A STUDY TO DEVELOP STANDARDS FOR USE IN PLANNING OR RENOVATING INDUSTRIAL ARTS LABORATORIES IN PUBLIC SCHOOLS

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OR RENOVATING INDUSTRIAL ARTS LABORATORIES
IN PUBLIC SCHOOLS

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CHAPTER I

INTRODUCTION

Many physically attractive school buildings exist and are considered to be ideal and well prepared to accommodate students in all aspects of educational activities. However, the view of the inside, especially the industrial arts laboratories, may be disappointing. While the beauty of the building may be a tribute to the architect's design ability, the physical facilities provided may prove to be inadequate to meet the demands of the educational program that are needed.

When planning and designing industrial arts laboratories, physical facilities to accommodate present and future needs of the program are of vital importance. Aspects such as safety, equipment arrangement, floor area, window area, lighting, grade level, and student population must not be overlooked. Industrial arts teachers, school administrators, and architects involved in the process of planning or renovating industrial arts laboratories must do a good job for the school board, the community, themselves, and last, but far from least, the student.
Statement of the Problem

This is a study to develop standards to be used by industrial arts teachers, school administrators, and architects when planning new industrial arts laboratories or renovating existing industrial arts laboratories for grades seven through twelve in the State of Texas.

Need for the Study

Industrial arts teachers, school administrators, and architects have often asked, "Where can I look? What will I find?" to facilitate the planning or renovating of industrial arts laboratories. These questions have frequently arisen when new industrial arts laboratories or the renovation of existing industrial arts laboratories were being contemplated.

Many excellent resources exist to assist in the planning or renovating of industrial arts laboratories. However, opinion differences are evident. It is possible that the confusion produced by contrasting opinions may be responsible for many inadequate industrial arts facilities in schools today. Also, because of the dissemination of the multitudinous sources, much time and effort may be needlessly spent in the preliminary stages of planning.

In order to expedite planning or renovating of industrial arts laboratories, it is imperative that harmony and agreement prevail among all participating persons. This is
not always an easy matter. However, progress would be accelerated by the existence of one compact source containing standards for use in planning adequate physical facilities for industrial arts.

Bulletin 615 of the Texas Education Agency, entitled Principles and Standards for Accrediting Elementary and Secondary Schools and Description of Approved Courses Grades 7-12, states, "The school shall provide adequate physical facilities, materials, and supplies for industrial arts courses being offered."¹ A publication, entitled Preliminary Guide for Planning a Secondary School Building Program, suggests, "The physical facilities should be adequate for those courses being offered. . . . (For detailed information on industrial arts facilities, write to the Industrial Arts Consultant, Texas Education Agency)."² To determine what constitutes adequate physical facilities, W. A. Mayfield, Consultant for Industrial Arts, Texas Education Agency, was consulted. He reported that there was no printed material available from the Texas Education Agency pertaining to standards for industrial arts laboratories. Also, he was

¹Texas Education Agency, Principles and Standards for Accrediting Elementary and Secondary Schools and Description of Approved Courses Grades 7-12, Bulletin 615 (Austin, Texas, 1961), p. 142.

asked, "Do you believe that a study of this nature would be of value?" He replied that a study of this nature would be of value, and sent one mimeographed sheet of which two lines related to industrial arts laboratories by stating area allowances per student. Mayfield also stated that he had written to twenty-five states employing industrial arts consultants and indicated that, upon receipt, this information pertaining to standards for planning industrial arts facilities would be available for use in this study. Based upon the limited material supplied by the Texas Education Agency relating to the planning and equipping of industrial arts laboratories and Mayfield's observations, this study was initiated.

Purpose of the Study

The purpose of this study was threefold:

1. To analyze the approved courses of study for industrial arts to identify the learning activities recommended and physical facilities needed to implement them.

2. To study the professional literature in the area of schoolhousing concerning industrial arts laboratories to

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3Letter from Bernice S. Campbell, graduate student at North Texas State University, Denton, Texas, June 15, 1967.

4Letter from W. A. Mayfield, Consultant for Industrial Arts, Texas Education Agency, Austin, Texas, June 20, 1967.

5Ibid.
identify recommended standards for use in the planning of laboratories that will encourage and permit optimum teaching-learning situations.

3. To compile the recommended standards, where a reasonable degree of agreement exists, into a checklist that can be used in the planning or renovating of industrial arts laboratories and that will facilitate the learning activities in the approved courses for industrial arts.

Basic Assumptions

This study was made with the following basic assumptions:

1. It is assumed that if the curriculum offers both general and advanced courses in industrial arts, the laboratories will be designed and equipped to accommodate both phases of learning.

2. It is assumed that a study of the literature will reveal that suggestions by leaders in the field have been made concerning the various aspects of industrial arts laboratories and the suggestions can be developed into standards for use in planning industrial arts laboratories.

Delimitations of the Study

The study was made with certain delimitations, which are as follows:
1. The study was limited to the development of standards for use in planning new industrial arts laboratories and in renovating existing industrial arts laboratories in the Texas public schools for grades seven through twelve for each of the basic areas of industrial arts as set forth in Bulletin 615. These areas are woodworking, metalworking, drafting, electricity and electronics, graphic arts, power mechanics, and handicrafts.

2. Professional literature dated from 1956 to the present was reviewed.

3. In order to develop guidelines which would conform to the guidelines of other states for use in planning and equipping industrial arts facilities, the primary sources of data were limited to publications available and supplied by the following state departments of education: California, Florida, Georgia, Illinois, Indiana, Kentucky, Maine, Mississippi, New York, Ohio, and West Virginia.

Definition of Terms

For clarification purposes, certain terms used in the study are defined as follows:

"Industrial arts" is defined as those phases of general education that deal with industry--its organization, materials, occupations, processes, and products--and with the

problems resulting from the industrial and technological nature of society.  

"Introductory courses" are those courses offered in grades seven and eight which include a variety of exploratory experiences to assist the student in identifying and understanding his abilities and interests.  

"General courses," usually offered in grades nine and ten, are those courses limited to activities within a group of related industries. For example, general graphic arts includes units on letterpress printing, offset lithography, silk screen printing, and photography.  

"Advanced courses," usually offered in grades eleven and twelve, are those courses which provide for intensive study of a single or closely related group in industries and involve work in such areas as woodworking, metalworking, drafting, electricity and electronics, power mechanics, graphic arts, and handicrafts.  

"Unit shop" is an industrial arts shop organized and equipped for a single subarea of instruction, such as cabinet-making, machine shop, or sheet metal. The major function of

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8Texas Education Agency, Principles and Standards for Accrediting Elementary and Secondary Schools, p. 140.  
9Ibid.  
10Ibid.
this type of organization is to provide a concentration in one industrial arts subarea.11

"Limited general shop" is an industrial arts shop organized and equipped to provide instruction in two or more subareas of a single industrial arts instructional area. A limited general shop in the area of graphic arts includes subareas such as bookbinding, linoleum block printing, and type setting.12

"Comprehensive general shop" is a shop organized and equipped to provide industrial-technical experiences which have been selected from a variety of activities in two or more instructional areas of industrial arts. The comprehensive general shop should have provisions for instruction in several areas, such as drafting, electricity and electronics, metalworking, woodworking, and power mechanics.13

"Open shop area," sometimes referred to as "free working area," is that area in an industrial arts laboratory utilized by students when performing learning tasks. Space to be provided for auxiliary areas, such as storage, office, finishing room, planning areas, etc., is excluded when determining open shop area needed per student.

12Ibid.
13Ibid.
"Laboratory," defined by Good as "Laboratory of Industries," is a space or room, or a number of rooms, adequately equipped with tools, materials, visual aids, and machines characteristic of several phases or forms of industry. 14

"Standards," as used in this study, refers to established recommendations, obtained from printed materials, for the development, planning, and/or renovating of industrial arts facilities.

Sources of Data

Data for the study were secured from five major sources. Professional literature in the field of laboratory planning and layout for industrial arts programs was utilized. Information was also obtained from unpublished related materials such as theses and mimeographed materials. W. A. Mayfield of the Texas Education Agency contacted twenty-five state departments of education employing industrial arts consultants and requested any available printed material they might have related to the planning or equipping of industrial arts laboratories. Eleven of the departments responded by sending publications for use in the planning and equipping of industrial arts facilities. These eleven states were California, Florida, Georgia, Illinois, Indiana, Kentucky, Maine, Mississippi, New York, Ohio, and West

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Virginia. These publications, upon receipt, were supplied by the Texas Education Agency, and are the primary sources of data used in this study. And last, through the cooperation of the Texas Education Agency, existing printed material available in Texas for use in the planning of school building programs was reviewed. Other contributions were personally obtained through observation and instruction at North Texas State University.

Procedure

The study is organized into five chapters. Chapter I contains an introduction to the study, a statement of the problem, the need for the study, the purpose of the study, basic assumptions, the delimitations of the study, the definition of terms, the sources of data, procedure, and recent and related studies.

Chapter II presents the approved curricula for industrial arts courses offered in Texas schools and an analysis of the activities to identify the types of facilities needed in the industrial arts program to provide optimum teaching-learning situations.

Chapter III is concerned with space requirements for industrial arts laboratories inclusive of floor space, storage and special areas, doors and corridors, ceiling heights, and all physical space requirements.
Safety and health, special facilities, and construction requisites are treated in Chapter IV. Some of the features, such as lighting, climatic control, acoustics, exhaust and electrical systems, and shape and location of the laboratory, will be included in this chapter.

Chapter V will be a summary of the study and conclusions based upon the data presented in the study. The Appendix includes a check list to be used for planning and equipping industrial arts facilities or renovating existing industrial arts facilities.

Recent and Related Studies

In an effort to ascertain and utilize materials pertinent to the study, numerous sources were examined. Some of the studies reviewed had elements of relationship to this study. However, because of the obsolescence of most of the thesis material, only a brief description of each is stated.

In 1951 Marvin D. King made a study which related to one section of this study. The purpose of King's study was to ascertain to what extent the lighting in the industrial arts laboratories in selected public schools was in agreement with recognized standards for school lighting. The result of the study indicated that inadequate lighting still existed in several laboratories, although much work had been done to remedy the illumination problem. The reason for the poor illumination in these industrial arts laboratories was
because the location and allotted window area of the laboratories prevented optimal use of direct sunlight. This created the necessity to use only artificial light, which was inadequate.\footnote{Marvin D. King, "A Study of the Lighting Conditions in the Fort Worth Public Schools," unpublished master's thesis, Department of Industrial Arts, North Texas State College, Denton, Texas, 1951.}

In 1952 Richard G. Strickland made a study of the housing facilities provided for industrial arts in the junior high schools of seven Panhandle counties in Texas. The purpose of the study was to ascertain the extent to which the housing facilities provided for industrial arts in these schools met the recommended standards. After gathering data from professional literature, check lists, and personal interviews, it was revealed that the housing facilities for the industrial arts programs in these schools were only partially adequate.\footnote{Richard G. Strickland, "A Study of the Housing Facilities Provided for Industrial Arts in the Junior High Schools of Seven Panhandle Counties," unpublished master's thesis, Department of Industrial Arts, North Texas State College, Denton, Texas, 1952.}

Harry V. Wylie in 1953 made a study of standards for industrial arts housing facilities and developed proposals for housing facilities for industrial arts in a specific senior high school in Fort Worth, Texas. Data for the study were secured from professional literature, the school annual
reports, and personal interviews. From the information presented in Wylie's study, it was concluded that the housing facilities for the industrial arts program in the school partially met the recommended standards as established by authorities in the industrial arts field.\textsuperscript{17}

That same year, Irvin M. Rushing made a study to ascertain to what extent the housing facilities provided for industrial arts programs in the Beaumont Public Schools met recommendations concerning housing facilities as stated by five arbitrarily selected authorities in the field of schoolhousing. Rushing concluded that the schools surveyed met the recommended standards of the authorities only in part. Therefore, he offered recommendations for the improvement of the physical facilities in numerous areas.\textsuperscript{18}

In 1955 Marshall R. Box made a study of the housing facilities provided for industrial arts at North Texas State College with recommended standards and suggestions for use in planning and constructing additional facilities. The

\textsuperscript{17}Harry V. Wylie, "A Study of Standards for Industrial Arts Housing Facilities for Industrial Arts at Arlington Heights Senior High School, Fort Worth, Texas," unpublished master's thesis, Department of Industrial Arts, North Texas State College, Denton, Texas, 1953.

data from professional literature, recent and related studies, and records located in the registrar's office and the Industrial Arts Department at North Texas State College, Denton, Texas, were presented. Finding the physical facilities at North Texas State College to be inadequate, Box presented recommendations for change.19

The most recent study, and the one found to be most closely related to the present study, was that of James H. Latham in 1961. His study was to determine what constitutes adequate or desirable physical facilities for industrial arts laboratories in public schools. To determine the adequacy of physical facilities, recommendations and standards were synthesized and analyzed from professional literature, industrial arts teachers, and by recognized leaders who served as a jury in the area of industrial arts. Latham then presented a composite set of recommended standards which were derived from the synthesis and analysis.20


CHAPTER II

FACILITIES NEEDED FOR OPTIMUM TEACHING-LEARNING SITUATIONS IN THE APPROVED COURSES FOR THE STATE OF TEXAS

In order to determine what constitutes adequate physical facilities for the industrial arts program, a study of the approved courses for grades seven through twelve and a study of the activities to be performed in the various areas of instruction were made. A study of this aspect of the stated problem was necessary in order to identify specific experiences and activities to be achieved and the facilities that are necessary for them to be achieved. Materials presented and treated in this chapter will be the basis for the development of standards for use in planning industrial arts facilities, which will be treated in Chapters III and IV.

