given paint is applied. Paints vary in brightness when used in combinations resulting in brightness contrasts. If the contrasts is extremely sharp, it may prove distracting and will interfere with the visual comfort of the child. Paint colors, then, are extremely important in bringing about differences within the field of view. In regard to these different colors reflecting varying degrees of light, Pleason emphasizes:

> It is pertinent to know the light reflection qualities of the colors one is using, in order to insure sufficient light and more even distribution of it, and to avoid disturbing brightness contrast. Reflection factors of woodwork, furniture, floors, and equipment are also to be taken into consideration.[9]

By studying the light reflecting values it is possible to select paints that will promote visual comfort. The National Council on Schoolhouse Construction has set up the following guide to be used in refinishing school interiors.[10]

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[9] Ibid., p. 83.

[10] National Council on Schoolhouse Construction, Part II, Guide For Planning School Plants (Nashville, Tennessee: National Council on Schoolhouse Construction, 1946), pp. 64-65.

On ceilings an 85 per cent reflection factor is needed. A white or nearly white flat paint having either an oil or a casein base should be used because of its high reflection factor. The finish should be flat or non-glossy in order that there will be no glare. A white ceiling will also pick up the wall color by reflection and thus blend with any color scheme used. Acoustic treated ceilings, when painted, will lose some of its acoustic qualities, but if left unpainted the reflection will fall below the 85 per cent.

The sidewalls should be finished with a minimum 50 per cent reflection factor paint. This limits the color somewhat to the pastel tints. The trim, including wainscot, trim or baseboard, should be finished with a 60 to 40 per cent reflection factor paint. It may be of a different color from the walls but should retain the same reflection factor values in order to avoid an objectionable brightness-difference.

The American School Administrators advise, "The reflection factor should be measured exactly or purchased on a dependable guarantee."[11] A competent person can measure it by a measuring device, or it can be read from the label on the can if it is put out by a good company which gives the reflection factor.

Colors are chosen with regard to the room orientation or exposures and what is seen out of the window. In those rooms with a

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[11] American Association of School Administrators, American School Buildings; Twenty-seventh Yearbook, (Washington, D. C.: the Department, 1949), p. 240.

warm exposure, such as south and west, the cooler colors—green, blue greens and blue are used. In rooms with a cool exposure, the warmer colors—tans, buff, red, yellow, cream and neutral grays are used. To help in selecting these colors the Division of Art Education in the Baltimore schools has designed a color compass.

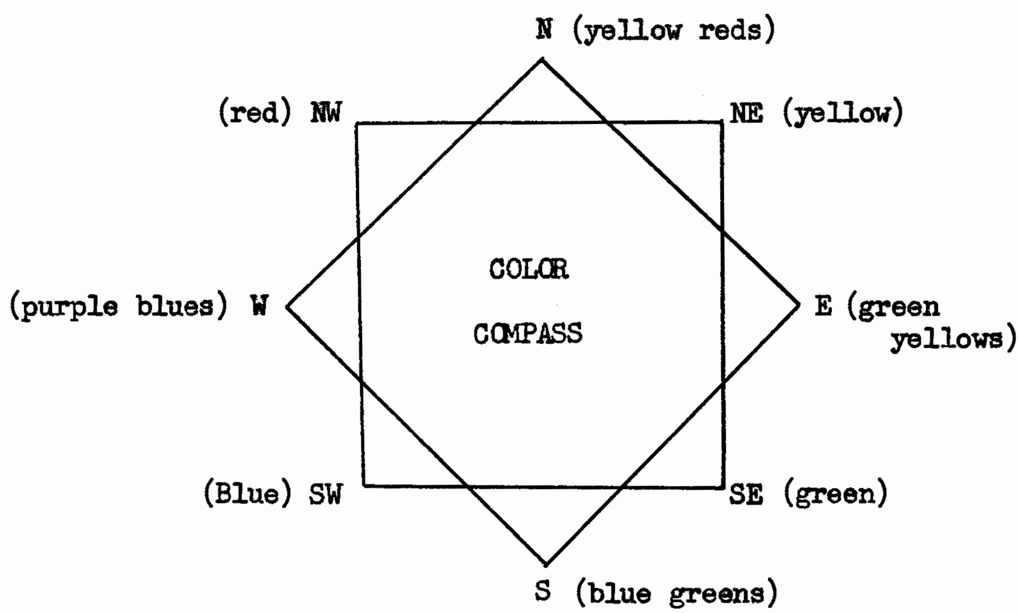

FIGURE 4

SUGGESTED COLORS
FOR DIFFERENT EXPOSURES[12]

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[12] Leon Winslow, "Color in the Classroom," School Executive, 66:33, July, 1947.

The foregoing is only a rough generalization, a cue as to where to start, and not a fixed rule. Other factors may enter in, such as overhanging roofs, neighboring buildings, trees and other external objects that may tend to shut off or to reflect the natural light received. Samples at least one foot square should be painted and tried out before the whole room is done. It is important, also, to select colors under the light to which they are going to be subjected as different types of light will give different qualities.[13]

Harmon's Color Technique

Harmon has probably done more than any one else in the study of color in the schoolroom. He was confronted at the start with trying to mix a paint not only to provide light reflectivity and light diffusion, but also to utilize color without disturbing brightness ratios subjectively. Harmon found that various colors of the spectrum do not appear equally bright to the human eye even though paints in various colors have been equally saturated as to pigments. Colors toward the middle of the spectrum appear much brighter than the colors on the extreme. Subjective brightness is this difference in brightness between colors and affects the child's performances the same as contrasts. Harmon worked out formulas so that through

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[13] American Association of School Administrators, op. cit., p. 239.

combinations of mathematically determined shading, two or more different colors could be used in a classroom without conflicting contrasts of subjective or color brightness. The formulae were worked out in casein emulsion paints. Resin emulsion paints were used on dados, where the maintenance problem is usually greater. These paints can be washed. Both paints are water thinned.[14]

Most color authorities have accepted the view that the distinction between warm and cool colors is psychological. Harmon's research proved that the distinction is measurable, at least partly, in physical terms. He found that as much as a five-degree change in room temperature can be effected by changing the color of paint on the walls and ceiling. Harmon explains it this way:

> The explanation of this phenomenon lies in the rapidity of heat reflections by some colors. If the classroom has on walls and ceilings a paint that will absorb heat, the heat will stay on the surface of the wall and be re-radiated very slowly. If it reflects heat waves, the heat will radiate out into the room rapidly, to soon be felt by those in the room.[15]

To decorate a classroom in the Harmon Color Technique five steps are outlined. The exposure of windows must first be determined. If the classroom has windows on only one side, note the direction it faces. If there are windows on more than one side determine the exposure as follows:

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[14] Mildred Whitcomb, "Classroom Lighting: The Harmon Technique," The Nation's Schools, 39:38, May, 1947.

[15] Loc. cit.

If room has windows on adjacent sides, compromise between the two exposures--For example: windows on South and West sides mean a Southwest exposure. When windows are on any opposing sides, or on any three sides arbitrarily select South as the exposure even if there are no windows in South wall. Disregard clerestory windows in determining exposure.[16]

The next step is to look at the Harmon Color Chart and find the acceptable color combination. From this chart acceptable color combinations may be found.

For example, if exposure is Southwest you may use Combination B, C, D, or G. Note: The East, West, and South octants require special attention to the dotted lines. In the Eastern octant, a Due East exposure makes B preferable to E or G; but if the room exposure is a few degrees North of East, E is first choice; and if a few degrees South of East, G is first choice. The West octant shows a similar distinction. The South octant specifies I for the few degrees East of South.[17]

Special circumstances require special treatment as follows:

a. Southerly exposures with excessive glare or open horizon: Use Combination I.

b. Northerly exposures with excessive glare or open horizon: Use Combination E.

c. Northerly exposures with dense foliage, dark adjacent buildings, limited window area, etc.: Use Combination A.

d. For use as kindergarten, first or second grade: Combination G is recommended for all exposures.[18]

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16 <u>How to Decorate Classrooms in the Harmon Technique</u>, (Brochure put out by Makers of Luminall Paints, Chicago, Illinois: National Chemical and Manufacturing Company, 1948), p. 3.

17 <u>Loc</u>. <u>cit</u>.

18 <u>Loc</u>. <u>cit</u>.

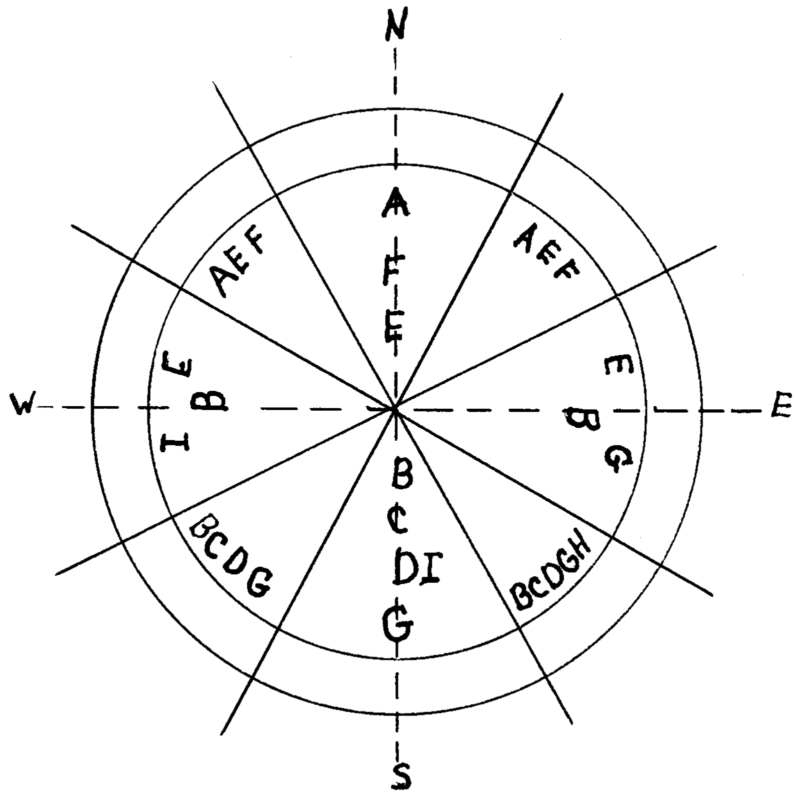

FIGURE 5

HARMON COLOR CHART[19]

The third step is the selection of the color scheme from a color card which shows ten classrooms with walls opened out. These color schemes will be found on Table II.

