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Lightning: Its Effects on Learning and Behavior in Industrial Arts

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LIGHTING: ITS EFFECT ON LEARNING

AND BEHAVIOR IN INDUSTRIAL ARTS

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THE SCHOOL'S PART

Sight is the most cherished of our five senses. While all of our senses are important in providing us with impressions of things around us, we receive most of our knowledge of our environment through sight. The major demands upon man's vision today are quite different from those of prehistoric man. In ancient times, man used his eyes more under daylight conditions and more distant viewing. Today man often lives and works much of his life indoors and under electric illumination, using his eyes almost constantly at close range tasks. Ancient man also relied keenly on all his senses whereas, during man's development, the sense of sight became more and more important until modern man is considered to receive most of his impressions through his eyes.

Dr. Arnold Gesell, in his research of child development has described the seeing eye as a "prehensory organ," which has the ability to grasp, grope, and manipulate.[1] It is this unusual ability which makes vision such a complex process and more is involved than just the eyes. Man does not see (in terms

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[1]Gesell, Arnold, M.D., "Vision and Reading from the Standpoint of Child Development," Clinical Studies in Reading, II, Supplemental Educational Monographs, 77, pp. 129-136, The University of Chicago Press, Chicago, January, 1953.

of vision) with his eyes alone; he needs light in order that the eyes may form images of the object and a brain to interpret the meaning of the resulting impulses.

Lighting is a universal problem in the home, school, business, and industry. Business and industry are more conscious of the problems because to them it is a matter of dollars and cents. Since Industrial Arts laboratories are attempting to provide a basis for the development of an understanding and appreciation of the industrial world, a study of light and the problems which result cannot be overlooked. The objective of this paper is to provide the writer with a better understanding of the relationship of light and sight and some facts about the use of light. The writer is sincerely interested in the lighting of Industrial Arts laboratories because it is his assumption that lighting plays a decisive and vital role in how students respond and how well they learn in school.

From the time a child enters school, the school is obligated to cooperate in helping him become a happy and efficient member of society. Conditions that interfere with good seeing make the child's work in school more difficult.

> Various research studies point to uncorrected defects of sight as one of the causes of lack of progress among school children. Further observation suggests that children learn more readily in well-lighted rooms than they do in poorly lighted ones, although further investigation of this subject is needed.[2]

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[2]National Education Association, Teaching About Light and Sight (Washington, D.C.: NEA Publications Division, 1962), pp. 12-13.

As the student attempts to compensate for poor lighting, he pays a high price in lack of concentration, decreased interest in reading and study, and a definite degree of eye strain. These result in less than his optimum performance and finally in poorer grades. Performance in today's world demands that young people achieve a higher level of learning at an earlier age and at a more rapid rate than ever before. Good grades require an investment of space, time, effort, and money it takes to plan and provide a well-lighted classroom.

Research has established that approximately ninety percent of all learning takes place through the experience of the eye.[3] Lighting which enables one to see easily, accurately, and comfortably is a necessity for more effective learning. Therefore, it is the school's duty to provide comfortable seeing conditions for its students. This writer is presently employed in a school system in which the Industrial Arts laboratories are poorly lighted. Shadows are bad, sometimes the glare is nearly unbearable, while the amount of light is inadequate. The goal should be to improve these surroundings so optimum learning conditions can result. The teacher must understand light in order to accomplish this goal.

School lighting is complex in nature and should be prescribed by a lighting expert, but every teacher should be aware of the opportunities he has in the classroom to promote visual comfort and efficiency. During the course of this paper, major

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[3]"Better Light Can Lead To Better Grades," <u>Prairie Farmer</u>, (March, 1968), p. 65.

aspects of light and the environment necessary for the most efficient and comfortable seeing will be researched. It is believed that once lighting problems are solved many of the behavior problems will also be resolved. Lighting should be provided of such quality and quantity as to enable the eyes to accomplish their task with accuracy, speed, and ease, without danger to vision.[4]

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[4]Editorial, Dr. Edward Jackson, American Journal of Ophthamology, September, 1936.

FACTORS AFFECTING LIGHT

Light is measurable just as temperature. Candle power is the general measure for intensity of light and it is expressed in terms of candles. This term is an outgrowth of the widespread use of candles at a time when more modern methods of illumination were being developed. Candle power is used when one wants to measure light intensity that leaves a source in a given direction--it does not; however, measure total intensity of the light given off. It must also be realized that the amount of light given off does not change no matter how far one may get from the source.