Since general courses will usually be taught at the high school level in grades nine through twelve, it can be assumed that when a school district provides the needed facilities for these particular courses, the necessary facilities will also be provided for teaching advanced courses in the same laboratories. Based upon this assumption, general and advanced courses will be treated as one in ensuing pages of this study for the purpose of determining
the facilities which must be provided in the areas of wood-
working, metalworking, drafting, electricity and electronics,
power mechanics, graphic arts, and handicrafts. Therefore,
determining the facilities to be provided in the areas of
woodworking, metalworking, drafting, electricity and elec-
tronics, power mechanics, graphic arts, and handicrafts will
be based upon the assumption that one laboratory will be
planned and equipped to accommodate both general and advanced
courses.

There are seven basic areas of instruction in industrial
arts, and, in each, courses have been described and approved
by the Texas Education Agency. The Texas Education Agency
states that "the ideal local program includes units of study
or a sequence of courses in each instructional area: wood-
working, metalworking, drafting, electricity and electronics,
graphic arts, power mechanics, and handicrafts. These areas
are taught in courses at three levels of difficulty and com-
plexity." The courses, with respect to levels, are
described as follows:

Introductory Courses, Grades 7 and 8--Introductory
Ceramics, Introductory Drafting, Introductory Elec-
tricity, Introductory General Shop, Introductory Handi-
crafts, Introductory Leathercraft, Introductory Metal-
working, Introductory Plastics, Introductory Woodworking,
General Courses, Grades 9-12--General Drafting,
General Electricity, General Graphic Arts, General

1Texas Education Agency, "Principles and Standards for
Handicrafts, General Metalworking, General Power Mechanics, General Shop, General Woodworking.


The activities to be performed in the approved courses in these various areas will be discussed according to their sequence.

Woodworking Sequence

In the area of woodworking, courses have been designed and approved that will provide levels of instruction with respect to difficulty and complexity. These levels have been identified and are referred to as Introductory Woodworking, General Woodworking, and Machine Woodworking I and II.

The introductory course has been designed and approved to be offered in grades seven or eight, and when taught, must provide a minimum of 65 hours of class time but not more than a total of 160 hours.³ The learning activities and physical facilities with respect to tools, equipment, materials, processes, and related information are described as follows:

²Ibid., pp. 141-142.
³Ibid., p. 149.
Introductory Woodworking is a survey of basic woodworking hand tool skills, construction procedures, and materials. Students plan procedures for work on individual projects, make bills of materials, and use working drawing. Projects are selected that include desired learning experiences: measuring and laying out rough stock; cutting with crosscut, rip, back, and coping saws; smoothing with planes, scrapers, and finishing abrasives; forming with files and rasps; drilling and boring; driving and setting nails, screws, and other fasteners; and finishing with brush. Simple joinery is taught only as joints are used in the construction of useful projects, not as exercises to be done for practice.4

When the above learning experiences and activities were studied, it was found that it would be possible to teach an introductory woodworking course by using hand tools only and limited materials. To provide activities that would involve industrial practices, certain power driven machines, such as the lathe, saw, jointer, surfacer, drill press, and sander, would be needed. These machines, if utilized, would necessitate providing electrical services and an exhaust system. Provisions should also be provided in the laboratory for the storage of tools, materials, and student projects, and areas for planning and finishing projects.

The general woodworking course has been designed and approved to be taught in grades nine through twelve. From one-half to one unit of credit may be earned by a student. The learning activities, tools, materials, processes, and equipment recommended for General Woodworking are as follows:

4Ibid.
General Woodworking includes a variety of design, construction, maintenance, finishing, testing, and repairing experiences with wood and wood products. Pre-planning is stressed; working drawings, bills of materials, and written work procedures are prepared by students before project work begins. . . . Time is scheduled for study of industrial products which are comparable to projects constructed at school. . . .

Hand tool skills learned in Introductory Woodworking are refined and instruction is extended to new tools. Instruction in use of power equipment is begun as soon as students demonstrate sufficient maturity to operate the equipment safely. They set up and operate the following power tools: circular saw, band saw, jointer, thickness surfacer, jig saw, sander (disc or belt), drill press, and wood lathe. Portable power tools are demonstrated and students make frequent use of the belt and orbital sanders, drill, saber saw, and router.

A variety of methods of surface decoration and finishing by brush and spray are taught. Students experiment with wood finishes and devise finishing formulas.

Talented students may do research on new materials and processes in the woodworking industries, such as fiberglass, synthetic resins, and wood laminates. The class begins studies of woodworking industries and occupations.5

Courses in Machine Woodworking I and II have been designed and approved to be taught in grades ten through twelve, and from one-half to two units of credit may be earned by a student. The content and facilities involved in Machine Woodworking I and II are as follows:

Machine Woodworking is designed to refine and extend skills taught in General Woodworking, to survey woodworking production methods, and to develop skill in shop operation and machine maintenance.

Individual student projects in millwork and furniture making require extended periods of work on

5Ibid., pp. 149-150.
complicated machine setups and operations. The quality of craftsmanship expected equals that of the industrial job shop. Individual projects and production jobs include the full range of woodworking operations with machines: drill press, circular saw, radial arm saw, band saw, jointer, mortiser, shaper, belt and disc sanders, and wood lathe. Portable tools used include the router, saber saw, circular saw, drill, and sanders. Custom and production finishing techniques include work with natural and synthetic resins. If the aforementioned learning experiences and activities are taught, facilities should be provided. These facilities may be divided into two groups. One group involves the physical laboratory which should provide adequate space for work benches, power equipment, provisions for assembling and finishing projects, storage for student projects and materials, instructional materials, and demonstration and planning areas. The second group involves the tools and equipment needed. The equipment, such as the jointer, band saw, circular saw, thickness surfacer, jig saw, wood lathe, radial arm saw, mortiser, shaper, and sanders, will require electrical service and should be equipped with a dust collection system.

Metalworking Sequence

In the area of metalworking, courses designed and approved to provide levels of instruction with respect to difficulty and complexity are Introductory Metalworking,

6Ibid., pp. 150-151.
General Metalworking, Machine Metalworking I and II, Sheet Metalworking, and Welding.

The introductory metalworking course can be offered in grades seven or eight, and when taught, should provide a minimum of 65 hours of class time but not more than a total of 160 hours. The activities to be performed and physical facilities with respect to tools, equipment, materials, processes, and related materials are as follows:

Projects are selected which include: measuring and laying out strip, bar and extruded stock; enlarging patterns; cutting sheet and bar stock; drilling and punching holes; using hand taps and dies; fastening metal with rivets, screws, and bolts; smoothing metals with files and abrasives; heating metals to forging temperatures; shaping and forming hot metals; doing simple heat treating; wiring an edge, turning a hem, making folds and seams by hand; cutting, forming, and peening soft metals; making sand molds; pouring molten, nonferrous metals; finishing sand castings, finishing metals by painting, lacquering, and polishing.

Introductory metalworking courses could be taught by using hand tools and hand operated machines only and limited materials. However, to assimilate industrial practices, certain power equipment, such as the drill press, lathe, saw, sander and furnace, would be needed. Providing adequate electrical services, an exhaust system, and gas, water, and air outlets would be necessary if this equipment is utilized. Provisions should also be provided in the

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7Ibid., p. 153.

8Ibid.
laboratory for the storage of tools, materials, and student projects, and areas for planning and finishing projects.

The general metalworking course has been designed and approved to be taught in grades nine through twelve, and a student may earn from one-half to one unit of credit. General metalworking would encompass learning activities, tools, materials, processes, and equipment as follows:

General Metalworking is a study of four or more of the metalworking areas selected from art metalworking, bench and wrought metalworking, machine metalworking, welding, founding, sheet metalworking, and metal spinning.

The art metalworking unit includes planishing and peening, electroplating, and spray finishing. . . . Tools and equipment introduced include the power hack saw and special bending jigs. . . . Metals are annealed, tempered, and hardened. In the welding unit, techniques of oxy-acetylene and electric welding are practiced. Students make butt, lap, and flange welds. . . .

The forging unit includes study of furnaces, their safe operation, and heat treatment of metals. Forging skills are refined. In the founding area, sand casting is emphasized and molds are made with solid and split patterns, green and dry sand cores. . . .

Hand tool skills in working with sheetmetal are refined through application in complicated projects. Machines introduced include the box and pan brake, forming rolls, rotary machine, squaring shears, and spot welder.

Machine metalworking includes work on basic machines: the engine lathe, drill press, milling machine, and/or shaper. . . . Semi-precision and precision measuring instruments are used with skill. Metal spinning is introduced with instruction on design, chucks, the metal spinning lathe, and spinning operations.10

9Ibid., p. 154. 10Ibid.
The following courses have been designed and approved to be offered in grades ten through twelve, and units of credit which may be earned in these courses are Machine Metalworking I and II, one-half to two credits; Sheet Metalworking, one-half to one; and Welding, one-half to one credit. The content and facilities included in these areas of instruction are as follows:

Machine Metalworking develops a high level of technical skill in operation of basic machine tools and understanding of machine tool design principles. Instruction is given on the engine lathe, milling machine, drill press, surface grinding machine, tool grinder, and shaper. Skill is developed by constructing useful projects which require multiple operations on several machines. As skill in machine setup and operation increases, projects require accurate and precise work and opportunities are afforded to use machinery handbooks. Instruction in blueprint reading includes interpreting drafting symbols, tolerances, dimensions, conventional representations, interpreting notes and work orders. Sketching is also taught.

Sheet Metalworking develops advanced technical skills in fabricating sheet metal products represented in such industries as heating, ventilating, air conditioning, and aircraft. Hand tool skills begun in General Metalworking are refined and job shop machines are used in work with ferrous metal, aluminum, brass, and copper. As students progress, complex layouts are made using trade short cuts.

New tools and machines introduced include the spot welder, various sheet metal stakes, ring-and-circle shears, power breast drill, and hole saw.

Welding is a study of oxy-acetylene and electric welding equipment, processes, and materials applied in fabrication, repair, and maintenance.

The following subject matter and skills content is included: production, storage, safe handling, and use of oxygen and acetylene; design, operation, and
care of welding and cutting torches, regulators, and generators; chemistry of the oxy-acetylene flame; characteristics of welding materials and weldable metals; destructive and non-destructive testing of welded joints; rough flat cutting; techniques for welding sheet metal, steel plate, cast iron, and aluminum; bronze welding and hard soldering; transformers and generators, their operation and adjustment; electrodes; metallic arc welding techniques—flat, vertical, and overhead; weld joints—butt, tee, lap, corner; jigs and fixtures; occupational opportunities in welding.\textsuperscript{11}

Facilities must be provided if the aforementioned phases of the industrial arts program are taught. These facilities may be arranged into two groups. The first group consists of the physical laboratory, which should provide adequate space for work benches, welding booths, furnaces, pouring of molten metals, and power equipment; provisions for assembling and finishing projects, storage for students' projects and materials; instructional materials; and demonstration and planning areas. The second group consists of the tools and equipment needed. Equipment, such as the engine lathe, metal spinning lathe, milling machine, drill press, surface grinding machine, tool grinder, shaper, spot welder, power breast drill, hole saw, arc welding machines, power hack saw, and band saw, will require electrical service. An exhaust system will be required in the spray finishing room and for furnaces used in the founding and forging areas. A manifold and exhaust system should be installed in the

\textsuperscript{11}\textit{Ibid.}, pp. 155-156.
oxy-acetylene area, and individual booths should be provided for the arc welding area. Gas, water, and air outlets will also be required for a metalworking laboratory of this type.

Power Mechanics Sequence

General Power Mechanics I and II have been designed and approved for grades nine through twelve, and if taught, one-half to two units of credit may be earned by a student. These levels of instruction, with respect to difficulty and complexity, and the learning activities and physical facilities, with respect to tools, equipment, materials, processes, and related information, are as follows:

General Power Mechanics I is a study of selected power units; their design, theory of operation, and function. The first course (first unit of credit) is organized so that fundamentals covered in lectures and demonstrations are reinforced by regularly scheduled laboratory work with mock-ups, models, cutaways, and small live engines. Students perform experiments to determine physical and operational characteristics of power units: horsepower, thrust, efficiency, and specifications (measurements of size, weight, and volume). They disassemble, assemble, and test components of power units; study and identify parts in these components, and do elementary maintenance and repair. Power units studied include model jet and reciprocation engines, and small air-cooled and automobile engines.

Students use basic tools and test equipment with skill sufficient to perform required laboratory work.

General Power Mechanics II (second unit of credit) includes study in depth of the design and use of selected power units and components: industrial power units, tractors, fluid couplings, hydraulic systems,

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12 Ibid., p. 152.
power control systems (mechanical, electrical and electronic), gearing, and steering geometry. Laboratory experiments are given less emphasis; time is devoted to work with complete live units. Students locate and diagnose mechanical troubles, do necessary repairs, and perform routine maintenance. They work independently using tools and test equipment with a degree of skill. Study of occupations in power industries receives additional emphasis.13

The facilities that must be provided if the preceding areas of instruction are taught may be placed into two classifications. One classification is the physical laboratory, which should provide adequate space for test equipment, work benches to assemble and disassemble power units, power equipment, one or more automobiles, demonstration and planning areas, storage of power units, materials, and instructional materials. The second classification involves the tools and equipment needed. Electrical service will be required for equipment, such as the battery charger, grinders, brake drum lathe, drill press, honing machine, engine and accessory analyzer, valve refacer, valve seat grinder, Sanders, polishers, and drying lamp. Provisions should also be made for a sewer system with special grease and sand traps, one or more hydraulic hoists, chain hoist with trolley and monorail, and plumbing with necessary outlets for air, steam, cold, and hot water. An exhaust system will also be required to remove carbon monoxide fumes and fumes in the spray finishing area.