Using the chart for complete painting specifications is the fourth step. These specifications will also be found on Table II.

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19 Loc. cit.

The last and final step is to determine whether to use Luminal Casein Emulsion Paint or Ultra Luminall Resin Emulsion Paint.[20]

No matter what the technique, or what color or color combination that might be used, it must be remembered that the decoration is for the children. Pleason sums it up this way:

> Each room presents its particular needs and possibilities. Children love color and respond to it with delight and enthusiasm. Besides the joy it adds to school life, it increases efficiency, improves health, and raises the morale of the children, teacher, and whole community.[21]

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[20] Loc. cit.

[21] M. Pleason, editor, Color Planning for School Interiors (prepared for use in St. Paul Public Schools by Department of Education, St. Paul: Ramalay Printing Company, 1948), p. 98.

TABLE II

PAINTING SPECIFICATIONS FOR EACH COLOR COMBINATION

	Color	Locations	R. F.
A	Rosedale White Luminall	Ceiling and drop to 10' above floor.	90.6
	Rosedale Cream Luminall	Front and side walls from drop to chalk rail. Back wall from drop to mop board. Window wall from sill to mop board.	76.0
	Rosedale Beige Luminall	Dado (Chalk rail to mop board) on front and side walls only.	63.0
	Rosedale Ivory Trim	Doors, cabinets, woodwork.	70.0
B	Rosedall White Luminall	Ceiling and drop to 10' above floor, except window wall drop to sill.	90.6
	Rosedale Light Sea Green Luminall	Front and side walls from drop to chalk rail. Back wall from drop to mop board. Window wall from sill to mop board.	73.5
	Rosedale Sea Green Luminall	Dado (chalk rail to mop board) on front and side walls only.	60.0
	Rosedale Ivory Trim	Doors, cabinets, woodwork.	70.0

TABLE II (continued)

PAINTING SPECIFICATIONS FOR EACH COLOR COMBINATION

	Color	Location	R. F.
C	Rosedale White Luminall	Ceiling and drop to 10' above floor, except window drop to sill.[1]	90.6
	Rosedale Light Sage Green Luminall	Front and side walls from drop to chalk rails. Back wall from drop to mop board. Window wall from sill to mop board.	68.0
	Rosedale Sage Green Luminall	Dado (chalk rail to mop board) on front and side walls only.	57.0
	Rosedale Ivory Trim	Doors, cabinets, woodwork.	70.0
D	Rosedale White Luminall	Ceiling and drop to 10' above floor, except window wall drop to sill.[1]	90.6
	Rosedale Gray Blue Luminall	Front and side walls from drop to chalk rail. Back wall from drop to mop board. Window wall from sill to mop board.	65.5
	Rosedale Powder Blue Luminall	Dado, same as above	57.0
	Rosedale Cool Gray Trim	Doors, cabinets, woodwork.	45.0

TABLE II (continued)

PAINTING SPECIFICATIONS FOR EACH COLOR COMBINATION

	Color	Location	R. F.
E	Rosedale White Luminall	Ceiling and drop to 10'above floor, except window wall drop to sill.[1]	90.6
	Rosedale Ivory Luminall	Front and side walls from drop to chalk rail. Back wall from drop to mop board. Window wall from sill to mop board.	73.5
	Rosedale Beige Luminall	Dado, same as above.	63.0
	Rosedale Warm Gray Trim	Doors, cabinets, and woodwork.	55.0
F	Rosedale White Luminall	Ceiling and drop to 10' above floor, except window wall drop to sill.[1]	90.6
	Rosedale Rose Gray Luminall	Front and side walls from drop to chalk rail. Back wall from drop to mop board. Window wall from sill to mop board.	66.5
	Rosedale Rose Beige Luminall	Dado, same as above.	55.5
	Rosedale Warm Gray Trim	Doors, cabinets, and woodwork.	55.0

TABLE II (continued)

PAINTING SPECIFICATIONS FOR EACH COLOR COMBINATION

	Color	Location	R. F.
G	Rosedale White Luminall	Ceiling and drop to 10' above floor, except window wall drop to sill.[1]	90.6
	Rosedale Yellow Luminall	Front Wall from drop to chalk rail. Back wall from drop to mop board. Window wall from sill to mop board.	73.5
	Rosedale Turquoise Blue Luminall	Side wall from drop to mop board. Front wall from chalk rail to mop board.	72.0
	Rosedale Cool Gray Trim	Doors, cabinets, woodwork.	45.0
H	Rosedale White Luminall	Ceiling and drop to 10' above floor, except window wall drop to sill.[1]	90.6
	Rosedale Cream Luminall	Window wall from sill to mop board. Front wall from drop to chalk rail. Back wall drop to mop board.	76.0
	Rosedale Beige Luminall	Front wall from chalk rail to mop board.	63.0
	Rosedale Light Sage Green Luminall	Side wall from drop to chalk rail.	68.0
	Rosedale Sage Green Luminall	Side wall from chalk rail to mop board.	57.0
	Rosedale Ivory Trim	Doors, cabinets, and woordwork.	70.0

TABLE II (continued)

PAINTING SPECIFICATIONS FOR
EACH COLOR COMBINATION

	Color	Location	R. F.
I	Rosedale White Luminall	Ceiling and drop to 10' above floor, except window wall drop to sill.[1]	90.6
	Rosedale Ivory Luminall	Window wall from sill to mop board. Front wall from drop to chalk rail. Back wall from drop to mop board.	73.5
	Rosedale Light Sage Green Luminall	Side wall from drop to chalk rail.	68.0
	Rosedale Beige Luminall	Front wall from chalk rail to mop board.	63.0
	Rosedale Sage Green Luminall	Side wall from chalk rail to mop board.	57.0
	Rosedale Ivory Trim	Doors, cabinets, and woodwork.	70.0
J	Rosedale White Luminall	Ceiling and drop, same as above	90.6
	Rosedale Light Sea Green Luminall	Window wall from sill to mop board. Front wall from drop to chalk rail. Back wall from drop to mop board.	72.0
	Rosedale Sea Green Luminall	Front wall from chalk rail to mop board.	60.0

TABLE II (continued)*

PAINTING SPECIFICATIONS FOR EACH COLOR COMBINATION[22]

	Color	Location	R. F.
	Rosedale Light Sage Green Luminall	Side wall from drop to chalk rail.	68.0
J	Rosedale Sage Green Luminall	Side wall from chalk rail to mop board.	57.0
	Rosedale Ivory Trim	Doors, cabinets, and woodwork.	70.0

* The formulae for mixing the paint have been left out of the table. They are in the original table.

[1] If window wall glass area is less than twenty per cent of floor area, or if wall space between windows is wider than two feet, change to read "Ceiling and drop to 10' above floor on all walls." At same time change all "sill to mop board" locations to "drop to mop board." If ceiling is lower than 12' use a 2' drop on front, side and back walls, but in no case drop lower than 9' above floor on these walls.

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[22] How to Decorate Classrooms in the Harmone Technique, op. cit., pp. 6-7.

CHAPTER IV

UTILIZATION OF LIGHT

To make the process of seeing easier and more comfortable is the purpose of any light source used in a classroom. There is a growing recognition of the effects of indoor visual environments upon the physical development and educational achievements of children. Because of this recognition and because there is more knowledge concerning the factors involved in effective seeing, there has been more serious consideration of visual environment than ever before.

"Since daylighting is provided naturally," says the Illuminating Engineering Society, "and is universally available during much of the time schools are in session, careful and intelligent use of it should be made."[1] But when natural light becomes insufficient an artificial lighting system should be used to supplement it.

Whether the light source be natural, artificial, or both, the factors of quantity and quality must be the criteria for evaluating school lighting. Quality means proper distribution, absence of glare and correct brightness control.

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1 Illuminating Engineering Society, American Institute of Architects, American Standard Practice for School Lighting (New York: American Standards Association, 1948), p. 14.

Natural Lighting

The principal function of schoolroom fenestration is to provide natural daylight for seeing within the classroom. Availability and controllability are two important factors encountered in the natural lighting of schoolrooms. Daylight varies according to the seasons and weather and it is during the months of the school year that the values are lower. Geographic location also determines the availability. Uneven distribution of light and the amount of glare introduced is going to have to be carefully controlled in order to get the best results.[2]

The problem of daylighting, according to George,[3] has several related features.

1. Adequate light on more days of the year.
2. Better light at all times.
3. More even light distribution through the interiors.
4. More uniform light intensity throughout the day.
5. Elimination or reduction of glare and reduction of solar heat.

Unilateral Lighting

Schools in the early days frequently had windows placed on opposite sides of the room and sometimes three or four sides. This

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[2] _Ibid._, p. 17.