The quantity of light on a surface is measured in units called footcandles. "One footcandle is the amount of illumination falling on a point on a surface one foot away from a standard candle, or any light source of one candlepower."[5]

A footcandle of illumination may also be described as one lumen per square foot. "The lumen is the unit of measurement for the flow of light in all directions from a source of one candlepower."[6]

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[5]Better Light Better Sight Bureau, Lighting Handbook for Industrial Arts Classes (New York: The Bureau), p. 23.

[6]National Education Association, Teaching About Light and Sight, p. 21.

"The unit of measurement for the luminance of an object--that is, the amount of light reflected from it--is the foot-lambert."[7] Since there is no perfectly diffusing surface, the number of footlamberts is in reality equal to the number of footcandles illuminating the surface multiplied by the reflectance of that surface. Reflectance is the ratio between the light shed on a surface and the light reflected from it.[8]

Light can be categorized according to its source. There is daylight, which is primarily from the sun, and manufactured light. Daylight should be both abundant and well controlled to avoid visual difficulties resulting from poor lighting. Man-made light may be produced in several ways. For centuries lighting devices consisted of an open flame. One such method is to burn gas as was the custom during the early and middle nineteenth century.

Another method is to heat materials until they glow or become incandescent as the filament of an electric bulb. Today filament-type lamp bulbs fill many important needs. The light is produced by a current of electricity passing through a filament of very thin tungsten wire. The electrical resistance of the wire created enough heat to make the filament white-hot. To prevent the filament from burning up, the oxygen is removed by exhausting all the air possible, thus creating a vacuum; then sealing the bulb. There are many varieties of incandescent lamps, different in size, shape, structure,

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[7]Ibid., p. 22.

[8]Ibid.

and even color. They are widely used today because of the attractive advantages they provide. The bulbs are interchangeable, therefore, it is easy to obtain the correct amount of illumination by simply changing bulbs. Incandescent bulbs are inexpensive and easy to operate. They can be dimmed using a simple rheostat, and they give light instantly when turned on.

Incandescent lighting also has its disadvantages in that it produces heat which may prove to be an annoyance when placed close to a person, and it has an effect on color by intensifying the yellows and reds.

Another source of man-made light is that produced by bombarding the molecules of a gas with electrons and producing light such as that given off by neon signs or mercury lamps.

A fourth method is to use fluorescent tubes where visible light is produced by the action of invisible ultraviolet rays on chemicals with which the inside of the tube is coated. This produces a cooler, more efficient light. The life of these bulbs are approximately four to five times that of incandescent bulbs. Fluorescent light can also be made to approach the color composition of average daylight at noon on a clear day.

In designing and installing fluorescent lighting units, and other units as well, attention must be given to shielding the eyes by the use of baffles or translucent materials. Although bare fluorescent tubes are brighter than the highest recommended brightness for school lighting, they are much less bright per square inch of surface than ordinary incandescent bulbs.[9] This superiority is advantageous if care is taken to see that the light is distributed evenly and comes from as large an area as possible.

In addition to the proper quantity of light, there are certain essential quality factors of illumination that must be provided of which glare, diffusion, brightness difference, and color are the most important.

Glare is the enemy of vision and may be defined as "any brightness within the field of vision of such character as to cause discomfort, annoyance, interference with vision, or eye fatigue."[10] Direct glare may result from a high brightness or inadequately shielded light source in the field of view. Glare is also caused by glossy surfaces which reflect light from unshaded bulbs. To eliminate such glare, light sources toward the eye and the visual task should be shielded. It is definitely undesirable to expect children to endure extensive direct glare for a whole school day.

A brightness difference is caused when either the same level of illumination falls on surfaces of different reflectances or two or more surfaces in the surroundings and within the field of view receive different amounts of illumination. It must be understood that some brightness differences are desirable to prevent

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[9]Ibid., p. 21.

[10]Paul W. Seagers, Light, Vision and Learning, (New York: Better Light Better Sight Bureau, 1963), pp. 57-58.

monotany; however, extreme differences are undesirable. The ideal situation for critical seeing occurs when the background brightness is equal to the brightness of the task. This is rarely possible, however. Comfortable brightness differences can be secured by a careful balancing of all the factors involved, including not only the light sources, but also the reflectance of the ceiling, wall, and furnishings.