13Ibid.
Drafting Sequence

Approved courses and levels of instruction in the area of drafting are referred to as Introductory Drafting, General Drafting, Architectural Drafting I and II, Machine Drafting I and II, Pre-engineering Drafting, Pre-engineering Descriptive Geometry, and Technical Drafting I and II.

The introductory course has been designed and approved for grades seven or eight, and when taught, should provide a minimum of 65 clock hours or a maximum of 160 clock hours per student.\(^{14}\) Pertinent information with respect to learning activities and physical facilities for the introductory course is as follows:

Introductory Drafting emphasizes fundamentals of graphic representation frequently used in the junior high school shop. Orthographic multiview projection is studied functionally, as a way of drawing solid objects in full size views, rather than as the theory of projection.

Pictorial drawing is introduced in brief units on isometric and oblique. Simple rectangular prisms are drawn and some advanced problems may include inclined plane surfaces and cylindrical parts. Single stroke Gothic lettering is introduced.

Dimensioning is taught as a way of supplementing representations in multiview, oblique, and isometric with sufficient measurements and notes so that construction is facilitated. Computations are practiced in mechanical drawing layout. Only those American Standard symbols and conventional representations applicable to shop drawings made by students are taught.

A degree of drafting skill is expected using the following instruments: T-square, 30°-60° triangle, 45° triangle, architect's scale, draftsman's compass and dividers.\(^{15}\)

\(^{14}\)Ibid., p. 143.  \(^{15}\)Ibid.
Based upon the above-mentioned activities, the physical facilities required for a laboratory of this type may be divided into two categories. The first category involves the physical laboratory, which should provide adequate space for the drawing desks, instructional area, storage of the equipment, materials, and instructional materials. The second category pertains to the instruments and equipment needed. These items are as follows: T-square, 30°-60° triangle, 45° triangle, architect's scale, draftsman's compass, dividers, drafting desk, drafting machine, and drafting board.

The activities to be performed in General Drafting, Architectural Drafting I and II, Machine Drafting I and II, Pre-engineering Drafting, Pre-engineering Descriptive Geometry, and Technical Drafting I and II were synthesized, and the content and facilities included in these areas were treated as one. The grade placement in these areas and the units of credit which may be earned by a student in these areas are as follows: General Drafting, grades nine through twelve, one-half to one; Architectural Drafting I and II, grades ten through twelve, one-half to two; Machine Drafting I and II, grades ten through twelve, one-half to two; Pre-engineering Drafting, grades ten through twelve, one-half to one; Pre-engineering Descriptive Geometry, grade twelve,
General Drafting develops understanding of the basic principles of orthographic multiview, isometric, oblique, and perspective projection. Drafting skill receives added emphasis.

Multiview study includes sketching and instrument drafting of views from real objects, completing one or more views, and constructing complete views from given views. Sectioned views drawn include full, half, revolved, lines, circles, and irregular shapes.

Oblique drawing includes cavalier and cabinet projections of simple prismatic and cylindrical objects, and problems of similar difficulty are solved in isometric.

Freehand and mechanical perspectives are drawn of simple prismatic objects using both one- and two-point methods. Inclined surfaces and nonparallel lines may be included in the more difficult problems.

Size specification receives added emphasis. Principles of size and shape description are applied in the drafting of two or more types of working drawings (such as machine, architectural, topographical, aircraft, structural, electrical, plumbing, mechanical construction, charts and graphs). Reproduction of drawings is taught in conjunction with working drawings.

Geometric constructions include tangent circles, ellipses, regular and irregular polygons, parallel, perpendicular, and oblique lines. Neatness, speed, and accuracy are given special emphasis.

Some solutions require extended periods of work.

As problem solving becomes more complex, limited skill is developed with instruments not introduced previously, such as the irregular curve, extension compass, engineer's scale, and various templates (circle guide, ellipse guide, symbol guides).

A study is begun of American Standards, particularly those used in architectural and machine drawing: conventional lines, sections, and surface intersections.

Single stroke Gothic lettering is practiced and both upper and lower case forms are used on plates and working drawings. Lettering instruments and templates are demonstrated.

16Ibid., pp. 143-148.
Architectural Drafting provides guidance and technical skills for talented students who plan college study of architecture or engineering. Students with average ability gain knowledge needed by the home owner and broaden drafting skills.

Architectural Drafting I (first unit of credit) surveys fabrication methods and materials used in residential construction. Problems assigned permit teaching of building construction fundamentals concurrently with drafting a complete set of working drawings for a small building. Architectural symbols for common construction materials and electrical, plumbing, heating, and ventilating components are drawn.

Architectural lettering, dimensioning, multiview, and pictorial projection are applied in units on plot plans, foundations, floor layouts and framing, wall sections, exterior elevations, interior elevations, and details.

Architectural Drafting II (second unit of credit) includes techniques for rendering building structures in perspective. One-, two-, and three-point mechanical perspective drawings form the base for renderings with pencil, ink wash, and water color. Freehand perspective techniques are practiced by drafting plots, foliage, and other irregular shapes. Related study includes: building structures, custom detailing, standard building components, modular construction, and public housing.

Written building specifications and cost estimates are prepared. Scale models are constructed to represent building features, construction methods, and complete residences.

Machine Drafting I is advanced study of machines, machine parts, jigs, and fixtures. Subject matter is taught by drafting complex machines in multiview and pictorial projection, studying standard machinery handbooks and fabrication methods, and doing independent work in elementary machine design.

Special emphasis is given to dimensions and tolerances in preparing a set of detail drawings for parts in a machine assembly. Shop processes are studied first hand. A working knowledge is required of common measuring tools: the machinist's steel rule, inside and outside spring calipers, inside and outside micrometer calipers, vernier calipers, and combination square.

Assembly drawings are made by multiview and pictorial methods. Represented in major problems are
American Standard symbols and conventional representations including basic machine elements: gearing, cams, threaded fasteners, rivets, machine keys and pins, springs, shafts, and bearings.

Machine Drafting II (second unit) emphasizes drafting skills. Neatness, accuracy, and orderliness approach the professional level and work is done with only occasional assistance and direction. Students keep time on some jobs and meet frequent deadlines. Talented students may do elementary machine design in lieu of regular assignments if fundamental drafting skills are developed.

Pre-Engineering Drafting is designed for talented students who plan college study of engineering, architecture or related technological fields. College textbooks, workbooks, and other advanced instructional materials are used.

The principles of engineering graphics are studied in units of multiview orthographic, isometric, dimetric, trimetric, oblique, and perspective projection. Free-hand and instrument drawing are taught. Students work with increasing independence using professional drafting instruments and equipment.

Multiview orthographic study includes complicated problems from given views, pictorials, and written specifications. Sections are drafted using half, full, offset, revolved, and auxiliary methods. Both primary and secondary auxiliary views are drawn of prismatic, cylindrical, conical, and irregularly shaped parts.

Problems are assigned in each of the basic methods of flat pattern development: parallel line, radial line, and triangulation. A unit on intersections includes basic problems on intersecting cones, cylinders, and prisms.

An introduction to machine drafting is included so that students may apply principles in the solution of working drawing problems. Both detail and assembly drawings are drawn and reproduced. Such machine parts as threaded fasteners, shafts, bearings, and machine keys are presented conventionally in working drawings. American Standard tables are used with skill.

Pre-Engineering Descriptive Geometry is designed for talented students who plan college study of engineering, architecture, or related technological fields. The subject matter content of the course emphasizes the graphical solution of problems involving points, lines, and planes in space. Engineering applications of these solutions are not usually included since they are made
in college courses in Descriptive Geometry. College textbooks, workbooks, and other advanced instructional materials are used.

The principles of multiview projection are studied intensively, and problems are solved in each unit: principal views, primary auxiliary views, secondary auxiliary views, planes, parallelism, perpendicularity, angle between planes, revolution, intersections, and developments.

Solutions to problems require orderly work and a high level of skill in the use of professional drafting instruments and equipment.

Technical Drafting may be organized for two distinctly different student groups. Those who have completed Pre-Engineering Drafting should have technical drafting that approaches college courses in depth of study and in quantity of work. Students of average ability who have completed General Drafting should have technical drafting which emphasizes drafting skills and related technical knowledge. Both groups may be taught concurrently in the same class but different assignments are given.

Technical Drafting I (first unit of credit) includes study of structural steel drafting, machine design and drafting, aircraft drafting, patent office drafting, electrical drafting, plumbing and mechanical construction layout, topographical drafting, and jig and fixture design. Problems are assigned in each area.

Students use drafting instruments and devices usually found in industrial drafting departments such as mechanical lettering guides, drafting machines, special curves, templates, and print reproduction machines. Drafting skill approaches professional quality and some problems require extended periods (10 to 30 hours) of independent work.

Standard handbooks, tables, and engineering data are studied in each area. A technical vocabulary is developed and occasional technical reports are written; written specifications are prepared to accompany some problem solutions.

Technical Drafting II (second unit of credit) provides for some specialization. Students are assigned problems from one or two of the areas studied in the first course and receive only occasional assistance from the teacher. High level drafting skill is expected.17

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17 Ibid., pp. 143-148.
If the aforementioned courses are taught, facilities should be provided. These facilities involve the physical laboratory, which should provide adequate space for drawing desks, instructional area, storage of equipment and instruments, materials, instructional materials, library, tables to store and/or display scale models, blueprint or print reproduction machine, copy printer, study and planning area. Involved also are the instruments and equipment needed, such as the T-square, drafting machine, special instruments and devices, drafting instruments, drafting board, drafting desks, lettering instruments, mechanical lettering guide, architect's scale, engineer's scale, electrical eraser, inside and outside spring calipers, vernier caliper, inside and outside micrometer calipers, machinist's steel rule, combination square, copyprinter, paper cutter, and trimming shears. Equipment such as the blueprint machine will require an exhaust system to remove ammonia fumes. These instruments and equipment will be necessary if the assimilation of industry is to be accomplished.

Graphic Arts Sequence

Courses that have been designed and approved in the graphic arts area are General Graphic Arts, Printing I and II, and Photography I and II. These courses have been designed to provide levels of instruction with respect to difficulty and complexity. The grade placement in these
areas and units of credit which may be earned by a student in these areas are General Graphic Arts, nine through twelve, one-half to one; Printing I and II, ten through twelve, one-half to two; Photography I and II, ten through twelve, one-half to two. The content and facilities involved in these areas are as follows:

General Graphic Arts is a survey of graphic arts processes presented in several related units; basic principles of graphic design are emphasized in units on letterpress printing, offset lithography, silk screen printing, and photography.

In letterpress printing, students become familiar with the type case and spacing materials, study proof marks and elementary composition. Skills practiced include setting type, locking up forms, taking proofs, reading and marking proofs, correcting forms, and operating the hand press.

Offset lithography includes preparing copy, photographing copy, stripping and opaquing negatives, making plates by both manual and photographic processes, and setting up and operating the offset press.

Silk screen printing includes making frames, making designs for silk screen reproduction, making a stretch, preparing stencils, applying stencils, printing in single and multi-colors, and caring for equipment.

In photography, students use both amateur and professional types of cameras, process film and prints (develop, fix and dry), make enlargements, mix chemicals, care for cameras and darkroom equipment, and study composition.

Letterpress and offset lithography processes introduced in General Graphic Arts are expanded and refined.

Photography I (first unit of credit) emphasizes basic camera skills, negative processing, print making, toning, print spotting, print mounting, and picture evaluation. Students develop basic skills with the following equipment: simple and complex cameras,

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18Ibid., pp. 159-160.
standard camera accessories (flash, close-up attachments, tripods, filters, supplementary lenses), contact printers, enlargers, print washers, print dryers, and timers.

Photography II (second unit of credit) permits refinement and extension of skills, and the introduction of color photography. Students develop such advanced camera skills as computing depth of field, computing exposure for bellows extension in copy work, and adjusting view cameras. They tint pictures with oil colors, mix photographic chemicals, do negative retouching, intensification, and reduction. Specialized applications that are emphasized include portraiture, copy and layout (tone and line), photo journalism, fashion, public relations, and advertising.\textsuperscript{19}

If the aforementioned courses are to be taught, adequate facilities should be provided. Upon dividing the facilities into two groups, it was ascertained that the first group involved the physical laboratory, which should provide adequate space for the machines and power equipment, work benches, storage of materials, supplies, instructional materials, student projects, instructional area, planning and demonstration area.

In addition to the above, space should be provided for separate rooms in the photography and offset plate-making areas. Each of these rooms should be equipped with a dark-room. These rooms should also provide adequate space for work tables, sinks, equipment, and storage of materials, equipment and supplies. Since this phase of the industrial arts program requires the utilization of chemicals, film and

\textsuperscript{19}\textit{Ibid.}, pp. 159-161.
paper, a separate room should also be provided for the storage of these items, and this room should be climatically controlled.

The second group of facilities involves the tools and equipment needed. Major pieces of equipment that would require electrical service are the offset printing press, platen press, cylinder press, typesetting machine, linotype machine, and the print dryer. There are other pieces of equipment which require electrical service; therefore, adequate wall receptacles should be provided.

Other pieces of equipment needed in a laboratory of this type are the proof machine, hand press, camera, carbon arc lamp, refrigerator, enlarger, plate whirler, offset plate maker or printer, paper cutter, paper drill, stereotyping unit, mitering machine, press numbering machine, and bookbinding unit. Darkrooms and rooms where chemicals are to be mixed should be equipped with an exhaust system.