[3] N. L. George, "Glass Blocks in School," _School Management_, August, 1946, p. 12.

window placing caused shadows and created so much glare that unilateral lighting became the accepted practice. Unilateral lighting is required in many states.[4]

With this type of lighting much of the light entering through the windows never reached the other side of the room. Because of this reason standards were set saying that a room should not be wider than twice the height of the windows.

Biesele, head of the department of electrical engineering at Texas University, has been carrying on an extensive investigation for the past two years and is still continuing.[5] His purpose has been to develop information that will assist in effective design for daylight in the schools. The study has been conducted in a penthouse school on top of the steam plant at the University. The classroom is thirty-two feet square and so oriented that its windows face the cardinal points of the compass. It has movable partitions so it can be fixed so any side can receive the light.

Because more schools traditionally provide lighting on one side and because they are usually the most economical to construct, he has confined his study to unilateral lighting. His main conclusions were that windows should extend the full length of the left wall

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[4] Don L. Essex, "Lighting for School Buildings," The American School and University, 20:126, 1948-49.

[5] R. L. Biesele, "Daylight in Classroom," American School Board Journal, 120:35-36, June, 1950.

and as near as practical to the ceiling. That is where a greater part of the useful light enters. Structural support of windows should give minimum interference to imput of light. These surfaces should be light in color.

Biesele[6] suggested clear flat glass where possible and if necessary to use glass blocks, adequate shielding was essential in order to provide control of brightness.

Bilateral Lighting

In more recent years as balanced brightness and uniform distribution of light in classrooms came to be accepted it became obvious that controlled daylight from more than one source could help achieve those objectives. It was found that they did. Bilateral lighting is the name given when light enters from two opposite sides. Probably the most recent method along this line is the clerestory windows installed on classroom walls opposite the main window wall. It is usually achieved by lowering the corridor ceiling and introducing windows between the corridor roof and classroom. These clerestory windows are high enough above the usual line of vision so glare is eliminated. It is reported by Smith[7] that this type of bilateral lighting is possible in multi-storied schools if the school rooms are

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[6] Biesele, loc. cit., pp. 35-36.

[7] Eberle M. Smith, "Fenestration and School Lighting," School Executive, 66:65, February, 1947.

on one side of the corridor only. By bringing into the exterior corridor walls a large exposure of glass and using borrowed light between the corridor and the classroom, some secondary light can be gained in the classroom.

Many deviations from these plans have been devised. Some use a sloped ceiling to reflect light into the interior. Others use mirror-like surfaces to reflect the light upward through the windows.

A scheme tried out in the Union High School at Lafayette, California, was to have the full window oriented to the north and a high clerestory of small windows to the south. They found glare was eliminated to a considerable extent, the necessity for mechanical shades diminished and a more flexible structural frame could be used. The windows to the south side, however, continued to raise problem in contrast. Diffusing glass or mechanical methods for light control could not solve satisfactorily all the contrast of these windows when exposed to the direct sun rays.[8]

White Oaks School at San Carlos, California, used the same idea but here the roof was extended far out on the south side to provide a shade against the sun shining directly through the windows. The north side is almost wholly glass. They found the bilateral system to have shortcomings too. First, it limited the size or width of the

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[8] Ernest J. Kump, "Development of a Natural Lighting System for Modern School Buildings," American School Board Journal, 116:35-36, June, 1948.

classroom and second, by elevating the overhang, the lower portion of the south walls or covered corridor was exposed to the seasonal southwesterly rains.[9]

Another experiment in bilateral lighting was to be tried in an Auburn, Massachusetts, school, where they have an overcast sky 50 per cent of the days of the year. The rooms were to be thirty feet square. The windows on one side of the classroom were to be entirely glazed and the opposite side have a continuous bank of windows set high in the wall adjoining the corridor. The brightness was to be controlled by scientifically designed louvers. They chose artificial lighting of a fluorescent type.[10]

"The use of clerestory windows in the far West has been effective," believes Essex. "Whether they will be equally effective in sections of the country with heavy snowfall is yet to be determined. Experimentation to make this determination is now going on."[11]

Trilateral Lighting

Designs for modern school buildings in California, where sunshine is abundant, have been centered around the control of natural lighting. A scheme hasn't been devised over night and even though

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9 Ibid., pp. 36-37.

10 S. W. Haynes, "A Bilaterally Lighted Elementary School Building," American School Board Journal, 117:37, July, 1948.

11 Essex, op. cit., p. 126.

studies have been in progress for a good many years they are still going on.

By trying to overcome the faults they found in bilateral lighting they introduced trilateral at San Mateo, California. Here, as in bilateral, windows were provided on both sides but with an overhang on both sides over the window areas. In addition, a continuous light source was installed at the mid-point of the roof controlled by an egg-crate light diffusing grill. This diffused the light and kept the direct rays from striking the interior. In this manner a three-way lighting system was achieved.[12] Jack, the superintendent of schools at San Mateo, in answer to a letter about their trilateral lighting writes:

> I am happy to report that teachers are very satisfied with the results. Trilateral lighting, in our situation, has proved very successful. In some instances, glare resulted when the position of the sun was directly over the glass skylights of the classrooms. This was corrected by the installation of special colored glass.
>
> I consider that trilateral lighting in San Mateo City Elementary Schools has produced the best natural light that we have been able to provide.[13]

Another school at Barstow, California, used the same idea but the diffusing grill was placed on the same plane as the floor and it gave a greater degree of diffusion.[14] In his reply to a letter

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[12] Kump, op. cit., p. 37.

[13] Walter A. Jack, superintendent of schools in San Mateo, California, made this statement in letter written June 27, 1950.

[14] Kump, op. cit., p. 37.

inquiring about their trilateral lighting system, Steed, the District Superintendent, writes:

> I wish to state that so far as the teachers and pupils are concerned, this type of lighting has proven very satisfactory in our schools. We have nearly 100-candle capacity across the classroom, and have had little use for artificial lighting in the daytime. The big improvement that I can tell in the good lighting facilities in the rooms has been the lack of children in the adolescent age having to secure and wear glasses, even though the academic load has not been lessened during this period.[15]

Another type of trilateral lighting was tried in the Colin Kelly Junior High School at Eugene, Oregon, where overcast skies and rains are common from October to April. The classrooms open off a common corridor and are separated from one another and have windows on three sides. The west sides of all rooms have high windows, the bottoms more than six feet above the floor and the full length windows are on the east. Additional full-length windows are on the north or south wall depending on which side of the corridor it is located. Artificial fluorescent fixtures are recessed in the ceiling of each room.[16] Hines writes:

> We have had very satisfactory results with the windows on three sides of the classrooms. It has been necessary on some of the high windows on the West that get the late afternoon sun to install venetian blinds for light control. The trilateral lighting arrangement used in the classrooms of this

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[15] Eli R. Steed, District Superintendent of Schools in Barstow, California, made this statement in a letter written July 12, 1950.

[16] Clarence Hines, "For Long Rainy Season Try Trilateral Lighting," The Nation's Schools, 41;34, February, 1948.

> building has made it possible to use much less artificial light than is usually necessary in a school room. It is only on the darkest, most gloomy days that artificial light is necessary in the Colin Kelly classrooms.[17]

Natural Lighting Controls

Introduction of light into classrooms is only one of the two problems involved. The difficult problem still remains; that of avoiding high brightness ratios between the source of light and surrounding surfaces. A great many solutions to control glare have been devised.

Window shades. The most common solution is the ordinary window shade. This has two disadvantages. It reduces a great amount of light entering the room and it also means a constant adjustment. If window shades are used they should be installed in two separate sections so that they can be controlled separately.

Venetian blinds. Perhaps the next most common method of controlling light is venetian blinds. They, too, prevent considerable light from entering the room, but they do break up the light and reduce the brightness. Venetian blinds have two disadvantages. First, when they are used light is eliminated from the upper part of the windows, as well as the lower ones, and the best source of light is removed. Second, is the job of cleaning them. It becomes quite

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[17] Clarence Hines, Superintendent of Schools in Eugene, Oregon, made this statement in a letter written June 23, 1950.

a maintenance problem. Vertical venetian blinds do direct the light toward the front of the room.

Louvers. Locked types of louvers have been devised to be built in front of the windows. They can be locked into positions to properly deflect the light into the rear of the room and cut the glare. Louvers, very similar to these, have been devised for the exterior. Both of these have the disadvantage of being fixed. This means they will not meet the change in requirements for bright and sunny days.[18]

In one school it was found that excellent results could be obtained with louvers fixed at ninety degrees to the window glass. The louvers were four inches wide and spaced three and a half inches apart. For strength and easier cleaning they used louvers much larger than those in venetian blinds. They were made of steel in a very slightly S-shaped section. They swung out for washing. The spacing allowed the latch to be reached so they don't have to be swung out to raise the windows. Because of its surroundings, it was considered sufficient to have the louvers cover only the upper three-quarters of each window. A light translucent roller shade pulls behind the louver, but is used only to exclude direct sunlight. On a typical bright clear morning, the sky, seen at an angle through an unlouvered window, was 150 times as bright as the wall between

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[18] Smith, op. cit., p. 65.

the windows, report McDermitt and Allphin.[19] With the louvers in place the brightness was only seven times as great. This reduction in brightness contrast was made at the sacrifice of only twenty per cent of the daylight illumination on the row of desks farthest from the windows.

Overhangs. Overhangs may be in the form of a solid canopy extending beyond the window, or they may be a slatted canopy or trellis which will allow the light to filter through.