Diffusion of light is secured by causing it to come from many directions, rather than from one direction. Diffusion occurs when the light source is spread over a large area. Well diffused light produces practically no visible shadows. Ideal lighting for most visual tasks is considered to be daylight, on a partially overcast day with the sun shining.[11] Proper diffusion, then may be achieved by employing large-area, low-brightness light sources, by providing indirect lighting in which the ceiling and walls become secondary light sources, and by light colored matte finishes on ceiling, walls, and furnishings.

With equal foot-candles of illumination the variations in color quality seem to have little effect upon clearness and quickness of vision. In fact, it is true that in the typical school room, color effects are insignificant compared with a sufficient amount of light.[12] In most areas in which persons are

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[11]*Ibid.*, p. 61.

[12]Illuminating Engineering Society, *School Lighting* (New York: The Society, 1938), p. 15.

working or studying at a variety of tasks the best light source is one which produces a range of colors approximating daylight. The psychological effects of color of illumination are of very great importance. This aspect will be considered in the next chapter.

FACTORS INVOLVED IN THE VISUAL TASK

Three factors are involved in seeing; our eyes, what we are trying to see, and the light we have to see it with. These comprise the visual task which is the sum total of all the things that must be seen at a given moment. There are four important aspects of any visual task, namely brightness, contrast, size, and time it takes to see an object. To this also could be added color which is related to contrast and brightness.

Brightness is a primary factor in the visibility of a visual task. This is as much dependent upon the nature of the object's surface as it is upon the light that surface receives. This brightness of reflecting objects depends upon the proportion of the light it reflects in the direction of the eye. Thus precautions should be taken to insure against sharp contrast in brightness between the seeing task and immediate surroundings. Brightness can be made brighter by increasing the density of the illumination and less bright by reducing that density. Surfaces with low reflectances must be seen under high levels of illumination to give them the same visibility as surfaces with high reflectances.

The Illuminating Engineering Society has established a brightness ratio in which all the physical factors involved in lighting a task are taken into account in setting some rules for brightness ratio.

> Generally, the area adjacent to a visual task should be no brighter than the task, but not less than one-tenth as bright; for tasks of long duration or those requiring relatively high brightness, the adjacent area should not be less than one-third as bright. The general surroundings not immediately adjacent to the task can be anywhere from one-tenth as bright as the task to 10 times as bright. However, maximum brightness at either the high or the low end of this range should not be used over substantial areas or be adjacent to each other.[13]

By increasing the brightness as well as making sure the proper adjacent area is of the optimum, the ability to see properly and the ability of the student to work better, is increased.

The second aspect of the visual task is contrast. We see better when objects are in sharp contrast with their background, as was discussed in the above paragraph. Contrast is the relationship between the reflectances of an object or detail and its background. The greater the contrast the more easily the visual task is performed under a given level of brightness. Usually one must accept the task the way it comes, for example: a mechanical drawing made with a hard pencil on yellow paper. Often the difficulty of seeing certain objects can be corrected by simple changes in contrast. One may use a tinted paper; however, research has shown that the use of tinted papers do not improve readability or reduce eye fatigue.[14] The primary benefit from these papers

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[13] National Education Association, Teaching About Light and Sight, pp. 28-29.

[14] Matthew Luckiesh and Frank K. Moss, Reading As A Visual Task (New York: D. Van Nostrand Company, 1942), p. 29 and pp. 221-234.

is due to their non-glossy surfaces. Dull paper is easier on the eyes than shiny paper, which can cause annoying reflections. In general then one could say that tasks involving poor contrast require more illumination than do similar tasks with greater contrasts. In the Industrial Arts laboratory there are many tasks in which the contrast cannot be controlled; but lighting is the one factor that can be controlled. And good lighting will always make seeing easier, even when the task is of low contrast. One should have enough light, of good quality and properly placed.