Electricity and Electronics Sequence

In the area of electricity, the courses are designated as Introductory Electricity, General Electricity, and Basic Electronics. The introductory course can be offered in grades seven or eight, and when taught, should provide a minimum of 65 hours of class time but not more than a total of 160 hours.20

20Ibid., p. 161.
The content and necessary facilities encompassed in this area are as follows:

Introductory Electricity is a course in electrical fundamentals, common electrical components, and electrical devices. Laboratory work is based on wiring and testing simple electrical devices and constructing elementary projects which exemplify electrical fundamentals.

Principles of electricity studied include: magnetism, electromagnetic induction, sources of electrical energy, series and parallel circuits, and electrical measurement.

Common electrical components and devices used in laboratory work include: chemical cells, electromagnets, permanent magnets, heating elements, rheostats, fuses, switches, simple motors and generators, conductors, and insulators.

A measure of skill is developed in wiring and tracing simple circuits, soldering, measuring voltage, current, and resistance, and constructing or assembling such low-voltage devices as buzzers, motors, and chemical cells. Hand tool skills required are comparable to those specified in Introductory General Shop.21

After studying the above learning experiences and activities, it was found that if introductory electricity is to be taught, facilities should be provided. These facilities are divided into two groups. The physical laboratory should provide adequate space for work benches, equipment, supplies, materials, storage of student projects, instructional materials, and areas for instructing, demonstrating, and planning. The second group is comprised of the tools and equipment needed. Electrical service will be required for the testing equipment and panel, and drill press and

21Ibid.
grinder. Air and water outlets will also be necessary in a laboratory of this type.

General Electricity has been designed and approved to be offered in grades nine through twelve, and from one-half to one unit of credit may be earned by a student. Basic Electronics has been designed and approved to be offered in grades ten through twelve, and from one-half to one unit of credit may be earned by a student. Assuming that these courses will be taught in the same laboratory, pertinent information with respect to activities and facilities involved are as follows:

General Electricity provides study of selected electrical and related industries (power generation and distribution, home appliance, component manufacture). Study in depth of electrical fundamentals is begun and students apply theories by performing a variety of electrical experiments and constructing (or assembling) individual electrical projects.

Electrical fundamentals studied include: atomic theory (structure of the atom, atomic weight and number, ionization, charges), conductivity, Ohm's law, Coulomb's law, Kirchoff's laws, Lenz's law, sources of electricity (chemical and mechanical generators, static machines, piezoelectric effects, thermocouple, photo-cells), induction, motor principles, meter principles, alternating current, and transformers.

Students perform experiments, assemble and test electrical devices which require a substantial understanding of circuitry, electrical components, and test equipment. Precision electrical measuring instruments (such as voltmeters, ohmmeters, and ammeters), common hand tools, and light power equipment are used with increasing skill. Electrical drawings are read and interpreted to facilitate theory study and laboratory work. Hand tool skills are those specified in the General Shop course.

22Ibid., p. 162.
If the full one-credit course is given, fundamentals of electronics may be introduced.

Basic Electronics includes study of electron theory, basic electronic circuits, and selected devices which utilize thermionic tubes and semi-conductors. Electronic fundamentals are applied by performing a variety of experiments, analyzing basic circuits, and assembling individual projects. Students become familiar with electronic components, their theory of operation and functions in basic circuits.

Fundamentals studied include: electromagnetic waves, inductance, capacitance, detection, thermionic tubes, rectification, amplification, semi-conductors, electronic measurement, and conversions. Students assemble, or build and test, amplifiers, oscillators, detectors, and power supplies. Complicated schematic drawings are read and interpreted with skill.

In the latter phases of the course, students use industrial electronic testing equipment: vacuum-tube-voltmeter, oscilloscope, radio and audio signal generators, and tube checker. They work without continuous supervision, and basic tool skills become established. Occupational opportunities in electronics industries are studied.23

Based upon the above-mentioned activities to be performed in these courses, the physical facilities, which should be provided if these courses are taught, are as follows: the physical laboratory that will provide adequate space for work benches, finishing area, project storage, test benches and panels, power equipment, storage of tools, supplies, instructional materials, and materials, instructional area, demonstration and planning area. The tools and equipment needed consist of measuring devices, such as the voltmeter, ohmmeter, ammeter, vacuumtube-voltmeter, oscilloscope, radio and audio signal generators, tube checkers,

23ibid., pp. 162-163.
volt-ohm-milliammeter, and audio oscillator. Power equip-
ment, such as the drill press, generator, grinder, lathe,
undercutting machine, and coil winding machine, should be
provided. The above-mentioned test equipment and power
equipment will require electrical service. An exhaust
system will be required to remove fumes in the finishing
room, and water and air outlets should also be installed in
this type laboratory.

Handicrafts Sequence

In the handicrafts area the approved courses provide
levels of instruction with respect to difficulty and com-
plexity. These levels are referred to as Introductory
Handicrafts, Introductory Leathercraft, Introductory
Ceramics, Introductory Plastics, General Handicrafts I and
II, Leatherworking, Ceramics, Plastics, and Jewelry.

In the handicrafts sequence there are four introductory
courses which have been designed and approved to be offered
in grades seven or eight. The hours of class time, which
must be provided if these courses are taught, are as
follows: Introductory Handicrafts, 65 hours minimum and 160
hours maximum; Introductory Leathercraft, Introductory
Ceramics, and Introductory Plastics, 65 hours minimum and
80 hours maximum.24 The learning activities and physical

24Ibid., pp. 163-164.
facilities with respect to tools, equipment, materials, processes, and related information in these areas are as follows:

Introductory Handicrafts includes a survey of two or more handicraft areas. The subject matter and skills content in the course is outlined in descriptions for introductory courses in ceramics, leathercraft, metalworking (part metalworking only), and plastics. Additional handicrafts (i.e., textiles, weaving, woodcrafts, bookbinding, model making, and jewelry) may be taught provided the basic areas are included in the course.

The course is arranged so that all students do some work in each handicraft; however, the time need not be divided equally among the areas. Introductory Handicrafts may be followed by more intensive study in one area of work, such as leathercraft.

Introductory Leathercraft is a course in leather construction methods, materials, and design applied in construction of elementary projects.

Skills content includes fabrication of light and heavy leather products and their surface enrichment by stamping, carving, and dyeing. Related information is included on design in leather, scaling templates and patterns, tanning and finishing leathers, sources and uses of leather, history of the leather industry, and occupations in leatherworking industries.

Introductory Ceramics includes study of ceramic products, especially pottery, and the design principles, materials, and construction methods of ceramics industries. Skills and knowledge are applied in projects and experiments with ceramic materials.

Processes taught are those of creating designs, preparing clay and slip, forming pieces by coil and slab methods, casting in one- and two-piece molds, finishing and decorating leather-hard pieces, applying underglaze decoration, and firing bisque and glaze.

Introductory Plastics is a survey course in plastic materials, fabrication processes, and elementary design in plastics. Students construct simple projects of plastic materials and study industries that make extensive use of plastics.

Processes taught include: making bills of materials and plans of procedure, measuring and laying out
stock, cutting sheets, rods and tubes, carving surfaces, using hand and light power tools (bench drill, jig saw, portable router and sander), heat forming, casting liquid plastics, and assembling plastic parts.25

Adequate facilities should be provided if the aforementioned courses are to be taught. The physical laboratory should provide facilities, such as adequate space for work benches, tools, equipment, materials, supplies, planning, assembling and finishing areas, and storage for student projects. Provisions should also be made for power equipment, such as the ball mill, grinder, buffer, vacuum forming press, bench drill, jig saw, portable router and sander. This equipment will necessitate electrical service if they are utilized. Equipment, such as the ovens, kilns, and spray guns, will require an exhaust system. Gas, water, and air outlets should also be provided in the laboratory.

The general handicrafts I and II courses may be taught in grades nine through twelve. From one-half to two units of credit may be earned by a student.26 The content and facilities involved in these areas are as follows:

General Handicrafts is a survey course in ceramics, plastics, art metalworking, and leatherworking industries.

General Handicrafts I (first unit of credit) may be for two different student groups. Those who have completed Introductory Handicrafts work at the level described in Leatherworking, Ceramics, Plastics, and Jewelry. For beginners, instruction starts with fundamental tool skills, processes, and design principles.

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25Ibid. 26Ibid., p. 165.
This content is described in Introductory Ceramics, Introductory Leatherworking, Introductory Metalworking (art metalworking only) and Introductory Plastics. Beginners advance rapidly into more difficult subject matter.

In General Handicrafts II (the second unit of credit), students study one or two crafts areas included in General Handicrafts I. . . .

The advanced courses (Leatherworking, Ceramics, Plastics, and Jewelry) have been designed to be offered in grades ten through twelve, and from one-half to one unit of credit may be earned by a student. The content and facilities included in these areas of instruction are as follows:

Leatherworking includes study of selected leather industries, their materials, processes, and products. Because there is no prerequisite, the course begins with subject matter and skills outlined in Introductory Leathercraft. Beginners advance rapidly to projects that require extended periods of work and application of complex operations. Machine sewing and construction of leather garments are introduced; skills in leather carving, tooling, and dyeing are refined. Design in leather is emphasized and students plan complete leather articles including surface carving, embossing and tooling. The level of craftsmanship approaches work done by professional saddlemakers.

Ceramics is a course of study in the materials, processes, and products of ceramics industries. Original designs are developed for pottery pieces which are fabricated by a variety of methods. Contemporary ceramic pieces and artifacts of significant historical periods are studied and the evolution of ceramic design is traced. Students evaluate their ceramic pieces in comparison with commercial products.

Since Ceramics has no prerequisites, skills included in Introductory Ceramics are taught, after which students attain a high level of skill in pottery work in which each of the fabrication methods is used: pinch and ball modeling, coil and slab building, throwing

27 Ibid.  
28 Ibid., pp. 165-167.
of the potter's wheel, drain and solid casting. Plaster molds for drain and solid casting are designed and constructed.

A study is made of clay and glazes; formulas for mixing glazes are determined by experiment. Both electric and gas kilns are fired and safe work procedures are developed.

Plastics includes study of selected plastics industries, their materials, processes, and products. Since Plastics has no prerequisite, skills and knowledge included in Introductory Plastics are taught. Also, such power machines as the circular saw, bandsaw, jointer, portable router, wood and metal lathe are used in laboratory work. Internal carving and forming with heat and pressure are introduced.

Jewelry is a course in silversmithing, coppersmithing, and lapidary skills. It develops appreciation for the handicrafts, technical skill with materials, and rewarding avocations. Though instruction may begin with either jewelry or lapidary work, some in both is done early in the course so that each area complements the other.

In lapidary work, students identify precious and semi-precious stones and practice hand and machine methods of cutting, polishing, and engraving. Sources of semi-precious stones are located and field trips are made in search of them.

Since silver and copper are used extensively in jewelry making, many of the processes are similar to those described in Introductory Metalworking. In addition, permanent molds are used in casting silver alloys, and castings are finished by hand processes. Advanced students may fabricate silverware and tableware pieces by hand processes. Some commercially made jewelry findings may be used if the fabrication processes required are not within the scope of laboratory equipment.29

The facilities needed for the advanced courses may be divided into two groups. The physical laboratory should provide adequate space for work benches, power equipment,

29Ibid., pp. 166-167.
tools, materials, supplies, planning, finishing and assembling areas, and storage for student projects. The second group involves the tools and equipment needed. Equipment, such as the jointer, band saw, circular saw, wood and metal lathe, ball mill, grinder, buffer, vacuum forming press, jig saw, jointer, portable router, portable sander, drill press, trim saw, gem-cutting unit, and lapidary drilling unit, will require electrical service. Some of the equipment should be equipped with a dust collection system. Provisions should also be made for gas, water, and air outlets, and an exhaust system for equipment, such as the oven, kiln, spray gun, and furnace.

General Shop and Pre-engineering Materials Laboratory Sequences

There are two additional sequences in the industrial arts course offerings; they are the General Shop and the Pre-engineering Materials Laboratory. These courses can be designed or planned by using information already presented in this study. For example, the Introductory General Shop, which encompasses two or more phases (four are recommended) of modern industry selected from woodworking, metalworking, electricity, and drafting, could be designed by utilizing information pertaining to introductory courses in the various areas previously discussed. Likewise, General Shop I,

\[\text{Ibid., p. 157.}\]
which is a survey of two or more phases (four are recommended) of modern industry selected from woodworking, metalworking, electricity and electronics, and drafting,\textsuperscript{31} and General Shop II, where the students spend more time working in one or two areas and complicated machine operations are performed,\textsuperscript{32} could be planned or designed by utilizing information previously presented pertaining to general courses in the various areas.

The Pre-engineering Materials Laboratory, which involves a study of industrial materials and manufacturing processes presented in a comprehensive view of the technological industries,\textsuperscript{33} could be conducted by utilizing one or more of the laboratories (general and advanced laboratories) discussed previously. This type course would be taught by using the existing laboratories in a school plant.

In summary, the seven basic areas of instruction can be grouped into two classifications with respect to course offerings. One group is the introductory courses offered in grades seven or eight, and the second group is the general and advanced courses offered in grades nine through twelve.