Louvers are sometimes constructed like an awning and built of a series of angle louvers extending diagonally out and down from the head of the window.

Diffusers. Diffusers are covered extruding frames that are installed across the entire upper window area. The cheapest and in some respects the best is Harmon's muslin burlap diffusers. These may be made for the cost of material if done as a project in the woodworking classes or by the school carpenter. Diffusers reflect about fifty per cent of the light up to the ceiling and then it is reflected from there. Some fifty per cent of the direct light will penetrate the material, be diffused and illuminate the room. Roll shades may be used in the lower half. They may be less pleasing in appearance than Venetian blinds.[20]

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19 C. W. McDermitt and Willard Allphin, "Lighting Can Be Controlled in a Modern Schoolroom," School Management, June, 1946, p. 11.

20 W. T. Walters, "Schools Can Be Lighted Economically," American School Board Journal, 120:35, February, 1950.

Another type of diffuser has the frame covered with light-diffusing fiberglass.

Glass Blocks. Light enters a directional glass block and when it emerges it is bent upward. Thus a more uniform distribution of interior illumination is possible when used with a reflecting ceiling. This control of transmitted light is accomplished by means of horizontal prisms on the two inside faces. Sunlight is so refracted that the greater part of the transmitted light is directed toward the ceiling, with a minimum directed downward. The prism construction is all on the inside so the light-directing surfaces are protected from damage or dirt. All that is necessary is to wash them to keep them clean. In ordinary situations rain will keep the outside of the block clean. An occasional hosing will keep them in good condition.

Usually a section of clear glass is installed below the glass block to permit seeing out. Shades or baffles are needed over this vision strip and are often necessary over the directional glass block.[21]

"The cost of initial installation is estimated as twice the cost of brick and windows," reports George. "But there has been no adequate research as to how much is saved in better light transmissions, more uniform light, conservation of fuel, reduction in maintenance and in cleanliness and sanitation."[22]

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[21] American Association of School Administrators, American School Buildings (Washington, D. C.: The Association, 1949), p. 230.

[22] George, op. cit., p. 12.

Vanderark has this to say about the use of glass blocks in their school:

> We are fully satisfied with directional glass block lighting. It is especially good for economical upkeep. However, for north side lighting, it does not allow as much light into the room as clear windows, and there I would prefer windows. We have not been bothered with the warmth, but on especially warm days, we can notice the difference, in that they do warm up more than conventional windows. Yet for future building we will continue using them, except on the north side.[23]

Another satisfactory report comes from the Rosedale school in Texas. White writes:

> The use of the glass block wall and clerestory are features which are good for directing the light to the upper off-white areas. This type of glass block is made especially for directional lighting and the prisms in the face of the block seem to take care of the light. This block also is a benefit in the matter of heat control since it is a semi-vacuum of five-inch depth. This is an item in Texas since we have summer delayed into September and October; and April and May sometimes are a bit warm too. This matter of insulation is good for our other extremes also since our January-February season sometimes is sub-zero.[24]

"Glass blocks will eventually have a secure place in school building planning," thinks Essex. "They appear to have considerable value as a part of the main fenestration of a classroom, but their use should still be considered experimental."[25]

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[23] Mark Vanderark, Superintendent of Oaksdale School in Grand Rapids, Michigan, made this statement in a letter.

[24] Margaret F. White, Principal of Rosedale Elementary School in Austin, Texas, made this statement in a letter written July 6, 1950.

[25] Essex, op. cit., p. 126.

Artificial Lighting

Even though much progress has been made in controlling natural light, it still must always be supplemented by the best system of artificial lighting available. There are many different sorts of fixtures available and each has its own advantages and disadvantages. One can provide almost any lighting effect desired with their proper selection and use. Whatever type of fixtures are used they are likely to distribute light in one of the following ways.

1. Direct lighting sends about ninety per cent of the light downward. It takes less current but is difficult to provide diffused lighting or avoid glare. It is useful for local lighting.

2. Semi-direct lighting sends ten to forty per cent of the light upward and sixty to ninety per cent downward. Some light is received from the ceiling but the greater part comes directly from the equipment to the surface. This is a study type of light.

3. Indirect lighting sends ninety to one hundred per cent upward and up to ten per cent downward. The lamps are above a bowl open at the top. Indirect fixtures take more electricity than direct. Maintenance is a problem, too, because the efficiency of the lighting depends very much on the cleanliness of the ceiling, walls and fixtures. "Indirect light is the least efficient," says the American Association of School Administrators, "as from ten to forty per cent of the light is absorbed by the ceiling, but it is

the most desirable in quality."[26]

4. Semi-indirect lighting sends upward sixty to ninety per cent of the light, and downward ten to forty per cent of the light. They utilize the ceiling as the main source of light. More light per watt is obtained than from indirect lighting but glare and shadow are increased.

5. General diffused lighting sends light out in all directions. Most of the light falls directly on the working surface with a considerable amount from the ceiling. Glare and shadow make it difficult to use in classrooms.

Incandescent Lights

The trend in incandescent filament lighting has been and is to indirect and luminous-indirect luminaires. This provides the best illumination with good distribution, absence of glare and brightness control. Incandescent lighting has the advantage of lower initial cost. The lamps and fixtures are less expensive than other types. The lamps are interchangeable so the amount of illumination can be changed with a different watt globe. The lamp of an incandescent lamp is not greatly affected by the number of times it is turned off and on and has an average life of about 1000 hours. There is no flickering when they start nor is there any sound while burning.[27]

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[26] American Association of School Administrators, op. cit., p. 235.

[27] American Association of School Administrators, loc. cit.

On the other hand, incandescent lighting is high in operating cost. The wattage required is approximately three to four times that of a fluorescent system, so in old constructions, a rewiring program is generally required to bring illumination values up to today's standards. Considerable heat is given off with this lighting and this might become a problem when high levels of illumination are maintained. Up to thirty footcandles of light, however, can be maintained in an average classroom without excessive heat. "When current costs are low," says Lewis, "and where lamps do not have to be burned for many hours each day the incandescent lamp will probably be used with fixtures that will meet modern standards."[28]

The type of equipment chosen should be easy to keep clean and one which will show clearly when it needs cleaning. "Luminous-indirect units of plastic or glass," reports Putnam and Anderson, "are very satisfactory in this respect, as the presence of dirt can be readily seen. The brightness ratio of these units with the background of ceiling and upper wall are very comfortable."[29]

Concentric ring. This type meets many standards of value in school design. It gives a dispersal of light upward, downward, and laterally and is simplicity itself in maintenance. To give an upward

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[28] John W. Lewis, "Cold Cathode Fluorescent Lighting," American School Board Journal, 118:30, January, 1949.

[29] R. C. Putnam and J. R. Anderson, "Latest Techniques in School Lighting," (Reprinted) The Magazine of Light, Number 2 Issue, 1946.

cast to its rays, the 300-watt or 500-watt globe is silvered at the bottom.[30] According to Putnam and Anderson these silverbowled lamps have the advantage of furnishing a new reflecting surface every time a lamp is changed.[31]

Egg-crate louvers. This installation consists of egg-crate louver panels that make a solid surface in the ceiling to within three feet of each of the four walls. The grills are hung from four channel iron chains suspended from the ceiling. Incandescent bulbs or fluorescent tubes can be installed above the grills. Servicing is easy. To replace a bulb one of the light weight panels is taken down. Cleaning is done in the same manner. An advantage of this system is that some parts of the room can be lighted intensely and other parts less tensely.[32]

Ceiling of light. This system consists of all over louvers. The louver sections are made of plastic and are translucent. Smaage reports "The louver material has a seventy-one per cent transmission factor and a nineteen per cent reflection factor."[33]

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[30] Kump, op. cit., p. 37.

[31] Putnam and Anderson, op. cit., p. 8.

[32] Wheeler and Will Perkins, "Better Lighting for Better Teaching," The Nation's Schools, 36:39, November, 1945.

[33] Leon Smaage, "Proper Classroom Lighting A Pre-Requisite to Learning," The Nation's Schools, 41:35, April, 1948.

There are eight fixture units in six rows or forty-eight units, each consuming 100 watts, or a total of 4800 watts, installed above the louvered ceiling. This concealing of the light source makes it possible to use high intensities to obtain footcandle levels where required, and afford an even distribution of brightness.[34]

Since the louver panel material is hard and non-porous the problem of maintenance in this type of lighting is not too difficult. Dust does not adhere very readily and can be removed easily by removing and washing the louvers in lukewarm water.

This type of lighting has been used in Des Plaines, Illinois, as an experiment and they feel is deserving of careful analysis and further study. No study has been made by them to obtain objective evidence of pupil improvement but observations have led them to believe there has been improvement in posture, work habits and mental alertness. There seems to be an atmostphere of happiness and security with little tension.[35] Of this lighting Smaage writes:

> The "ceiling of light" installation in one of our classrooms has proven very successful. Ideal lighting conditions without any shadows have been continuously maintained in the room. We have found it necessary to clean the louvers only once a year. This is easily done by dipping the louvers in a flat pan of a Dreft solution.
>
> In most of our other classrooms we use fluorescent row lighting with suspended fixtures since this type of installation is

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[34] Smaage, _loc. cit._

[35] _Loc. cit._

cheaper than the "ceiling of light" installation.[36]

Fluorescent Lighting

The fluorescent lamp makes possible an entirely new approach to school lighting. Because of their high efficiency and low radiant heat emission, higher lighting levels can be reached at reasonable consumption of electrical energy and with physical comfort. Very often fluorescent lamps can be used in old buildings because they give off twice the amount of light for the same amount of current. Thus the building will not have to be rewired.