The size of an object is the most generally recognized and accepted factor in the visual task. The larger the object, the more readily it can be seen. Under low lighting levels, machine operators, for example, may have difficulty in spotting faulty pieces of small-sized materials. Higher lighting levels enable the operator to see the small-sized materials better thus improving the quality of the product. All things being equal, the larger the object the easier it is to see, since its greater surface reflects more light. Sight is also directly related to distance. As an object moves away from an observer's eye it appears to become smaller and thus more difficult to see. In the Industrial Arts laboratory the size of the object cannot be enlarged so it becomes imperative that a sufficient quantity of light be available.

The fourth factor of seeing is the time it takes to see an object. Seeing is not an instantaneous process. Good illumination is needed for accurate inspection of an object being produced.

If objects and their details are to be seen quickly, then high levels of illumination are necessary. If there is plenty of time, even small details can be seen under rather low light levels. Under low light level a wheel will appear to rotate rapidly and as the lighting level is increased the wheel appears to slow down. This is of great importance whenever rate of motion must be estimated such as working with moving machinery. It is obvious then that the more illumination the shorter the time needed for sight. The less illumination, the more time is needed for sight. "Tests have proven that the eye takes its visual snapshots more quickly and clearly under good illumination than under poor illumination."[15] Other things being equal, a lesson is learned more quickly, and with less expenditure of energy, if the conditions of the eye and of the illumination are such that visual images are perceived rapidly and clearly.

In practical application, especially in the Industrial Arts Laboratory, it is not possible to increase the time element. In working at a lathe or drill press the job must often be done at split second speed. The only solution to faster, more accurate seeing is to increase the amount of illumination.

Color is considered to be the fifth factor of seeing but in reality it actually is inseparable from the other four already mentioned. Color is seen by the human eye and brain by the interpretation of various wavelengths of light as various colors.

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[15]Further Observations on the Speed of Retinal Impression, P. W. Cobb, Journal of Experimental Psychology, IX, 1926, p. 95.

White light contains all of the wavelengths or colors that the eyes can see. So we see color of objects by the properties of their pigmentation to absorb or subtract certain wavelengths from the light and reflect others.

Today color is assuming an even more important place in our lives than formerly, with the increase in its emphasis in design and decoration and the use of more and more color in books and magazines. This constant use of color results in many unusual effects on human behavior. It can create an atmosphere of comfort and well-being, it can stimulate and inspire, but it can also subject both students and teachers to severe eyestrain, create a depressing atmosphere, and possibly develop nervous tension. Color can be used to change the appearance of size and distance of objects, aid people to see objects more clearly or make them less distinct, make objects seem to change in weight, stimulate the eye or rest the eye, or make people feel warmer or cooler.

In addition to the purposes mentioned above, the effective use of color would be especially useful in Industrial Arts laboratories to stress safety guards, locate fire extinguishers, machine safety zones, and numerous other distinquishing factors. By proper visual contrast between machines and the materials being fabricated, visibility is increased and errors are reduced.

Appropriate choices of color combinations can often improve visibility by increasing both brightness and color differences. For example, if something were to be printed in blue ink of low reflectance it would be more visible if printed on yellow paper than on light blue paper of the same reflectance because this would produce a difference in color as well as brightness. The same thing happens to a student's eyes when the color of the material he is working with is too similar to the color of his machine. The extra effort required to differentiate between the material and the machine is a potential source of eye strain. A student who glances up from a light colored piece of laboratory equipment to a dark wall will experience a somewhat blinding effect.

> . . . steady fixation upon a given task is fatiguing. Eyes are more comfortable when their direction of gaze changed frequently. Hence it is both natural and restful to glance up from work being done from time to time. If surroundings are dark, the effect of such glances will be to require the readjustment of the eyes for a different light intensity, and a second readjustment when the eyes again return to work. This requires time and a loss of efficiency results.[16]

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[16]Pittsburgh Plate Glass Company, Color Dynamics (Pittsburgh, Pennsylvania, 1943), p. 5.

LIGHT, LEARNING AND BEHAVIOR

Studying is one of the hardest tasks eyes have to do. The amount of book-reading required by the time the average student graduates from high school would be a stack eighteen feet high. Book-reading is usually easier on the eyes than such seeing tasks as writing, figuring and drawing, where the contrast between pencil marks and paper may be poor. Most people do not realize how important good light is for studying and learning. Teachers have students do schoolwork in poorly lighted areas. But when the conditions are not right for studying and learning fatigue sets in and attention wanders. Schoolwork becomes tedious and tiresome. Often the conditions are more conducive to sleep than they are to studying.