If these learning experiences and activities are to be taught, adequate facilities should be provided to insure optimum teaching-learning situations. These facilities

\textsuperscript{31}\textit{Ibid.}, p. 158. \quad \textsuperscript{32}\textit{Ibid.} \quad \textsuperscript{33}\textit{Ibid.}, p. 168.
divided into two groups are the physical laboratory and the tools and equipment needed. With respect to the tools and equipment needed, it was ascertained that most introductory courses could possibly be taught by using hand tools only and limited materials. However, to assimilate industry, a minimum of power driven equipment should be provided. It was also found that general shop courses and pre-engineering materials laboratories could be designed or planned by utilizing the information pertaining to the seven basic areas of instruction or by using existing laboratories in the school plant.
CHAPTER III

SPACE REQUIREMENT STANDARDS FOR USE IN PLANNING
INDUSTRIAL ARTS LABORATORIES IN
PUBLIC SCHOOLS

In order to determine what constitutes adequate or desirable physical facilities with respect to space requirements for the industrial arts laboratories in public schools, a study of current literature in the area of planning and building of industrial arts laboratories was made to secure the recommendations of leaders in industrial arts.

Physical facilities for the seven basic areas of instruction (woodworking, metalworking, drafting, electricity and electronics, power mechanics, graphic arts, and handicrafts) will be treated in this chapter. The literature will be studied to gather and present recommendations concerning the following aspects of an industrial arts laboratory. The organization of this chapter is as follows: square feet of floor area per student, height of ceiling, windows and window area, demonstration and/or instructional area, and exits and outside doors; teacher's office and conference room, storage space for materials and supplies, and storage space for students' projects and personal belongings; finishing, assembling, and gluing facilities, library and
planning area, display area, toilet facilities, and equipment storage (tools, auxiliary machine parts, etc.). It should be noted that the aforementioned organization of this chapter may vary because of the nature of the activities to be performed in the various areas of instruction. Some of the basic areas of instruction may require additional physical facilities where others may warrant the omission of some of the previously stated facilities.

Suggestions, recommendations, and standards as stated in numerous sources were studied. This was deemed necessary so that a cross sectional view, rather than the views of one source, might be presented concerning these areas.

Woodworking Area

Space requirements for the area of woodworking are as follows:

**Square Feet of Floor Area per Student**

In the area of woodworking, a study of the literature indicated a range varying from a minimum of 50 square feet to a maximum of 125 square feet of floor area per student.

William E. Huss, in a space allocation chart (courtesy of Paul L. Scherer) based on a class of twenty-four students in a general wood laboratory, recommended 50 square feet as a minimum, 75 square feet as adequate, and 100 square feet as the desirable square footage of open laboratory area per
student at the junior high level. For the senior high level he recommended 75 square feet as a minimum, 100 square feet as adequate, and 125 square feet as desirable.¹

The Illinois Board of Vocational Education and Rehabilitation recommended from 80 to 100 square feet per student, plus the auxiliary area, for a general woodworking laboratory.² Suggestions from the West Virginia Department of Education, based on a maximum of twenty-four pupils in a laboratory, were to, "generally, consider 50 square feet per pupil minimum for junior high school and 75 square feet per pupil minimum for senior high school."³ Georgia State Department of Education recommended that "a minimum of 75 square feet per pupil should be provided in shops exclusive of machine and storage areas."⁴ New York State Education Department recommended the following with respect to the size of the laboratories:


The total area in each shop should be determined on the basis of 75 square feet of floor space for each pupil in the largest class. . . . This figure is based on the assumption that shops will be planned to accommodate a maximum of 24 pupils.5

California State Department of Education recommended 75 square feet per student as a minimum, 100 square feet as adequate, and 125 square feet as desirable for the open area in junior and senior high schools, based on a class size of twenty-four students.6 Herbert M. Brant, in agreement with the above recommendation, suggested 75 square feet as a minimum, 100 square feet as adequate, and 125 square feet as the desirable square footage of floor area per pupil.7

Ohio State Department of Education, with respect to laboratory size, recommended that "100 square feet of floor space per pupil should be considered as the minimum for the shop proper in all new buildings. This figure includes project and material storage space, tool supply and finishing room, and is based upon laboratories planned to accommodate twenty-five pupils or more."8

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8Ohio State Department of Education, "A Guide for Industrial Arts Shop Planning" (Columbus, Ohio, no date given), p. 5. (Mimeographed.)
After studying the preceding data, it was found that four of the eight sources recommended 75 square feet of floor area per student as a minimum for all secondary school levels. Three of the eight sources referred to specific school levels. Two of these sources recommended 50 square feet as a minimum for junior high schools and 75 square feet as a minimum for senior high schools. The other source suggested a minimum of 75 square feet for both junior and senior high schools.

It was also ascertained that only three of the eight sources referred to square footage per student in terms of minimum, adequate, and desirable. One of the sources suggested 50 square feet as a minimum, 75 square feet as adequate, and 100 square feet as desirable for the junior high school. For the senior high school, it was suggested that 75 square feet should be the minimum, 100 square feet should be adequate, and 125 square feet should be the desirable square footage of floor area per student. The two remaining sources were in agreement by recommending 75 square feet as a minimum, 100 square feet as adequate, and 125 square feet as the desirable square footage per student for the secondary school level.

Five of the eight sources recommended the number of students to be included when determining the square footage per student. Four of these sources recommended twenty-four
students, while the other source suggested twenty-five students or more.

Based upon the aforementioned recommendations and suggestions, it was found that the general agreement, when determining the amount of floor area per student at the secondary school level based on an average class size of twenty-four students, was 75 square feet as a minimum, 100 square feet as adequate, and 125 square feet as the desirable square footage of floor area to be provided per student.

**Height of Ceiling**

A study of the literature pertaining to ceiling height revealed a range varying from nine feet to sixteen feet. However, twelve-foot ceilings appeared to be the height most desirable. Indiana State Department of Public Instruction⁹ and Maine State Department of Education¹⁰ suggested that the ceiling height should not be less than ten feet. New York State Education Department recommended a minimum of nine-foot ceilings,¹¹ and was in agreement with Maine State

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¹¹New York State Education Department, *op. cit.*, p. 9.
Department of Education by further recommending that "twelve-foot ceilings should be provided whenever possible, especially where long materials will be handled." The publications from the States of Florida, Illinois, Ohio, Georgia, Kentucky, and California contained suggestions of a minimum of twelve-foot ceilings. However, California State Department of Education recommended a preference of fourteen-foot ceilings for vertical storage of materials, and Florida State Department of Education suggested fourteen to sixteen-foot ceilings as being preferable for balcony storage. Willard M. Bateson, in a research

13 New York State Education Department, op. cit., p. 9.
14 Florida State Department of Education and Industrial Arts Teachers of Orange and Seminole Counties, "County Course of Study, Industrial Arts" (Leon, Florida, 1966), p. 10. (Mimeographed.)
15 Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 8.
20 Ibid.
21 Florida State Department of Education, op. cit., p. 10.
study, recommended a minimum of twelve feet as the standard for ceiling heights.22 Marshall L. Schmitt, upon summarizing trends in industrial arts planning, ascertained that the present trend in ceiling height is eleven to fifteen feet.23 Mississippi State Department of Education, in discord with other recommendations, suggested that "the ceiling height of shops and similar areas measured from the floor to the principal plane of the ceiling should not be less than 16 feet."24

Upon studying the data pertaining to ceiling height, it was found that six of the thirteen sources recommended a minimum of twelve-foot ceilings, and three of the thirteen sources preferred twelve-foot ceilings. Therefore, the majority consensus was found to be a minimum of twelve feet. Other recommendations ranged from a minimum of nine feet to a maximum of sixteen feet.


Windows and Window Area

The various sources studied in the area of windows and window area agreed that natural lighting should be utilized. The percentage of window area to floor area ranged from 14 to 25, with 25 per cent being the most recommended. The height of the window sills ranged from thirty-six inches to seventy-two inches, with seventy-two inches being the most satisfactory.

In the publications from the States of Kentucky and Mississippi it was suggested that the window glass area equal at least 25 per cent of the floor area. Georgia State Department of Education recommended approximately 20 per cent, and Illinois Board of Vocational Education and Rehabilitation suggested the ratio of glass area to floor space be one to five or one to six. New York State Education Department recommended that "the length of the principal clear glass area in a shop should equal or exceed 80 per cent of the length of the wall in which the glass

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28 Illinois Board of Vocational Education and Rehabilitation, *op. cit.*, p. 9.
occurs." The Kentucky State Department of Education recommended that "the top of the window glass should extend to within at least six inches of the ceiling," and New York State Education Department suggested "not less than 36 inches above the floor to at least 96 inches above the floor." The recommendation contained in the publication from the State of Mississippi was to extend clear glass from a height of not less than sixty-six inches above the floor.

In the publications from the States of Indiana and Illinois, it was suggested that window sills should be placed seventy-two inches from the floor. The Industrial Arts Consultant for the State of Georgia recommended that window sills be from six to eight feet above the floor and that four-foot window sills should be provided in partition walls.

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29 New York State Education Department, op. cit., p. 10.
31 New York State Education Department, op. cit., p. 10.
32 Mississippi State Department of Education, op. cit., p. 22.
33 Indiana State Department of Public Instruction, op. cit., p. 40.
34 Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 9.
35 Georgia State Industrial Arts Consultants' Office, "Industrial Arts Facilities, Check List of Standards" (Atlanta, January, 1965), p. 3. (Mimeographed.)
William E. Huss stated, "Full advantage should be taken of natural lighting through maximum window area. . . . High windows with sills six feet above the floor provide wall space for tool boards and wall displays, yet a few low windows are needed for an outside view."36 Willard M. Bateson recommended the following: height of window sill—four feet; window area in shop—approximately 25 per cent; height of window tops—ceiling height.37

Upon studying the aforementioned data, it was found that the majority of the sources recommended that the glass area in a laboratory should be 25 per cent of the floor area. The majority also stated that the height of the window sills should be seventy-two inches above the floor. With respect to the top of the window glass, one source recommended ninety-six inches above the floor, another source suggested ceiling height, and the third recommended that the window glass extend to within six inches of the ceiling.

Demonstration and/or Instructional Area

The demonstration and/or instructional area is used in assembling the class for group instruction and is one of the most important features of an industrial arts laboratory.

36Huss, op. cit., p. 63.
37Bateson, op. cit., pp. 36-37.
The California State Department of Education referred to this area as the "shop classroom or instructional area" and suggested the following:

All shop auxiliary rooms and areas should be planned along with the rest of the shop.

A shop classroom of 480 square feet (20 by 24 feet) is large enough for most shops. For an instructional space in the open shop area, 12 by 18 feet should suffice. . . .

If instructional space in the open shop area is used instead of a classroom, it should be provided with a teacher's desk, chalkboard, necessary seating, and cabinets for storage of instructional materials. 38

For an instructional and planning area, Indiana State Department of Public Instruction recommended a minimum of 450 square feet for junior high school and senior high school industrial arts programs. 39 Recommendations from Florida State Department of Education were that "a small shop planning room or equipped instructional space in the open shop area is highly desirable for planning, instruction, and related studies. If a classroom is feasible, 360 square feet (15 x 24) is large enough for most shops." 40 Huss suggested, if applicable, 400 square feet as a minimum, 450 square feet as adequate, and 500 square feet as desirable

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38California State Department of Education, op. cit., p. 4.

39Indiana State Department of Public Instruction, op. cit., p. 46.

40Florida State Department of Education, op. cit., p. 12.
for a separate classroom or planning area.\textsuperscript{41} West Virginia Department of Education referred to this area as the "planning-conference room and instructor's office," and recommended that these areas may be planned as separate areas and that the size may vary from 125 to 500 square feet.\textsuperscript{42}

A study of the above-mentioned recommendations and suggestions revealed 450 and 500 square feet as the most frequently occurring figures. The figure "450" was suggested by two sources, of which one was a minimum figure and the other was recommended as adequate square footage for this area. The figure "500" was recommended twice as being the desirable square footage for a demonstration and/or instructional area.

Upon averaging the square footage according to its respective classifications, i.e., minimum, adequate, and desirable, the following space allocations were found to be 325 as a minimum, 430 as adequate, and 500 as the desirable number of square feet of floor area to be provided for a demonstration and/or instructional area.

\textbf{Exits and Outside Doors}

A study of the literature pertaining to exits and outside doors revealed varying opinions with respect to the

\begin{footnotesize}
\begin{enumerate}
\item Huss, \textit{op. cit.}, p. 59.
\item West Virginia Department of Education, \textit{op. cit.}, p. 39.
\end{enumerate}
\end{footnotesize}
type and width of doors. However, there was agreement with respect to the number of exits. The general consensus was that at least two exit doors should be provided in all laboratories.

West Virginia Department of Education suggested that the door to the corridor should be a minimum of forty-eight inches wide and that an overhead door should be provided to the service drive.\textsuperscript{43} Indiana State Department of Public Instruction recommended that "two three-foot doors with a removable center mullion should be provided as a service entrance. Overhead doors are not recommended."\textsuperscript{44} The Industrial Arts Consultant for the State of Georgia recommended that the width of the corridor door to the laboratory be sixty inches. Provisions for a service door, eight to ten feet wide of the overhead or hinged double door type,\textsuperscript{45} was also recommended. Bateson recommended that the width of the corridor door to the laboratory be sixty inches, the width of the service door to the laboratory be ninety-six inches, and that the service door be of the overhead type.\textsuperscript{46}

\textsuperscript{43}Ibid., p. 38.
\textsuperscript{44}Indiana State Department of Public Instruction, \textit{op. cit.}, p. 40.
\textsuperscript{46}Bateson, \textit{op. cit.}, p. 36.
In the publication from Illinois, the following specifications were recommended:

All student traffic doors should be at least thirty (30) inches wide. . . . Each laboratory to be used for woodworking . . . should be provided with two outside doors (30-36 inches wide) closing together with removable mullion to provide space for bringing in machines and materials and for removing large projects. 47

New York State Education Department suggested the following:

Inside doors--Generally, one inside entrance is sufficient if an outside entrance is provided. If there is no outside entrance, two inside doors are necessary in large shops. At least one should be sufficiently wide, usually five feet, to admit large equipment and supplies. Inside doors should be located at least seven feet from the corners of the room to permit maximum flexibility in the use of the space along the adjacent wall.