Fluorescent lamps are not generally interchangeable. A longer tube must be used to get more light. The installation, then, must provide all the needed illumination from the start. The life of the lamp is determined in part by the number of times it is turned off and on. The average life is about 2500 hours it if burns for an average of three hours every time it is turned on. The more times it is started the less hours it will burn.

The lamps require auxiliary equipment and as this is usually part of the fixtures they are more expensive. This extra equipment along with the difficulty of cleaning, creates a bigger maintenance problem. The ballast in the fixture may hum unless this is overcome by careful adjustment. Some lamps still have a flicker but they are

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[36] Leon Smaage, Superintendent of Des Plaines Public Schools, Des Plaines, Illinois, made this statement in a letter written June 26, 1950.

finding ways of overcoming this.

The question now seems to be: shall it be hot cathode fluorescent lighting or shall it be cold cathode fluorescent lighting. Cold cathode lighting is similar to the hot cathode lighting in basic principle but differs in the type of electrode it used.

One of the significant differences is that of lamp life. Cold cathode lamps are not affected by the number of times the lamp is turned off and on. The life of the cold cathode lamp is 10,000 hours. Such a long life is particularly important if the lamps are in places where they are difficult to replace.

It is frequently possible to locate transformers of cold cathode lamps operated in series outside of the classroom and eliminate the hum. If they have to be located in the room they can be mounted on rubber and this will greatly reduce the hum.

It also overcomes another objection sometimes made about hot cathode lamps--instantaneous starting. No starters are required for cold cathode lamps. This is possible for hot cathode but at an increase in cost of lamps and auxiliaries. According to Lewis[37] cold cathode installations have not been used enough in the classroom to get a final judgment in respect to quality. But he goes on to say:

> Hot cathode fluorescent installations have troublesome and costly maintenance problems in lamp replacement and repairs to starters and auxiliary equipment. Cold cathode installations

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[37] Lewis, *op. cit.*, p. 30.

which have a lamp life of 10,000 hours and which have no starters to give trouble, largely eliminate the maintenance problem. Low brightness, unshielded, cold cathode installations also reduce cleaning costs, since only the lamps and not the whole fixtures need to be cleaned. Where maintenance is a problem the somewhat higher initial cost of shielded cold cathode installations may be justified as compared with hot cathode installations.[38]

Lewis believes that some form of fluorescent lighting will more than likely be used when current costs are high and hours of burning long or when intensities in excess of thirty footcandles are desired.[39]

In writing about their experience with fluorescent lighting, Hines writes:

We have found the lighting in Colin Kelly very satisfactory. The fluorescent lighting used for artificial lighting in classrooms was recommended to us by the architect with reservations as he indicated that there might be a relatively high maintenance cost due to the limited life of the fluorescent tubes. Actually, fluorescent tubes have been improved so much since the war that we have not had nearly the depreciation cost the architect indicated we might have. There was also some question of whether or not the flicker from the fluorescent lighting might not have a detrimental effect as far as the use of lighting for study was concerned. To date we have not experienced this difficulty and we find that teachers and pupils are quite happy working under the type of lighting provided.[40]

There are many different types of fluorescent installations. Allen gives a brief description of a number of them.

Fluorescent four-lamp 40-watt fixtures. Due to the greater amount of light produced in each luminaire, four-lamp units may offer a lower initial cost and lower owning and operating cost than typical two-lamp unit fluorescent installations.

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[38] Lewis, loc. cit.

[39] Loc. cit.

[40] Clarence Hines, Superintendent-Clerk of Schools, Eugene, Oregon, made this statement in a letter written June 23, 1950.

For the same reason, the luminaires generally are slightly brighter and less comfortable and may tend to produce slightly less uniform lighting than continuous two-lamp systems. In old rooms with four outlets, the wattage requirement of an eight-unit arrangement permits easy conversion, usually without extensive rewiring.

If the row of units nearest the windows is moved in one or two feet from the usual equally spaced position, the lighting will be more uniform in the inner part of the room which receives less natural light.[41]

Two-lamp equipment. Luminaires of the two-lamp semi-direct design in general deliver a higher percentage of the generated light to the plane of the desks than do four-lamp equipments. The units should be mounted as high as possible, consistent with delivering a reasonably uniform lighting on the ceiling between units.... Because of its low total wattage this arrangement is of special value when relighting a classroom with relatively limited wiring capacity.[42]

Three-row installations. Schools that wish to provide more than 30 foot-candles might use this system. It consists of three continuous rows of two-lamp fixtures. It is recommended for sight-saving rooms, sewing rooms and other rooms where higher level lighting is desired.[43]

Crosswise installation. Some luminaires present a lower brightness crosswise than they do lengthwise. The front units of this type illuminate the chalkboard better. Arrangements for wiring and switching should be made so that the fixtures near the window

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[41] Carl J. Allen, "Classroom Lighting Technique," Pre-Printed from Progressive Architecture, August, 1948, p. 3.

[42] Ibid., p. 4.

[43] Loc. cit.

can be turned off when light isn't necessary there.[44]

> Troffers. This installation is best considered in a new construction. It also is specially suited where lighting levels above thirty foot-candles is desired. The etched aluminum type gives a very low comfortable brightness when viewed crosswise of the unit.[45]

A school system in Allentown, Pennsylvania, was faced with the problem of raising the level of illumination in their school. They knew if they added more efficient fixtures with high wattage output it would be necessary to rewire their schools completely and would be very expensive. The only other alternative was the use of fluorescent fixtures. They decided to install fluorescent lights in seven classrooms.

They tried to obtain every practical type of installations which was then available. They have fixtures mounted against the ceiling, suspended fixtures, fixtures in long rows, fixtures parallel to the windows and fixtures vertical to the window. They have regular fluorescent lights, cold cathode and then line types. Some are instantaneous and some are delayed starting. They have fixtures with shields, with egg-crate louvers, with single vertical shades, with reflectors and tubing with no fixtures except sockets. These various combinations have them some information about the types of lighting available. It did not, however, point out definitely and

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[44] Ibid., p. 5.

[45] Ibid., p. 6.

specifically a single most satisfactory solution to their problem.[46]

They did get the following information, though, reports Hosler.

> 1. Relighting 600 classrooms is going to be an exceedingly expensive problem.
>
> 2. The ordinary fluorescent fixture with its delayed starting is annoying in a classroom because it detracts the attention of the class at the time of turning on the lights.
>
> 3. Considerable shielding is definitely necessary in all fixtures, even those with a low surface light intensity.
>
> 4. A type of fixture with vertical surfaces and vertical louvers greatly decreases the maintenance problems for building custodians.[47]

The opinions expressed by all concerned with this school were so varied that the superintendent and former assistant give their own personal reaction which they say may change as the various installations are observed.

> We would prefer a classroom lighted with a slim line fixture suspended from the ceiling, with no reflector in the fixture, and with an egg-crate louver suspended below the tubes. We would prefer only four such fixtures to the room, with six tubes to each fixture.[48]

Their reasons for such preferences were:

1. They are instantaneous starting fixtures.

2. They gave complete shielding.

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[46] Fred W. Hosler and J. Chester Swanson, "Comparisons in Classroom Lighting," The Nation's Schools, 41:40-41, April, 1948.

[47] *Ibid.*, p. 42.

[48] *Loc. cit.*

3. They provided a minimum surface for the collection of dirt.

4. They have extremely long life.

5. With only four fixtures per room they are one of the cheapest installations.[49]

They both feel that the ideal fixture for classroom lighting has not been developed.

It is evident, then, that some people like fluorescent fixtures; others like the incandescent. Some like the indirect; others like the diffused. Sometimes it is a matter of opinion and choice. But as Gregg says, "Above all, let us not forget that the cost and type of fixtures are not the only factors to be considered. The problem of conserving children's eyesight outweighs most other considerations. So, let there be light.[50]

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[49] Hosler and Swanson, loc. cit.

[50] Russell Gregg, Planning Modern School Buildings (Madison, Wisconsin: University of Wisconsin, 1948), p. 60.

CHAPTER V

LIGHTING IN RELATION TO CLASSROOM ENVIRONMENT

If today's educators, with their new philosophy of education, are going to center their interests and endeavors on the child's growth, they will equip their schools with furniture and equipment that will make a contribution toward this development. Much serious thought and careful planning should be given to the selection and installation of essential furniture and equipment for school buildings. Light and lighting is one of the chief factors that must be considered in regard to choosing furniture and equipment that will contribute toward child development.

School Furniture

Harmon, through experiments, has shown that by redecoration, a changed pattern of seating and light control at the windows, will provide for visual comfort and efficiency. Redecoration of classroom walls and ceilings were discussed in Chapter III. But redecoration of walls, ceilings and woodwork isn't enough. Pupils' desks, teacher's desk, book cases and other furniture should also have a high reflection factor. Until recently, the standard finish of school desks was brown and, very often highly polished, which resulted in glare. The reflection factor was usually ten per cent or less, which falls short of the thirty to fifty per cent reflection factor now suggested by American Standard Practice for School Lighting.[1] Putnam suggests that the old desks can be refinished periodically. This will remove initials and scratches on the surfaces and then the wood can be left natural. Most of the desk tops will then fall within the thirty to fifty per cent reflection factor.[2]

The American Association of School Administrators gives suggestions on refinishing desks.[3] The painted or varnished surfaces should first be removed by a portable electric sander, preferably a "belt" type that follows the grain of the wood. A varnish remover can be used first, if desired. A floor-edging machine can also be used satisfactorily. A coarse grit sandpaper is usually necessary for the first sanding operation; but in all cases, a Number 00 sandpaper should be used for the final finish. If any cut places or defects are too deep for the sander they should be patched with plastic wood. These, too, should be sanded.