Much research is being carried on to better understand vision. There are many mysterious features of what happens between the eye and the brain but of several things one can be sure. The eye sees better with more light on the task. Visual acuity is the ability to see details and this ability increases as one increases the illumination.[17] With greater quantities of distributed light, it is possible to see contrasting details

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[17]Better Light Better Sight Bureau, Eyes Our Windows To The World (New York: The Bureau), p. 8.

more clearly. When the object one is trying to see and its background look alike, more light can help to distinguish their individual characteristics. It would take a great quantity of light to detect handwriting of white ink on near-white paper, for instance. White ink on black paper is very easy to read.

It has also been established that the eye sees faster with more light. This means that one can take in more information through the eye when the illumination is greater. Sufficient light shortens the time it takes to see an object. For example, if a person drives at night, good driving lights and good street illumination enables one to see the road and street signs quickly, accurately and safely. The same would be true of a student in the Industrial Arts laboratory who is working on a machine or building or designing a project.

Another influence of good lighting is depth perception; that is the ability to recognize small differences in distances away from the eye. Depth perception improves with more illumination. Given two objects of the same color and shape, but different in size, it would naturally be easier to see the larger object. With larger quantities of light one could see the small objects more clearly. These are some of the benefits of good lighting but better lighting can mean much more.

It has been established that the environment in which a student's eyes function can have the greatest influence on the amount and quality of his work. Educational methods in schools have changed sufficiently in recent years so that it is no longer adequate to consider a lighting arrangement on the basis of a fixed seating or working arrangement for pupils. Rather a more flexible lighting arrangement is desirable so that proper light conditions the entire classroom so that all usable space is usable. The illumination in classrooms should be sufficient for the pupil to work comfortably while facing in any direction. The comfort of the visual environment is important and providing it in the lighting of schools is a step in the right direction.

When proper steps toward better lighting are not taken it may cause symptoms which reflect the poorly lighted area. The teacher should be aware of the following early symptoms of a student who is working under such circumstances: increased rate of blinking, squinting, moving materials back and forth in front of his eyes for proper focus, poor alignment in his written work and increased irritability.[18] As the student attempts to compensate for poor lighting he usually shows lack of concentration, decreased interest in reading and study, and a definite degree of eyestrain. The result is less than his optimum performance and finally poorer grades. Since the eyes have such a critical effect on the performance of students, it is little wonder that factors which influence seeing are regarded more and more as important tools of learning.

The responsible teacher should be interested in the ease of seeing for reasons other than just increased learning. Bettter

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[18]Seagers, p. 31.

lighting also means better behavior as well as self-satisfaction in knowing that the student is being provided with the most modern facilities available.

Better behavior can be traced to work conditions which are conducive to less fatigue. Balanced lighting may reduce some unnecessary physical tensions and conserve physical energy. Good lighting helps avoid headaches and other ailments which can result from eye fatigue. Eye fatigue can also result in irritability; in fact, light can reflect how students will respond to the teacher, to the surroundings, and can play an important role in avoiding discipling problems. All things being equal, when physical facilities are attractive discipline problems are at a minimum.

Many of the students in the Industrial Arts classes will be of the lower academic group and from the lower socio-economic backgrounds. With little out-of-school incentive, and a school environment which reinforces this lack of initiative, little future of training or adjustment to social responsibility can be expected. If through a lack of adequate facilities, students have to repeat work in which they have done poorly the individual, the community, and society in general pay a big price. The sense of well-being which produces better morale also can easily be enhanced by the brightness of the student's surroundings.

When these areas are adequately lighted so that the student can see properly a substantial reduction in accidents is likely to occur. Better visibility means more safety, and safety results in better attitudes which in turn causes more learning. On the other hand, poor lighting conditions may sacrifice safety and may so effect the accuracy as to retard the progress of pupils and reduce the efficiency of the teacher.

All-in-all it can be said that work-area neatness as well as general behavior tends to improve as students find it easier to see and clean-up their surroundings because they will take a personal attitude and pride toward the task. Suitable lighting can create a cheerful environment. The importance of the psychological factors cannot be overemphasized for the learning processes are enhanced when a feeling of warmth, cheer and brightness is created.