Outside entrance--An outside entrance must be provided for shops in which automobiles, boats and other large items are to be admitted. The outside doorway should be at least eight feet wide and located not less than seven feet from the corner of the shop, preferably on the long side. An overhead type door is usually desirable for such an opening. 48

Mississippi State Department of Education recommended the following:

Generally, one inside entrance is sufficient if an outside entrance is provided. If there is no outside entrance, two inside doors are necessary in large shops. At least one should be sufficiently wide to admit large equipment and supplies. An outside entrance should be provided for shops. The outside doorway should be at

47Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 10.

48New York State Education Department, op. cit., p. 14.
least ten feet wide and located not less than seven feet from the corner of the shop, preferably on the long side. An overhead type door is usually desirable for such an opening. In addition to this there should be one regular size outside door.49

The aforementioned sources agreed that two exits should be provided for all laboratories. The majority of the sources suggested doors sixty inches wide for an inside entrance and from eight to ten-foot doors for an outside entrance. Opinions varied with respect to the type of door to be used for an outside entrance. However, the overhead type or the hinged double door type with a removable center mullion was the most frequently occurring recommendation.

Teacher's Office and Conference Room

When planning industrial arts laboratories, a teacher's office and conference room should be considered. Teachers need a private room for the storage of personal belongings, records, and supply and equipment catalogs. They also need this area for studying and holding conferences with students and other persons.

Brant stated, "The instructor's area should be located near the entrance of the shop. The instructor's office should have a desk, chairs, and file cabinet. It should be enclosed by clear glass windows. . . . There should be a

wardrobe locker for the instructor's use." Bateson recommended that the space for the instructor's area be approximately fifty-five square feet and that it should be located near the shop entrance.

In a book by Rockwell Manufacturing Company, fifty-five square feet were recommended as the minimum space requirement for the office area. The California State Department of Education only suggested that consideration be given to classrooms and/or conference rooms and teacher's office when planning industrial arts laboratories. Georgia State Department of Education, in answering some questions for critique for general shop organization, recommended 120 square feet for an office.

Emanuel E. Ericson stated, "Whether the teacher wishes to use a separate office or have a desk in the shop might be a matter of local preference. The size of an office, particularly for a shop where some supplies and special tools

50Brant, op. cit., p. 38.
51Bateson, op. cit., p. 37.
54Georgia State Department of Education, "Questions for Critique for General Shop Organization" (Atlanta, no date given), p. 13. (Mimeographed.)
are likely to be taken care of, should not be less than 8 feet square." Huss recommended 125 square feet as a minimum, 150 square feet as adequate, and 175 square feet as desirable for an office, if applicable.56

Upon studying the above recommendations, it was noted that the sources recommending area in square feet referred to office space only. The suggested square footage for an office ranged from 55 square feet as a minimum to 175 square feet as desirable. An average of the aforementioned data revealed 75 square feet as the minimum, 135 square feet as adequate, and 175 square feet as desirable square footage for a teacher's office and conference room. However, since the aforementioned recommendations were so diversified and since an office is also to be used as a conference room, which requires more space, it is indicative that when planning a teacher's office and conference room, 100 square feet should be considered as a minimum, 125 square feet as adequate, and 150 square feet as desirable.

Storage Space for Materials and Supplies

Each laboratory should have adequate space for the storage of materials and supplies. The supply or storage

56Huss, op. cit., p. 59.
room should be large enough to accommodate the storing of heavy or bulky materials and should be located, if possible, to facilitate easy unloading from delivery trucks.

Bateson\(^57\) and Brant\(^58\) recommended approximately 1000 cubic feet of storage space for materials and supplies, and John L. Feirer stated that the lumber room should be about 10 by 18 feet.\(^59\) With respect to material storage, Gordon O. Wilber suggested, "A minimum of from 5 to 15 per cent of the area of the shop proper is not unreasonable and for certain types of work should even run higher."\(^60\) The Industrial Arts Consultants for the State of Georgia suggested a minimum of 350 square feet for tools, supply, and material storage space,\(^61\) and Florida State Department of Education recommended that a minimum of 300 square feet be provided for a material storage room.\(^62\) The book from Rockwell Manufacturing Company, with respect to the material storage

\(^57\)Bateson, op. cit., p. 37.
\(^58\)Brant, op. cit., p. 37.
\(^62\)Florida State Department of Education, op. cit., p. 11.
area, contained the suggestion that "this facility should measure at least 10 x 20 feet." 63

Upon examination of the preceding data, it was noted that terms used in the recommendations were cubic feet, square feet, per cent, and room size. Each of these terms appeared twice with the exception of per cent, which was suggested only once. By converting these terms into square feet, calculations could be made with respect to storage space for materials and supplies.

The aforementioned recommendations in square feet ranged from minimums of approximately 100 square feet to 350 square feet. Upon consideration of all calculated recommendations, it was found that the average minimum storage space for materials and supplies was 230 square feet. By using this calculation, the minimum square footage for materials and supplies would be 225 square feet, 275 square feet should be adequate, and 325 square feet should be considered desirable.

Storage Space for Students' Projects and Personal Belongings

The allocation of storage space for students' projects and personal belongings is an important problem to consider when planning industrial arts laboratories.

63 Rockwell Manufacturing Company, op. cit., p. 18.
Arthur B. Mays and others, in a book entitled *Modern School Shop Planning*, and Bateson suggested that approximately 200 cubic feet should be devoted to the storage of pupils' property—small projects, aprons, etc. Further suggestions were that approximately 300 cubic feet of space should be devoted to large project storage. Brant stated, "Satisfactory size for student lockers is 18 by 18 by 18 inches. . . . There should be about 300 cubic feet of storage space for large project storage." Feirer recommended the following:

Student storage for project parts, aprons, and other personal items.—The average shop must have project storage for about 120 to 150 students. The ideal situation is for each student to have an individual locker. . . . In the average junior-high school, the parts that go to make up most of the projects can be stored conveniently in a 10" x 12" x 20" locker, but for senior-high school shops some larger lockers should be added.

Indiana State Department of Public Instruction recommended 150 square feet of project storage space for both junior high and senior high schools. In the check list of

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65 Bateson, *op. cit.*, pp. 36-37.


67 Feirer, *op. cit.*, pp. 174-175.

68 Indiana State Department of Public Instruction, *op. cit.*, p. 46.
standards supplied by the Industrial Arts Consultants for the State of Georgia, it was suggested that approximately 240 cubic feet be provided for individual student locker space for pupil property (small projects, aprons, etc.). Recommendations contained in the publication from the State of Florida were as follows:

Project storage for each junior high school student, if located in or below benches should provide a compartment of at least two cubic feet plus one other area for safe storage of some large completed projects. A total of 300 square feet of storage room floor space is needed for regular day classes.\(^7^0\)

Huss recommended 250 square feet as a minimum, 275 square feet as adequate, and 300 square feet as desirable storage space for the junior high school general woodworking laboratory. For the senior high school general woodworking laboratory he recommended 275 square feet as a minimum, 300 square feet as adequate, and 325 square feet as desirable.\(^7^1\)

Upon studying the aforementioned data, it was found that recommendations in terms of cubic feet were the most frequently used. However, it is obvious that when lockers and shelves are installed, floor space is utilized. If shelves for storage space are suspended above floor level,


\(^7^0\)Florida State Department of Education, op. cit., p. 12.

\(^7^1\)Huss, op. cit., p. 59.
improvisations, such as ladders, have to be used to place or remove the projects. This creates a safety hazard and also increases the chance of damaging the projects. Therefore, upon consideration of these facts, the recommendations for storage space for students' projects and personal belongings will be stated in square feet.

Based upon Feirer's recommendation of providing project storage for about 120 to 150 students, calculations for locker space were made. These calculations indicated that from 75 to 100 square feet of floor space should be provided for lockers. This would be adequate for the storage of pupils' property (small projects, aprons, etc.). For the storage of large projects, it was found that space allocations would be 200 square feet as a minimum, 225 square feet as adequate, and 250 square feet as desirable.

Financial and Assembling Facilities and Glue Room

Adequate floor space should be provided for assembling, gluing, and finishing projects. The assembly and glue room may be combined; however, it should join the finishing room. The finishing room should be a separate dustproof room with an adequate exhaust system.

Florida State Department of Education suggested the following with respect to finishing and assembling:

72Feirer, op. cit., p. 174.
A finishing room free from dust and well ventilated with fireproof storage for finishing materials and shelving and benches for wet projects is essential. One hundred fifty square feet is a minimum for a finishing room. Forced ventilating facilities, fire resistant construction, and explosion-proof electrical devices are recommended.

An adequate area should be allocated in each comprehensive general shop, wood shop, and other shops requiring space for project assembly. A 10' x 15' open space is adequate. The Industrial Arts Consultants for the State of Georgia suggested that approximately 5 per cent of the total laboratory area be devoted to a finishing room, while Indiana State Department of Public Instruction recommended 150 square feet for both junior high and high schools' finishing rooms. West Virginia Department of Education recommended that the size of the finishing area may vary from 100 to 200 square feet and that this area be for a capacity of from four to six pupils.

Bateson and Mays and others recommended that approximately 10 per cent of the laboratory be available for

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75Indiana State Department of Public Instruction, op. cit., p. 46.

76West Virginia Department of Education, op. cit., p. 38.

77Bateson, op. cit., pp. 36-37.

78Mays and others, op. cit., p. 172.
an assembly area and that approximately 5 per cent of the total laboratory area be allotted for a finishing room. Mays and others further suggested that "the finishing room should be at least 9' x 12'." 79

Huss recommended 125 square feet as a minimum, 150 square feet as adequate, and 175 square feet as desirable for a finishing room in a senior high general woodworking laboratory. He recommended 100 square feet, 125 square feet, and 150 square feet for a junior high general woodworking laboratory. 80

Upon studying the above suggestions, it was found that the average square footage for each of these facilities was 150. However, when viewing the recommendations given in percentage of the total laboratory area, it was noted that the finishing room was allotted only half as much as the assembling room.

Based upon the above findings, it was believed that two sets of standards would be apropos for this section. For the finishing room it was found that 125 square feet would be the minimum, 150 square feet would be considered adequate, and 175 square feet would be the desirable space allocations. For the assembling and gluing room it was discovered that

79 Ibid., p. 169.
80 Huss, op. cit., p. 59.
the space to be provided would be 150 square feet as a minimum, 175 square feet as adequate, and 200 square feet as desirable.

**Library and Planning Area**

A library and planning area should be an integral part of any industrial arts laboratory. Therefore, a suitable area should be provided so that students may plan, investigate, search, and study to achieve the intent of the industrial arts course. Bateson suggested that approximately 10 to 15 per cent of the laboratory area should be provided for a planning center,\(^81\) while Huss stated:

> The type of work done in the planning area requires the use of reference materials by students and instructor. Reference materials should be housed in enclosed bookcases and shelves, and filing cabinets for easy access of plans and drawings are essential. A reading table is needed for student research and small group conferences. Small drafting tables or their equivalent should be provided. Other useful pieces of equipment for this area are tracing boxes and an opaque projector for enlarging well-designed magazine plans and drawings. In many of the newer plans the library and planning are incorporated with the teacher's office and is glass enclosed.\(^82\)

Huss further suggested that, if applicable, 400 square feet should be the minimum, 450 square feet should be adequate, and 500 square feet should be desirable for a separate classroom or planning area.\(^83\)

\(^{81}\)Bateson, *op. cit.*, p. 37.

\(^{82}\)Huss, *op. cit.*, p. 55.

\(^{83}\)Ibid., p. 59.
of Education suggested that 200 square feet be provided for a general laboratory planning area and recommended the following:

A small shop planning room or equipped instructional space in the open shop area is highly desirable for planning, instruction, and related studies. If a classroom is feasible, 360 square feet (15 x 24) is large enough for most shops. This may be equipped for the use of visual aids as well as the teacher's desk, chairs, and tables, chalkboard, tack board, shelves for books and cabinet for instructional materials.84

Indiana State Department of Public Instruction suggested the following:

The drafting-planning room . . . usually contains the industrial arts library materials, and serves as a planning room, classroom, and the teacher's office. . . . Separate drafting rooms and planning rooms should be provided when the enrollment is sufficient to utilize the drafting room for drafting classes only.85

Indiana State Department of Public Instruction further suggested that the instructing and planning area be 450 square feet for junior and senior high schools.86 In the book from Rockwell Manufacturing Company, it was recommended that up to 10 per cent of the total floor area be allotted for a planning center.87 California State Department of Education suggested the following:

84Florida State Department of Education, op. cit., pp. 8, 12.
85Indiana State Department of Public Instruction, op. cit., p. 42.
86Ibid., p. 46.
87Rockwell Manufacturing Company, op. cit., p. 20.
A small shop classroom is a highly desirable adjunct to most shops for planning, drafting, and related studies. A specially equipped space in the open shop area or a nearby standard classroom may be used for this purpose.

A shop classroom of 480 square feet (20 by 24 feet) is large enough for most shops. For an instructional space in the open shop area, 12 by 18 feet should suffice.

The shop classroom should be equipped with a teacher's desk, necessary chairs and tables, adequate chalkboard and tack board, shelving for books, and cabinets for storage of instructional material. The room should be acoustically treated.88

Upon studying the recommendations pertaining to a library and planning area, it was found that most of the recommendations referred to a classroom or instructional area with a library and planning area incorporated in the same room.