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[1] Russell C. Putnam, "The American Standard Practice for School Lighting—Its Preparation, Use and Value," The American School and University, 21:286, 1949-50.

[2] Loc. cit.

[3] American Association of School Administrators, American School Buildings (Washington, D. C.: The Association, 1949) pp. 255-56.

After the sanding has been completed, the finish should be applied. If the desks are of dark wood, they should be bleached. For oak, filler should be applied before the seal. When the bleach is thoroughly dried, it must be sanded smooth again and then a coat of seal must be applied. When dry, use steel wool and apply one coat of floor finish. The parts of the desk that are slightly curved and can't be sanded with a power machine can be painted with a light colored low-gloss enamel. Birch and maple desks can be treated the same way except that bleaching is not necessary.

New desks can now be obtained with natural wood finish.

Seating Arrangement

Another factor to improving classroom visual environment is a desk arrangement that will eliminate the areas of high brightness in the visual field. Children should not face a source of high brightness. Very often, in the traditional pattern of seating, many children on the window side of the room and those in the back of the room are forced to do this. As Ball puts it, "Changing the seat placement is one thing that can be done, without cost, to give more comfort through less fatigue and eyestrain."[4]

As a result of the experiment carried on in the daylight test house at Southern Methodist University, Biesele[5] says that

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[4] Lester F. Ball, "Providing a Homelike Atmosphere," The Nation's Schools, 42:60, September, 1948.

[5] R. L. Biesele, "Daylight in Classrooms," American School Board Journal, 120:35, January, 1950.

a desk arrangement which will eliminate the areas of high brightness in the visual field can be accomplished as follows: and as indicated in Figure 6:

1. Those seats located ahead of a line making an angle of 50 degrees with the window, and extending inward from the front of the window should be faced straight ahead.

2. Those seats located behind a line making an angle of 50 degrees with the window should be oriented so that no child faces forward at a horizontal angle less than 50 degrees with the window area.

3. The total number of seats so arranged is optional and should be governed by the requirements of the individual school or classroom.[6]

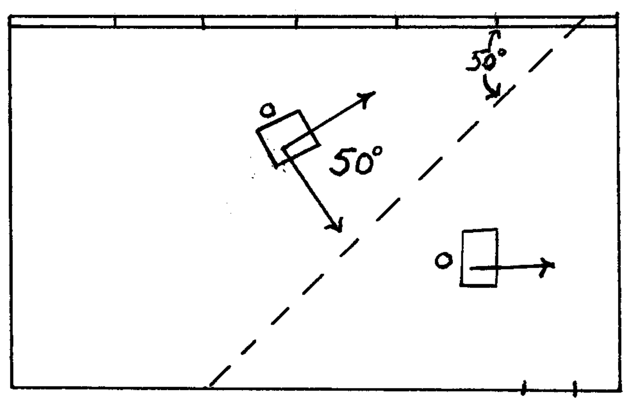

FIGURE 6

PRINCIPLES OF
DESK ORIENTATION[7]

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[6] Ibid., pp. 37 and 100.

[7] Ibid., p. 37.

When tables and chairs are used, careful placement must be observed so that children on one side of the table do not face the light or have their backs to the window. An ideal arrangement would have chairs on one side only. Essex warns that "an improper seating arrangement can negate the best efforts of an architect to provide good seeing conditions in a classroom."[8]

Floors

One can not consider the general decoration of the classroom without considering the floors. The National Council on Schoolhouse Construction recommends raising the floor color to a thirty or forty per cent reflection factor.[9] Floors treated with oil for twenty-five or thirty years present a very unsatisfactory condition.

Floors at Rosedale School, Austin, Texas, were bleached and sealed and are maintained at a reflectivity of from twenty-five to thirty-five per cent.[10]

If the floor is in bad condition, it may be necessary to lay a new floor. If new floor covering is used, it can be obtained with

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[8] Don L. Essex, "Lighting for School Buildings," The American School and University, 20:126, 1948-49.

[9] National Council on Schoolhouse Construction, Part II Guide for Planning School Plants (Nashville, Tennessee: State Department of Education, 1946), p. 65.

[10] Mildred Whitcomb, "Classroom Lighting: The Harmon Technique," The Nation's Schools, 39:38, May, 1947.

a recommended reflection factor. Table III gives the reflection factor of unfinished woods.

The use of asphalt tile or linoleum of some type can be used under certain conditions. The old flooring must provide a very smooth surface if linoleum is to be used. Otherwise the linoleum will wear unevenly and soon produce a very unsatisfactory appearance. Light shades of tan have proved satisfactory in composition floor covering because of their color and ease of maintenance. Floors having decided checkerboard patterns of color should be avoided.[11] An asphalt tile floor of light gray with a slight marbelizing pattern of black and red was installed over the old oiled wood floor, in the Bowditch School, Salem, Massachusetts. Experience proved that the marbelizing pattern did much to disguise heel marks, even of wartime rubber heels, and ordinary dirt did not unduly mar the surface. A thorough cleaning once in two months was found to be sufficient.[12]

Chalkboards

Chalkboards, for many years, have been a seeing hazard in schoolrooms. In order that the white chalk would show up well on the board, every effort was made to make the boards as dark as possible.

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[11] National Council on Schoolhouse Construction, op. cit., p. 65.

[12] P. T. Fallon and Willard Allphin, "Model Schoolroom, One Year Later," School Executive, 66:35, January, 1947.

TABLE III

REFLECTION FACTORS
OF UNFINISHED WOODS[13]

Kind of Wood	Reflection Factor
Curly Maple	40 - 50%
Oak	30 - 40%
Walnut	10 - 20%
Mahogany	15 - 20%
Stained Woods	10 - 30%

[13] Matthew Luckiesh, Light, Vision, and Seeing (New York: D. Van Nostrand Company, 1931), p. 79.

This has caused, perhaps, the biggest contrast in the traditional classroom. The reflection factor of the wall finish may be as high as eighty-five per cent while the black chalkboard reflects only about three per cent, which is not conducive to good seeing. To make matters worse, many older classrooms have black chalkboards on at least three walls which absorb whatever natural light there is and makes more artificial light necessary. Bursch, in the California State Department of Education, listened to many suggestions and then decided to get expert assistance in finding a way to get brighter and more cheerful classrooms. He wanted a chalkboard of higher reflectance value. He became more and more convinced that the answer would be a light green chalkboard and it was tried out. Many schools have accepted it. The light green chalkboard is not a cure-all but it is one more step toward providing attractive and healthier schoolrooms.[14]

The Bowditch School in Salem, Massachusetts, has had all its black chalkboards removed and replaced with white glass chalkboards at the front only and tackboards on the other side. A blue chalk was used, and while it gave a clean mark which is clearly visible from the back of the room, it does come off on the teacher's hand and clothes.[15] Fallon and Allphin suggested[16] that a light colored

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[14] Edgar W. Parsons, "Light Green Chalkboards," The American School and University, 19:122, 1947-48.

[15] P. T. Fallin and Willard Allphin, op. cit., p. 34.

[16] Loc. cit.

plastic board might be more suitable because a grease crayon could be used which would give a clean mark on the board, but still wipe off easily and leave the hands clean.

Nocha doesn't believe that colored chalk is any dustier than white chalk. He thinks it shows up more on hands and clothes. He suggests that maybe the chalk manufacturers could be persuaded to cover the chalk with paper jackets like crayons, or provide metal or plastic holder for chalk. But, as he says, this will merely keep the dust off the hand, but it will still dust off into the room.[17]

Endur 2-24 green chalkboard resurfacer paint is a specially prepared paint to cover slate chalkboards and change then to chalkboards with a twenty-four per cent reflection factor. Three applications are necessary with a sanding after each coat dries. After the third coat has been sanded it must be chalked in by rubbing yellow chalk well into the whole surface. This makes it easy to write on and will erase easily. A special chamois skin eraser and Yellow Alpha Colored Chalk is used for best results. The boards should never be washed with water or other liquids as the water tends to dissolve the chalk and gets into the board and grays the surface.

Another substitute Nocha suggests is the grease pencil and an overhead projector.[18] This can be used in a normally lighted room

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[17] Paul F. Nocha, "Chalkboardsand Its Future," The American School and University, 18:213, 1946.

[18] Nocha, loc. cit.

if the screen is relatively close to the projector. But, as in all cases, the cost is high and while it may never replace the chalkboard because it does not allow for individual pupil work, it does indicate the trend of times and new possibilities.

For classrooms that are equipped with black chalkboards the National Education Association Research Division offers a few suggestions:[19]

1. Reflected glare can be overcome somewhat by slanting the boards outward at the bottom.

2. Suitable local lighting also helps to overcome glare.

3. Dark boards could be covered when not in use. Roller shades might be used.

All but one section of the traditional black chalkboard space can be covered with some type of panel board. These can be painted to match the wall color. If panel boards cannot be obtained, the black chalkboard itself can be painted. This will help to improve the distribution of light in the room.

Accessories

Glass in doors and cupboards should not be shiny. They can, if necessary be given a rough surface by sand blasting. At the

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[19] National Education Association of the United States, Research Division, _Teaching about Light and Sight_ (Washington, D. C.: The Association, 1946), p. 50.