A growing understanding of the principles of good lighting and good seeing, combined with awareness of the importance of developing and perserving the visual skills of children are a must for the teacher in the educational process.[19]

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[19] National Education Association, Teaching About Light and Sight, p. 33.

ENVIRONMENTAL RECOMMENDATIONS

Eye muscles get tired--just as any other set of muscles. Yet, this tiredness is not commonly felt in the eye itself. Eye fatigue affects other parts of the body. A worker suffering from eye fatigue feels tired "all over." He may become the victim of headaches, nerves, digestive upsets and other disturbances. Eye fatigue and its various effects slow a person down both in quality and quantity of work while injuries increase. All of these are unnecessary physical conditions which need not occur. The balancing of the visual environment in school rooms is a task for the expert but the goal of school lighting should be to produce an environment in which the complete seeing process can be accomplished most efficiently. Correct lighting conditions vary greatly because of the variety of activities taking place but a satisfactory environment results when a proper balance is maintained between the task and all other surfaces within the view as a person works at the assignment.

A committee composed of representatives from the Illuminating Engineering Society, the National Council on Schoolhouse Construction and the American Institute of Architects has drawn up a series of goals where critical seeing tasks are performed for prolonged periods of time. The goals apply to light from either electric lights or from daylight. These goals are included in the American Standard Guide for School Lighting. (See Table I)

TABLE I RECOMMENDED ILLUMINATION FOR SPECIFIC SCHOOL AREAS[20]

AREA	Footcandles on Tasks
CLASSROOMS	
Art rooms	70
Drafting rooms	100
Home Economics rooms	
Sewing	150
Cooking	50
Ironing	50
Sink Activities	70
Note-taking Areas	70
Laboratories	100
Lecture rooms	
Audience area	70
Demonstration area	150
Music rooms	
Simple scores	30
Advanced scores	70
Shops	100
Sight saving rooms	150
Study halls	70
Typing	70
CORRIDORS AND STAIRWAYS	20
TOILETS AND WASHROOMS	30
OFFICES	
Accounting, auditing, tabulating bookkeeping, business machine operation and reading poor reproduction	150
Regular office work, reading good reproductions, reading or transcribing handwriting in hard pencil or on poor paper, active filing, index references, mail sorting	100
Reading or transcribing handwriting in ink or medium pencil on good quality paper, intermittent filing	70
Reading high contrast or well-printed material, tasks and areas not involving critical or prolonged seing such as conferring, interviewing and inactive files	30

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[20]Illuminating Engineering Society, IES Lighting Handbook, Third Edition (New York: The Society, 1959), pp. 9-76-84.

One of the difficulties associated with the use of daylight is that of controlling high brightness. The best use of daylight is provided by a building design which effectively shields the sky from direct view or softens the normal brightness. Several features that should be provided in the control of daylight are exclusion of a direct view of the sky, maintenance of a specific surface brightness, little or no manipulation to adjust to variations in the natural light, and provision for ease and economy of maintenance.[21] In providing a desirable visual environment daylight, electric light, or a combination of the two should be considered.

Industry has found that increased lighting can mean increased production, improved quality, better housekeeping and safety, and morale. One result, revealing the need for higher lighting levels in industry, is furnished by a recently completed ten-year research project by Professor H. Richard Blackwell--then director of the Vision Research Laboratories, University of Michigan. Dr. Blackwell's studies (10,000,000 visibility observations) established "beyond reasonable doubt the minimum lighting levels needed for various seeing tasks."[22] Interpretation of this independent research led the Illuminating Engineering Society to issue new recommended illumination standards for most visual tasks. Table II shows the standards for industry as based on this study. It is

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[21]Seagers, p. 67.

[22]Better Light Better Sight Bureau, Lighting for Industry, (New York: The Bureau), p. 3.

interesting to note some of the recommendations from this study which are as follows:

TABLE II RECOMMENDED ILLUMINATION FOR INDUSTRIAL LIGHTING[23]

AREA	Footcandles on Tasks
ASSEMBLY	
Rough easy seeing	30
Rough difficult seeing	50
Medium	100
Fine	500
Extra fine	1000
INSPECTION	
Ordinary	50
Difficult	100
Highly difficult	200
Very difficult	500
Most difficult	1000
MACHINE SHOPS	
Rough bench and machine work	50
Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	100
Fine bench and machine work, find automatic machines, medium grinding, fine buffing and polishing	500
Extra fine bench and machine work, grinding, fine work	1000
MATERIALS HANDLING	
Wrapping, packing, labeling	50
Picking stock, classifying	30
Loading, trucking	20
Inside truck bodies and freight cars	10
OFFICE LIGHTING	
General office work	100
Accounting, bookkeeping	150
Drafting	200

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[23] Ibid.