When the recommended amounts of square feet were averaged, it was found that the minimum square feet for a planning area was 270 square feet, and 423 square feet was the minimum for a classroom or instructional area and planning area. Based upon these findings, it was determined that a library and planning area incorporated with the classroom or instructional area should contain 400 square feet as a minimum, 450 square feet would be adequate, and 500 square feet considered as desirable.

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88California State Department of Education, op. cit., p. 4.
Display Area

An important consideration when planning an industrial arts laboratory is the displaying of students' projects. By displaying these projects, the rest of the school can observe the type of work being done in industrial arts. Displays also may be an incentive or may stimulate students to do better work. Bateson and the Industrial Arts Consultants for the State of Georgia recommended that a space with approximately thirty cubic feet be allotted for a display area. New York State Education Department stated:

> It is suggested that shops be provided with a recessed display case, equipped with doors and indirect lighting fixtures. A satisfactory location for this case is in a corridor wall near the inside door. It is also good practice to provide a display case for the industrial arts department in a main corridor or foyer of the building.

In addition to the display cases in the corridor described on page 14, each shop should have panels and shelves on the walls for exhibiting pupil or teacher-made articles and illustrative material. These units may be placed in or near each industrial section or work center in the shop.

Bulletin 180 from the State of Illinois contained the following recommendation:

> A generously sized display case should be provided for each department.

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89 Bateson, op. cit., p. 36.


91 New York State Education Department, op. cit., pp. 14, 26.
Two display cases may be needed for a series of laboratories.
A public corridor near the industrial arts department is a good location for the display case.
Display cases should be recessed in walls with back opening into the laboratory or classroom.
Each display case should be lighted with indirect lighting fixtures.92

Ohio State Department of Education suggested:

The cases should be provided for the display of pupil's work. These should have glass fronts, illumination, and shelves. They can be located at the entrance to the shop or in a corridor adjacent to the shop.
Additional exhibit space can be provided by placing shelves in strategic spots on the walls about the laboratory. These should be wide enough to take care of large projects which will not go in the display case.93

Mississippi State Department of Education recommended:

It is suggested that shops be provided with a recessed display case, equipped with doors and indirect lighting fixtures. A satisfactory location for this case is in the wall near the outside classroom entrance. It is also good practice to provide a display case for the Industrial Arts Department in a prominent place in the main school building.94

After examining the above recommendations, it was found that two of the sources recommended thirty cubic feet of space for a display area. Other quoted sources suggested that display cases should be provided; however, they did not

92 Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 14.
94 Mississippi State Department of Education, op. cit., p. 25.
give recommendations with respect to space allocations in terms of cubic or square feet. The general consensus was that one display case per laboratory be provided and that at least one display case be provided in a main corridor of the school building.

Toilet Facilities

Toilet facilities should be provided in the laboratory or in close proximity to it with a lavatory and drinking fountain in each laboratory, according to Mays and others.\textsuperscript{95} Ohio State Department of Education suggested that toilet facilities be provided in connection with the laboratory when not accessible nearby,\textsuperscript{96} while California State Department of Education recommended that "toilet facilities for all shops should be located at a central point in the shop building."\textsuperscript{97}

Florida State Department of Education suggested, "Toilet facilities for all shops should be located at a central point or be readily available to day students and adult evening classes.\textsuperscript{98} Recommendations from Maine State

\textsuperscript{95}Mays and others, \textit{op. cit.}, p. 15.

\textsuperscript{96}Ohio State Department of Education, \textit{op. cit.}, p. 7.

\textsuperscript{97}California State Department of Education, \textit{op. cit.}, p. 4.

\textsuperscript{98}Florida State Department of Education, \textit{op. cit.}, p. 11.
Department of Education were that "a toilet facility should be located in the shop or in close proximity and should include one urinal, one flush and one electric hand dryer."\textsuperscript{99}

Georgia State Department of Education suggested that 150 square feet be allotted for a lavatory in a general unit laboratory,\textsuperscript{100} while West Virginia Department of Education suggested, "Toilets--should be included in the industrial arts complex unless general toilets are immediately accessible, in which case only hand washing facilities are necessary."\textsuperscript{101} West Virginia Department of Education further suggested that 50 to 100 square feet be allotted and that the toilet facilities should be for a capacity of from three to four pupils.\textsuperscript{102}

A study of the above recommendations revealed that only two of the quoted sources recommended that a specific number of square feet of space be provided for toilet facilities. These recommendations ranged from 50 to 150 square feet.

\textsuperscript{99}Maine State Department of Education, \textit{op. cit.}, p. 16.

\textsuperscript{100}Georgia State Department of Education, "Questions for Critique," p. 13.

\textsuperscript{101}West Virginia Department of Education, \textit{op. cit.}, p. 41.

\textsuperscript{102}Ibid.
Equipment Storage (Tools, Auxiliary Machine Parts, etc.)

When planning industrial arts facilities, an area for the storage of equipment (tools, auxiliary machine parts, etc.) should be considered. With respect to equipment storage, Bateson recommended approximately 300 cubic feet of space be allotted for equipment storage (tools, auxiliary machine parts, etc.). New York State Education Department recommended the following:

Provision should be made in each shop for storing supplies and equipment. Recessed wooden cabinets, with adjustable shelves, are desirable. However steel cabinets which can be moved may be used for the same purpose if flexibility is a major consideration. Cabinets for storage of paints and other inflammable materials such as gasoline or benzene should be made of metal or some other fireproof material. Cabinets and drawers under benches or work counters provide additional storage facilities. This method economizes on floor space and adds to the utility and general appearance of the shop.

Panels, mounted on the wall, are recommended for hand tool storage. A panel, approximately 32 square feet in area, should be provided for storing tools commonly used in various industrial sections of the shop. This panel should be readily accessible to all sections. A smaller panel for special tools may be located in each work center.

Florida State Department of Education suggested the following:

Storage panels on the wall for the tools used in each area of work should have doors and locks. Each

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103Bateson, op. cit., p. 37.

104New York State Education Department, op. cit., pp. 19, 25.
shop will require at least 100 square feet of panel space. For large portable tools a bench cabinet or supply room space with locks should be provided.105

Upon studying the above suggestions, it was noted that the recommendations were very diversified. After calculating the cubic feet into square feet, it was found that from 50 to 60 square feet would be needed for the storage of equipment. By averaging the recommendations using the calculated square feet instead of cubic feet, it was found that 50 square feet would be the minimum, 75 square feet would be adequate, and 100 square feet would be desirable for equipment storage space.

Metalworking Area

Upon gathering data pertaining to space requirements for the area of metalworking, it was noted that only slight variations existed between this area and the woodworking area. Although variations existed, the results, with respect to space to be provided for each area, remained the same. Therefore, recommended space requirements for the area of metalworking will be the same as the space requirements for the area of woodworking, and will be presented in the form of a check list in a later portion of this study.

Although the requirements for metalworking will be the same as those for woodworking, it was deemed necessary to

point out in this section the sources that recommended the amount of square feet of space for woodworking, but not for metalworking, and the sources that presented varying space recommendations.

With respect to the number of square feet of floor area per student, height of ceiling, windows and window area, demonstration and/or instructional area, exits and outside doors, teacher's office and conference room, storage space for materials and supplies, library and planning area, display area, toilet facilities, and equipment storage (tools, auxiliary machine parts, etc.), all recommendations were verbatim.

Variations occurred in only two areas in the sources used, and they are as follows:

**Storage Space for Students' Projects and Personal Belongings**

Sources which presented recommendations, with respect to storage space for students' projects and personal belongings, for the woodworking area and failed to do so for the metalworking area were Feirer and Mays and others.

The sources presenting varying space recommendations were the following: Indiana State Department of Public Instruction recommended that a minimum of 125 square feet be

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^106^Feirer, *op. cit.*, pp. 174-175.

allotted for project storage in the general metals laboratory,\textsuperscript{108} while Huss recommended 200 square feet as a minimum, 225 square feet as adequate, and 250 square feet as desirable for storage space in the junior high general metals laboratory, and for the senior high general metals laboratory, 225 square feet as a minimum, 300 square feet as adequate, and 325 square feet as desirable.\textsuperscript{109}

The above-mentioned sources recommended less square footage for the area of metalworking than that of woodworking; however, since the variations were small, the results, as previously stated, remained constant.

\textbf{Finishing and Assembling Facilities}

Mays and others, in the publication \textit{Modern School Shop Planning},\textsuperscript{110} gave no recommendations regarding the finishing and assembling facilities for the area of metalworking. Indiana State Department of Public Instruction recommended that "when two or more General Industrial Arts Laboratories are planned, only those including instruction in woods are required to have a finishing laboratory."\textsuperscript{111} Huss recommended

\textsuperscript{108}Indiana State Department of Public Instruction, \textit{op. cit.}, p. 46.
\textsuperscript{109}Huss, \textit{op. cit.}, p. 59.
\textsuperscript{110}Ibid., pp. 156-166.
\textsuperscript{111}Indiana State Department of Public Instruction, \textit{op. cit.}, p. 47.
the same amount of square footage for both metal and wood. However, for the area of wood he suggested this space for a finishing room, and in the area of metal he suggested the space for a finishing room or project storage.\textsuperscript{112}

Since the above-mentioned recommendations are of little or no consequence to the overall space requirements, it was indicated that when providing space for a metalworking laboratory, the requirements would be the same as those for the area of woodworking, which were presented in an earlier section of this study.

\textbf{Drafting Area}

A study of the recommendations for the drafting area concerning space requirements revealed a number of variations. The only area which remained constant was toilet facilities. Space requirements which varied from those for the woodworking area will be treated separately for the drafting area.

\textbf{Square Feet of Floor Area per Student}

A study of the data pertaining to square feet of floor area to be provided per student in the drafting area revealed that the recommendations ranged from a minimum of approximately 26 square feet to a maximum of 125 square feet per student.

\textsuperscript{112}Huss, \textit{op. cit.}, p. 59.
Since the drawing area is considered as a light laboratory, i.e., activities performed are light in nature and do not require heavy or bulky equipment, the majority of the sources agreed that the drawing area may require less square footage per student than other industrial arts laboratories. For the drafting area Illinois Board of Vocational Education and Rehabilitation suggested 40 to 50 square feet per student, plus auxiliary areas, and Bateson recommended a minimum of 55 square feet per pupil.

Kentucky State Department of Education suggested, "Seventy-five square feet per pupil is usually regarded as the minimum. Some, such as drawing, may require less." West Virginia Department of Education recommended a minimum of 900 square feet and a capacity of approximately thirty-five pupils. After calculating the total square footage into square feet per pupil, it was found that this would be approximately 26 square feet per pupil for a drawing area.

Georgia State Department of Education suggested a minimum of 35 square feet per pupil be provided for a

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113Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 7.

114Bateson, op. cit., p. 36.

115Kentucky State Department of Education, op. cit., p. 35.

drafting room. In the "Questions for Critique" supplied by the Georgia State Department of Education, a minimum of 50 square feet per student was recommended for light work areas. California State Department of Education, based on a class size of thirty students, recommended 50 square feet as a minimum, 75 square feet as adequate, and 100 square feet as the desirable amount of space to be allotted for a drafting room.

Indiana State Department of Public Instruction suggested a minimum of 1100 square feet for a drafting area usually designed to accommodate twenty-four drafting stations. This would be approximately 45 square feet per pupil. Florida State Department of Education recommended that 1200 square feet be provided for a drafting room. Based on a class size of twenty-four students, it was found that this would be 50 square feet per student.

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119 California State Department of Education, op. cit., p. 2.

120 Indiana State Department of Public Instruction, op. cit., pp. 42, 46.

Huss suggested 50 square feet as a minimum, 75 square feet as adequate, and 100 square feet as desirable per student for a junior high drafting room. For the senior high drafting room he suggested 75 square feet as a minimum, 100 square feet as adequate, and 125 square feet as desirable per student.122

Upon studying the aforementioned recommendations and suggestions, it was found that most of the sources recommended space allocations in close proximity to 50 square feet per student. Since these recommendations were the minimum amount of square feet per pupil to be provided for a drafting room, it was discovered that 50 square feet would be a minimum, 75 square feet would be adequate, and 100 square feet would be desirable square footage per pupil for this area.

**Height of Ceiling**

The ceiling height for the area of drafting when compared to the ceiling height for the area of woodworking disclosed two variations. Illinois Board of Vocational Education and Rehabilitation suggested a minimum height of nine feet for ceilings in the drafting room,123 and

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123Illinois Board of Vocational Education and Rehabilitation, *op. cit.*, p. 8.
Mississippi State Department of Education recommended that classroom ceilings should be ten feet.\textsuperscript{124} All other recommendations were the same. However, it should be noted that the majority of these recommendations were suggested as the minimum ceiling heights with additional height for the storage of materials or for the handling of long materials.

After considering the above-mentioned variations and reviewing the recommendations in the area of woodworking, it was noted that the end results were the same, thereby making the ceiling height for a drafting room a minimum of twelve feet.

\textbf{Windows and Window Area}

A study of the recommendations in the area of woodworking relating to windows and window area indicated that the drafting area should be planned using the same space allocations. However, an examination of the data revealed that recommendations with respect to window sill height were seventy-two inches above the floor to provide wall space for tool boards, wall displays, and to prevent window breakage.

Based upon the above, it was found that space allocation for windows and window area for the area of drafting should vary from those of woodworking in one respect. Since the

\textsuperscript{124}Mississippi State Department of Education, \textit{op. cit.}, p. 22.
drafting area is considered a light laboratory, additional wall space for tool boards and wall displays will not be needed. Since the drafting area is also considered a classroom rather than a laboratory, i.e., in contrast to woodworking, metalworking, etc., the window sills do not need to be seventy-two inches high.