Rosedale School in Austin, Texas, the glass areas have been covered with a glass cloth that has the same degree of reflectivity as the adjacent walls. Transoms, used to transmit borrowed light and occasionally for ventilating purposes, have been replaced by opaque louvers covered with a highly reflective paint.[20]

Maintenance

Desks, chalkboards, windows and floors are cleaned regularly, but seldom is any attention given the walls or lighting fixtures. Actually they should receive as much care as the other equipment in the room, because dirty walls absorb a great amount of light and old and dirty bulbs and fixtures reduce the available light from them. If these losses are permitted to become large, the illumination available is greatly reduced while the cost of illumination remains the same. Figure 7 shows how the losses from lighting are distributed in a typical classroom where maintenance has been neglected.

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[20] Whitcomb, op. cit., p. 39.

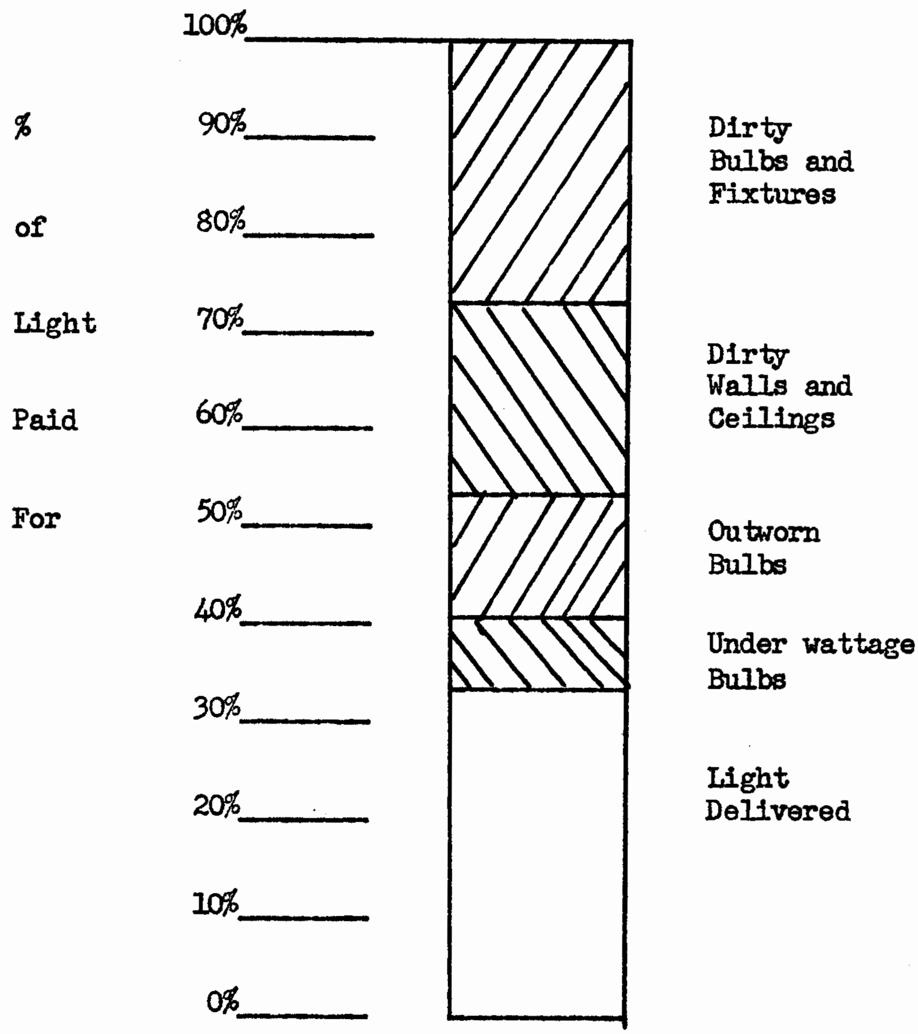

FIGURE 7

CLEANLINESS PAYS IN INCREASING THE PERCENTAGE OF LIGHT DELIVERED BY SCHOOL LIGHTING FIXTURES[21]

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[21] Willard Allphin, "Maintenance of School Lighting," American School Board Journal, 112:53, March, 1946.

The Illuminating Engineering Society reports that "Proper maintenance may result in as much as fifty per cent increase in the maintained level of illumination.[22] Figure 8 shows the progressive improvements in a lighting system as it is thoroughly renovated.

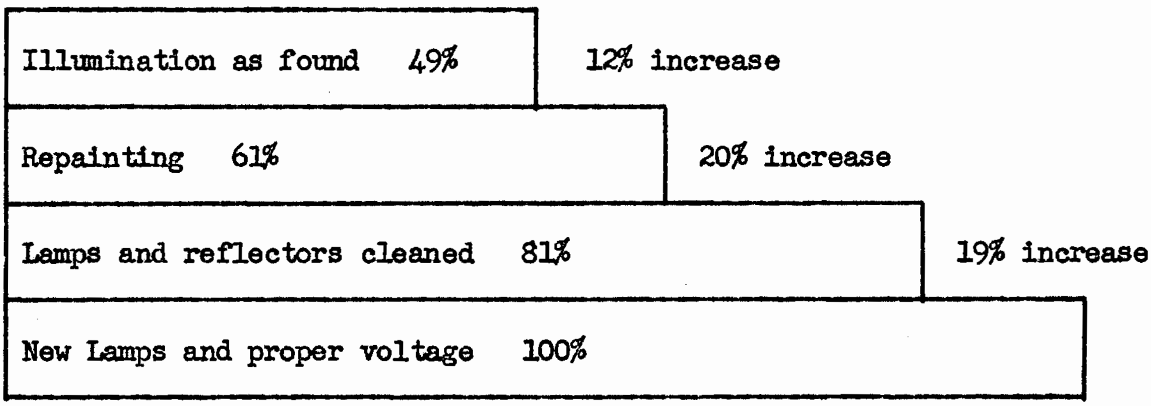

FIGURE 8

PROGRESSIVE IMPROVEMENTS
IN A LIGHTING SYSTEM[23]

If extra lighting can be obtained merely by the use of soap and water, it seems evident that a definite maintenance policy should be established in every school. Allphin[24] suggests a lighting maintenance crew. The lamps and fixtures could be cleaned and

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[22] Illuminating Engineers Society, American Institute of Architects, <u>American Standard Practice for School Lighting</u> (American Standards Association, Incorporated, 1948), p. 43.

[23] H. R. Heitzman, and R. L. Knapp, "Elements of Lighting Maintenance," <u>Illuminating Engineers</u>, (Reprint), April, 1943.

[24] Allphin, <u>loc</u>. <u>cit</u>.

relamped by a special crew. They could do it efficiently and quickly. If this can not be done a definite schedule should be set up and there should be someone in authority to see that it is followed. The Illuminating Engineers Society suggests that some type of maintenance form should be kept, such as the sample forms in Figures 9 and 10.

General Maintenance Schedule
Room Record--Room _____

Items to be Checked	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Check Foot Candles	x						x					
Clean Fixtures		x				x				x		
Make Visual Check			x	x	x	x	x	x	x	x	x	x
Check Decorations	x									x		

FIGURE 9

SAMPLE FORM OF MAINTENANCE SCHEDULE[25]

[25] Illuminating Engineers Society, op. cit., p. 45.

Lighting Check Sheet
Room No. 103

Date	Check Foot Candles	Clean Fixtures	Made Visual Check	Check Decoration
7/4			OK	OK
9/1	Low	OK	Relamped	OK
10/4	OK		OK	
12/28	Low	Cleaned	OK	OK
1/6	OK		OK	
4/2	Low	Cleaned	OK	Cleaned during Vacation

FIGURE 10

SAMPLE FORM OF CHECK SHEET[26]

Experience in a school for a year or two will indicate the best schedule for that particular school. One time-saving device suggested by Allphin, when cleaning is done by one man, is to carry a clean globe or reflector and a clean bulb up the ladder. They can be put in place and the dirty ones carried down and washed ready

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[27] Allphin, *loc. cit.*

for the next. This means only half as many trips.[27]

Summary

Any improvement, then, that can be made in school environment, in the color used and in the placement with respect to the light within the room, will improve the child's present comfort and will contribute to his future health.

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[27] Allphin, loc. cit.

CHAPTER VI

SUMMARY

The amount of light needed to produce the most efficient work is still subject to controversy. An adequate amount is recommended by everyone, but the definition of adequate varies as is evidenced in the amount of foot-candles suggested. But the emphasis now has shifted from "how much light should we have" to "how well can we see." Quantity and quality may now be regarded as the twin requirements for good lighting. This new look in school lighting can be summarized in two words—brightness control. It involves the control of brightnesses of everything in the visual field. This new emphasis not only betters visibility, but it improves the whole visual environment which results in greater comfort, increased efficiency and improved morale.

The foregoing chapters explained how seeing conditions in the classroom can be improved. For new buildings, there is little reason for not following the latest recommendations, as the difference in cost between a good and a poor installation will be comparatively very small. With existing classrooms, there are many possibilities. Many of the improvements can be made by the maintenance man. The desk tops can be sanded and refinished; the floors can be sanded and lightened also; the ceilings and walls can be repainted to have the recommended reflection factors; if roller type shades are used, they can be center hung; and the unusable portions of the chalkboards can be replaced with tackboard or painted to match the walls. The problem of lighting and controlling of the light is one that each school will have to decide for itself. What will help one might not help another. Maybe a school will try to improve one room a year until all are done. But those interested in a good visual environment for school children must beware of lighting codes, recommendations or standards of any kind that try to tell the story of adequate lighting in terms of foot-candles or try to sell any one light source as the answer to lighting problems. Light sources have changed and probably will continue to change. Whatever light source goes into a building will stay for years so the advice must be sound. As Luckiesh puts it, "Lighting experts and various components of the lighting industry must avoid and denounce commercialism and quackery just as medical practitioners and the medical industries have to a very great extent. If they serve the public welfare best, they serve themselves and their industries best."[1]

"If recommendations result in lighting which is uncomfortable or inadequate," warns Putnam, "much harm can be done. Recent advances

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[1] Matthew Luckiesh, Light, Vision and Seeing (New York: D. Van Nostrand Company, 1931), p. 15.

have furnished the methods, tools, and knowledge for quality lighting and efficient and comfortable seeing. They are ours to command for the welfare of our children."[2]

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[2] Indiana University School of Education, _Indiana and Midwest Building Conference: Proceedings_ (Indiana: Division of Research and Field Services, 1948), p. 53.