1. A pencil line on tracing paper required little light as compared with the white lines of the blue print showing through tracing which, in the sample measured, were found to require 400 footcandles.

2. In textile mill tasks, it was found that a broken thread on a spinner bobbin required 2900 footcandles.

3. The light required to detect the defects in the sample of redwood lumber varies from 71 to 381 footcandles.[24]

Since Industrial Arts laboratories are similar to laboratories of industry they should attempt to establish lighting requirements that are comparable to those of industry. Visual capacities of school children do vary widely. A few can read and work under lighting conditions below standard levels without suffering difficulties but pupils and teachers who attempt to work in inadequately lighted surroundings may suffer impaired efficiency and fatigue.

Little is gained without the proper management on the part of the teacher, alert to the needs of the pupils, and able to control lighting to create the desired learning situation. Many factors in creating this environment are under the teacher's control. Shades and blinds should be adjusted to maintain an even light level through the room. Electric lights should be used to make lighting levels equal throughout the room. With visual aids becoming increasingly important and more widely used in the teaching process, there is need for concern of proper lighting principles. There is no learning advantage to pupils if they cannot see these visual aids or take notes of material presented.

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[24]Ibid., pp. 3-4.

Lighting requirements for audio-visual presentations should be carefully planned as in any other learning situation. Ordinarily, in the presentation of black and white motion pictures or film strips, the overall lighting should be two to four footcandles. Color motion pictures or slides require that this be reduced to as little as one-fourth to one footcandle. It is particularly important that a minimum of light fall upon the screen, for this diminishes the contrast in the film and tends to fade out the color.[25] It is also important to maintain high contrast in all teacher-prepared materials such as charts, printed written, and duplicated materials.

The progressive teacher can use light to his advantage. The chalkboard and bulletin board can be provided with a concentration of light for obtaining and holding attention. In setting up a demonstration the Industrial Arts teacher could use supplementary lighting to make the demonstration more visible. If the lighting level in the remainder of the room is reduced somewhat, it will be possible to limit discussion and questions while the lecture or demonstration is in progress. When it is desirable to stimulate class discussions or questions, the lighting level should be raised so it is approximately equal throughout the room.[26] These methods of directing attention are only a few of the many possibilities available with the use of light.

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[25]Seagers, p. 73.

[26]*Ibid.*, p. 72.

A good example of applying the principles of desirable lighting conditions would be to compare the writer's present laboratory situation with that of the optimum classroom environment. In this particular situation both the quality and the quantity of light are lacking. Glare, caused by bare bulbs and reflector-type lighting fixtures, is both annoying and distracting. Shadows are also present making it difficult for the students to do their best possible work in certain work areas. These conditions make it difficult for the students to see properly, thus he looses interest and does not work to his fullest capacity. When proper lighting was requested, only an additional quantity of light was installed with little or no consideration given for quality. Many administrators do not understand the fundamentals of proper lighting and feel the proper amount is all that is necessary. In the Industrial Arts laboratory it would seem that the nature of the work would require that the proper lighting be necessary. These areas should be lighted according to the best practices of industrial lighting, with additional precautions taken into account the special safety problems around by the combination of inexperience, youthful high spirits, and potentially dangerous equipment.

From this it is now possible to describe the desired visual environment for the Industrial Arts Laboratory. Lighting should be sufficient in quantity to provide the desired level of illumination. The quantity factors of brightness, contrast, size, and time have been satisfactorily provided. The luminous environment of the room has been carefully balanced so that there is no areas of excessively high or low brightness, glare has been eliminated, harsh shadows do not exist, and colors have been selected both for their reflectances and for their psychological effects.

It would seem that the writer feels that lighting is all-important in creating a pleasant, cheerful atmosphere. It must be kept in mind that although lighting is important other environmental factors such as color, and texture must be used in conjunction with it rather than subordinate to it. When all of these factors have been considered in the classroom environment, student learning can reach its maximum.

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