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Jack, Walter A., Superintendent of San Mateo, California, Schools, in a letter to the author, June 27, 1950.

Smaage, Leon, Superintendent of Schools in Des Plaines, Illinois, in a letter to the author on June 26, 1950.

Steed, Eli R., Superintendent of Schools in Barstow, California, in a letter to the author on July 12, 1950.

Vanderark, Mark, Superintendent of Schools in Grand Rapids, Michigan, in a letter to the author.

White, Margaret, Principal of the Rosedale Elementary School in Austin, Texas, in a letter to the author written on July 6, 1950.

APPENDIX

EUGENE PUBLIC SCHOOLS

C O P Y

Eugene, Oregon
June 23, 1950

Mr. Walter A. Hotsko
902 East Second Street
Ellensburg, Washington

Dear Mr. Hotsko:

This will acknowledge receipt of your letter of June 20 asking about our experience with lighting in the Colin Kelly Junior High School.

We have found the lighting in Colin Kelly very satisfactory. The fluorescent lighting used for artificial lighting in classrooms was recommended to us by the architect with reservations as he indicated that there might be a relatively high maintenance cost due to the limited life of the fluorescent tubes. Actually, fluorescent tubes have been improved so much since the war that we have not had nearly the depreciation cost the architect indicated we might have. There was some question also of whether or not the flicker from the fluorescent lighting might not have a detrimental effect as far as the use of the lighting for study was concerned. To date we have not experienced this difficulty and we find that teachers and pupils are quite happy working under the type of lighting provided.

With regard to the natural lighting, in which I believe the article in the NATIONS SCHOOLS was most interested, we have had very satisfactory results with the windows on three sides of the classrooms. It has been necessary on some of the high windows on the West that get the late afternoon sun to install venetian blinds for light control. The trilateral lighting arrangement used in the classrooms of this building has made it possible to use much less artificial light than is usually necessary in a school room. It is only on the darkest, most gloomy days that artificial light is necessary in the Colin Kelly classrooms.

If you have specific questions that you would like to ask about the lighting in the building, please feel free to write me again.

Very truly yours,

(Sgn.) Clarence Hines

Clarence Hines
Superintendent-Clerk

CH:c

DES PLAINES PUBLIC SCHOOLS

C
O
P
Y

Des Plaines, Illinois
June 26, 1950

Mr. Walter Hotsko
902 East Second
Ellensburg, Washington

Dear Mr. Walter Hotsko:

Thank you for your letter of June 20. I am afraid that I do not have any additional information to give you other than what you read in my article on classroom lighting in the April 1948 issue of Nations Schools.

The "ceiling of light" installation in one of our classrooms has proven to be very successful. Ideal lighting conditions without any shadow have been continuously maintained in the room. We have found it necessary to clean the louvers only once a year. This is easily done by dipping the louvers in a flat pan of a Dreft solution.

In most of our other classrooms we use fluorescent row lighting with suspended fixtures since this type of installation is cheaper than the "ceiling of light" installation. If you wish to get further information pertaining to the "ceiling of light" installation, I suggest that you write Erick Church, Benjamin Electric Company, Des Plaines, Illinois, who are the manufacturers. They can give you, I am sure, the kind of data you want based on their experience.

Yours very sincerely,

DES PLAINES PUBLIC SCHOOLS

(Sgn.) Leon Smaage

Superintendent

LS:ss

BARSTOW SCHOOLS

C
O
P
Y

Barstow, California
July 12, 1950

Mr. Walter Hotsko
902 East Second Street
Ellensburg, Washington

Dear Mr. Hotsko:

I am sorry that I have not answered your letter before, but the rigors of closing school and getting everything ready for July 1, caused me to place your letter in the back of my file.

I have been associated with the Barstow Union Elementary School for the past six years, and the Barstow Union High School for the past three. We are using in both school districts some of the latest lighting facilities. In regard to the article that you referred to in the June issue of the American School Board Journal, I wish to state that so far as the teachers and pupils are concerned, this type of lighting has proven very satisfactory in our schools.

We have nearly 100 candle capacity across the classroom, and have had little use for artificial lighting in the daytime. The big improvement that I can tell in the good lighting facilities in the rooms has been the lack of children in the adolescent age having to secure and wear glasses, even though their academic load has not been lessened during this period.

If you have any other questions concerning our set-up here, I will be most happy to answer them. However, not knowing just exactly in what you are interested, and what you would like to know, I feel it would be easier if you would write out your questions on trilateral and bilateral lighting which we are using in our elementary school, and I will be happy to answer them to the best of my knowledge.

Very truly yours,

(Sgn.) Eli R. Steed

ELI R. STEED
District Superintendent

ERS/eb

C
O
P
Y

Dear Mr. Hotsko:

I am sorry this answer is delayed. Your letter was delivered to the wrong office, where no one comes during the summer.

We are fully satisfied with directional glass block lighting. It is especially good for economical upkeep. However, for north side lighting, it does not allow as much light into the room as clear windows, and there I would prefer windows. We have not been bothered with the warmth, but on especially warm days, we can notice the difference, in that they do warm up more than conventional windows. Yet for future building we will continue using them, except on north sides.

Yours sincerely,

(Sgn.) Mark Vanderark

Box 462
Liberty Hill, Texas
July 6, 1950

C
O
P
Y

Mr. Walter Hotsko
902 East Second Street
Ellensburg, Washington

Dear Mr. Hotsko:

Thank you for your interest in our school and its experimental lighting features. I am sending you under separate cover reprints from two copies of the Nation's Schools articles—one of May 1947 which gives the set-up of the experiment and March 1950 which gives the use of our findings as incorporated in the additional wings of the expanded building. Our original building was in a fast growing edge of the city and the original eight classrooms were soon outgrown. As a consequence we had to do some additional building and made use of the desirable features. These features which are especially satisfactory are marked in the magazine reprints--at least a part of them are in the magazine.

We are especially pleased with the use of color in the soft tile walls of our new rooms—not vivid colors but tints which are a bit greyed or neutralized. This seems to give a brightness to the room without glare and at the same time remain aesthetically pleasing and scientifically sound from a health standpoint.

The use of the glass block wall and clerestory are features which are good for directing the light to the upper off-white areas. This type of glass block is made especially for directional lighting and the prisms in the face of the block seem to take care of the light. This block also is a benefit in the matter of heat control since it is a semi-vacuum of five-inch depth. This is an item in Texas since we have summer delayed into September and October; and April and May sometimes are a bit warm too. This matter of insulation is good for our other extremes also since our January-February season sometimes is sub-zero.

Due to the clerestory and the glass block features we seldom need artificial lights and even then the natural lighting and light colored areas seem to do away with any shadows.

I am sorry for the delay in getting this information to you but I am visiting teacher at Southwestern University at Georgetown, Texas, a neighbor town of Austin, and your inquiry was not forwarded immediately.

Yours very truly,

(Sgn.) Mrs. Margaret F. White
Mrs. Margaret F. White, Principal
Rosedale Elementary School
Austin, Texas

CITY ELEMENTARY SCHOOLS

C
O
P
Y

San Mateo, California
June 27, 1950

Mr. Walter A. Hotsko
902 East Second
Ellensburg, Wash.

Dear Mr. Hotsko:

Thank you for your inquiry about our trilateral lighting in San Mateo City Elementary Schools.

I am happy to report that teacher are very satisfied with the results. Trilateral lighting, in our situation, has proved very successful. In some instances, glare resulted when the position of the sun was directly over the glass skylights of the classrooms. This was corrected by the installation of special colored glass.

I consider that trilateral lighting in San Mateo City Elementary Schools has produced the best natural light that we have been able to provide.

Very sincerely,

(Sgn.) Walter A. Jack

Walter A. Jack

Superintendent of Schools

WAJ:fc

SCHOOL DEPARTMENT
Salem, Massachusetts

C
O
P
Y

Bowditch School July 11 1950

To Mr. Hotsko
Re "Model Lighting" room.

Ref. by Supt. Carbone

Continuing from point of School Executive article.

We still have no scientifically controlled measurement experiment on the room, because of difficulty in setting up an adequately controlled situation that would be sufficiently valuable to us.

Changes: (1) the furniture pictured in the article proved inadequate and we replaced it with movable separate desk and chair units. A number of deficiencies, notably lack of sufficient desk top surface, led to this move. (2) the lights (fixtures) were replaced by continuous rows of fluorescents, parallel to the window. The original fixtures were directional lighting, suited to rows of desks and chairs facing front, and were not adapted to movable and varying group seating.

The light pastel color shades, in various tints, have since been adopted generally throughout this school system.

The continuous parallel rows of fluorescents have since been installed in another room in this building (a "Sight-Saving" class) at school department expense, in one other small building, and are being used in a new primary school being completed this summer.

(Sgn.) Patrick T. Fallon,
Principal