Based upon the above considerations and the recommendations for the area of woodworking, the window sill height for a drafting room should be from thirty-six to forty-two inches above the floor. Other recommendations for the area of drafting should be the same as those for the area of woodworking, thereby making the space allocation for windows and window area in a drafting room as follows: the glass area should be 25 per cent of the floor area; the height of the window sills should be from thirty-six to forty-two inches above the floor; and the top of the window glass should be ceiling height or within six inches of the ceiling.

**Exits and Outside Doors**

Upon examining the data gathered for the area of woodworking, it was found that the majority of the sources suggested doors sixty inches wide for an inside entrance. However, these recommendations were for laboratories which require doors sufficiently wide to admit large equipment, supplies, and projects. Since the drafting room is considered
a light work area and does not require heavy or bulky materials, "all student traffic doors should be at least thirty (30) inches wide," as suggested in Bulletin 180 from the Illinois Board of Vocational Education and Rehabilitation.

Teacher's Office and/or Conference Room

An examination of the data for the area of woodworking revealed that the space to be provided for a teacher's office and/or conference room should contain 100 square feet as a minimum, 125 square feet would be adequate, and 150 square feet desirable. Since this area would remain constant for all laboratories, the same provisions should be made for the drafting area, if applicable.

Storage Space for Materials and Supplies

Upon studying the recommendations presented in the woodworking area, it was found that the recommendations were general in nature; however, indications were toward the heavy work areas. Two recommendations specifically for the area of drafting were as follows: Huss suggested that the storage space for a drafting area be 100 square feet as a minimum, 125 square feet as adequate, and 150 square feet as desirable for a junior high school. For the senior high school he suggested 150 square feet as a minimum, 175 square feet as

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125 Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 10.
feet as adequate, and 200 square feet as desirable.\textsuperscript{126} It should be noted that this is the total storage space to be provided for a drafting area. Illinois Board of Vocational Education and Rehabilitation suggested that a supply room six feet by six feet be provided for the drafting area.\textsuperscript{127}

**Storage Space for Students' Personal Belongings**

Due to the activities performed in the drafting area, individual student lockers, such as those provided for the storage of small projects and personal belongings in the woodworking area, would not be applicable. However, space for students' books, coats, and hats should be provided.

**Blueprint or Reproduction Room**

To assimilate industry, reproduction machines housed in a separate room, but adjoining the drafting room, should be provided. Huss referred to this area as the blueprint or ozalid room, and suggested 125 square feet as a minimum, 150 square feet as adequate, and 175 square feet as desirable for a senior high school.\textsuperscript{128} In the publication from the State of California,\textsuperscript{129} as well as in the one from the State

\textsuperscript{126}Huss, op. cit., p. 58.

\textsuperscript{127}Illinois Board of Vocational Education and Rehabilitation, op. cit., no page number given.

\textsuperscript{128}Huss, op. cit., p. 58.

\textsuperscript{129}California State Department of Education, op. cit., p. 14.
of Illinois,\textsuperscript{130} it was recommended that space be provided for a blueprint room; however, the recommendations differed with respect to room size. California State Department of Education suggested a room size of eleven feet by fourteen feet,\textsuperscript{131} while Illinois Board of Vocational Education and Rehabilitation suggested the size of the room be seven feet six inches by twelve feet.\textsuperscript{132}

Upon calculating the above-mentioned room sizes, it was found that they were 154 square feet and 90 square feet, respectively. Based upon these and other recommendations, it was found that the space to be provided for a blueprint or reproduction room should contain 125 square feet as a minimum, 150 square feet would be adequate, and 175 square feet should be considered desirable.

\textbf{Display Area}

The recommendations with respect to display areas were found to be the same for all laboratories. Therefore, space to be provided for a display area in the area of drawing should be the same as those suggested for the area of woodworking.

\textsuperscript{130}Illinois Board of Vocational Education and Rehabilitation, \textit{op. cit.}, no page number given.

\textsuperscript{131}California State Department of Education, \textit{op. cit.}, p. 14.

\textsuperscript{132}Illinois Board of Vocational Education and Rehabilitation, \textit{op. cit.}, no page number given.
Power Mechanics Area

Recommendations presented in the woodworking section of this chapter, which remain constant for most laboratories and will be the same for the power mechanics area, are windows and window area, demonstration and/or instructional area, teacher's office and conference room, library and planning area, display area, and toilet facilities. Space requirements which differed from the woodworking area are as follows:

**Square Feet of Floor Area per Student**

Literature in the area of power mechanics indicated that more space should be provided per student due to the nature of the activities to be performed. California State Department of Education, based on a class size of twenty-four students, suggested, "In auto mechanics and auto essentials shops, due to the space required for automobiles that are being worked on, the open shop areas exceed 2400 square feet."\(^{133}\) Florida State Department of Education suggested that a power mechanics unit laboratory be an average of 2400 square feet for a class size of twenty-four students.\(^ {134}\)

\(^{133}\)California State Department of Education, *op. cit.*, p. 2.

Georgia State Department of Education recommended that the "auto shops require a minimum of 100 square feet per student." 135 Recommendations contained in Bulletin 180 from the State of Illinois were "100-130 square feet per student, plus auxiliary areas." 136 Maine State Department of Education, based on a total school enrollment of 750 to 1000 students, suggested that the power and transportation industries laboratory be forty feet by seventy-five feet or 3000 square feet plus auxiliary rooms. 137

Joseph D. Lunday recommended that eighty feet by forty-three feet be provided for a power mechanics laboratory based on a class size of from twenty-five to thirty-one students. 138 Huss suggested 75 square feet as a minimum, 100 square feet as adequate, and 125 square feet as desirable for a junior high school power mechanics laboratory, and 100 square feet as a minimum, 125 square feet as adequate, and 150 square feet as desirable for a senior high school auto mechanics laboratory. 139

136 Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 7.
137 Maine State Department of Education, op. cit., p. 22.
139 Huss, op. cit., p. 58.
After studying the preceding data, it was found that five of the eight sources recommended 100 square feet per student as the minimum for planning a power mechanics laboratory. Other recommendations ranged from 75 square feet to approximately 138 square feet. Based upon 100 square feet per student as a minimum, then 125 square feet should be adequate, and 150 square feet desirable when planning a power mechanics laboratory.

**Height of Ceiling**

Upon studying the literature pertaining to ceiling height, it was found that the recommendations for the area of power mechanics were the same as those for woodworking. Although these recommendations, with respect to the stated ceiling height, were the same, it should be noted that in the publications from the States of Maine\(^{140}\) and New York\(^{141}\) it was suggested that if auto lifts were to be installed in the power mechanics laboratory, the manufacturer of the lift should be consulted to ascertain if additional ceiling height should be provided.

**Exits and Outside Doors**

As derived in the woodworking area, recommendations for exits and outside doors remained constant for all heavy work.


\(^{141}\)New York State Education Department, *op. cit.*, p. 9.
areas. Recommendations contained in the publications from the States of New York\textsuperscript{142} and Illinois\textsuperscript{143} were that eight-foot doors of the overhead type be provided for an outside entrance for the power mechanics or auto mechanics laboratories. However, since these suggestions agree with previous recommendations, provisions for exits and outside doors remain the same as those for the area of woodworking. It should be noted that the power mechanics laboratory would require the overhead type door for an outside entrance.

\section*{Storage Space for Materials and Supplies}

Recommendations for storage space in the woodworking area were much the same as those studied for the power mechanics area; however, differences were noted. Brant\textsuperscript{144} Wilber,\textsuperscript{145} the Industrial Arts Consultants for the State of Georgia,\textsuperscript{146} Indiana State Department of Public Instruction,\textsuperscript{147} Florida State Department of Education,\textsuperscript{148} and New York State

\textsuperscript{142}Ibid., p. 14.

\textsuperscript{143}Illinois Board of Vocational Education and Rehabilitation, \textit{op. cit.}, p. 10.

\textsuperscript{144}Brant, \textit{op. cit.}, p. 37. \textsuperscript{145}Wilber, \textit{op. cit.}, p. 54.

\textsuperscript{146}Georgia State Industrial Arts Consultants' Office, "Check List of Standards," p. 2.

\textsuperscript{147}Indiana State Department of Public Instruction, \textit{op. cit.}, p. 46.

\textsuperscript{148}Florida State Department of Education, \textit{op. cit.}, p. 11.
Education Department\textsuperscript{149} recommended the same square footage for the power mechanics area as that for the woodworking area. However, Indiana State Department of Public Instruction\textsuperscript{150} was in agreement with New York State Education Department, who recommended that "additional space should be provided for storage of projects and materials either in or adjacent to certain shops such as . . . automotive mechanics."\textsuperscript{151} Other recommendations specifically for the power mechanics area were as follows: Lunday, in a recommended floor plan, suggested that the storage room be sixteen feet by thirteen feet.\textsuperscript{152} Huss suggested 175 square feet as a minimum, 200 square feet as adequate, and 225 square feet as desirable for junior high power mechanics. For senior high auto mechanics he recommended 200 square feet as a minimum, 225 square feet as adequate, and 250 square feet as desirable.\textsuperscript{153}

Upon studying the recommendations presented in the woodworking area and the above-mentioned suggestions, it was found that the average amount of square footage for power

\textsuperscript{149}New York State Education Department, \textit{op. cit.}, p. 7.
\textsuperscript{150}Indiana State Department of Public Instruction, \textit{op. cit.}, p. 46.
\textsuperscript{151}New York State Education Department, \textit{op. cit.}, p. 7.
\textsuperscript{152}Lunday, \textit{op. cit.}, p. 93.
\textsuperscript{153}Huss, \textit{op. cit.}, p. 58.
mechanics and the average amount for woodworking, with respect to materials and supplies storage space, differed by only three square feet. Based upon this finding, it was ascertained that storage space for materials and supplies in a power mechanics laboratory should be planned in accordance with the results presented in the woodworking area of this chapter.

**Storage Space for Students' Projects and Personal Belongings**

Since power mechanics is not an area where projects are built and constructed, only space allocations for students' lockers (storage for small parts, aprons, etc.) needs to be treated.

As found in the woodworking area, space to be provided for the storage of pupils' property was from 75 to 100 square feet. Some of the sources did not include power mechanics in their recommendations. However, those recommendations which included power mechanics were the same for all areas, thereby indicating that from 75 to 100 square feet of floor space should be provided for lockers in the power mechanics area.

**Equipment Storage (Tools, Auxiliary Machine Parts, etc.)**

A study of the literature pertaining to equipment storage produced recommendations from three sources. The
Florida State Department of Education suggested at least 100 square feet of panel space be provided for tools used in each area of work.\textsuperscript{154} Lunday suggested a tool room eight feet by sixteen feet.\textsuperscript{155} Edward V. Walters and Andrew D. Althonse stated, "Most automotive-mechanics teachers find that a tool room is necessary for storage of special tools and equipment. . . . The crib should be rectangular in shape, not less than 8' wide and 12' to 16' long. . . ."\textsuperscript{156}

Upon studying the above-mentioned suggestions, it was found that from 96 square feet to 120 square feet should be provided as the minimum amount of square footage for equipment storage. After averaging the square feet, it was found that the minimum square feet to be provided for equipment storage should be 109 square feet.

Electricity and Electronics Area

Recommendations presented in the woodworking section of this chapter were practically the same for most laboratories, and may be considered the same for the electricity and electronics area. They are as follows: height of ceiling, windows and window area, demonstration and/or instructional

\textsuperscript{154}Florida State Department of Education, \textit{op. cit.}, p. 12.

\textsuperscript{155}Lunday, \textit{op. cit.}, p. 93.

area, teacher's office and conference room, library and planning area, display area, toilet facilities, and equipment storage space. Additional space to be provided for special rooms will be treated in this section, and variations will be noted.

**Square Feet of Floor Area per Student**

A study of the literature in the electricity and electronics area with respect to the square feet of floor area to be provided per student was made. Upon comparing the data with the data gathered for the woodworking area, it was found that the space to be provided per student was the same with one exception. Illinois Board of Vocational Education and Rehabilitation recommended that sixty to eighty square feet per student, plus auxiliary areas, be provided for a general electricity course.\(^{157}\) This variation of twenty square feet per student did not alter the majority consensus of a minimum of seventy-five square feet per student; consequently, making the square feet of floor area to be provided per student in an electricity and electronics laboratory the same as the suggestions presented in the area of woodworking.

\(^{157}\)Illinois Board of Vocational Education and Rehabilitation, *op. cit.*, p. 7.
Exits and Outside Doors

An examination of the data for the area of woodworking revealed that doors sixty inches wide were suggested for an inside entrance. The recommendations presented for the drafting area were that doors thirty inches wide be provided for student traffic.

Since an electricity and electronics laboratory requires an entrance large enough to accommodate some relatively large pieces of equipment, but not as large as the equipment, supplies, and projects evidenced in the woodworking area, the door to the corridor should be a minimum of forty-eight inches wide, as suggested in the publication from the State of West Virginia.158

Storage Space for Materials and Supplies

The literature in the electricity and electronics area revealed that from 100 to 207 square feet should be provided for the storage of materials and supplies. Florida State Department of Education suggested that at least 100 square feet be provided for storage panels,159 while Illinois Board of Vocational Education and Rehabilitation recommended a room eleven feet six inches by eighteen feet be allocated.

158West Virginia Department of Education, op. cit., p. 38.

159Florida State Department of Education, op. cit., p. 12.
for a supply room.\textsuperscript{160} Indiana State Department of Public Instruction recommended 125 square feet for material storage.\textsuperscript{161}

Brant suggested that 1000 cubic feet be provided for the storage of supplies and materials.\textsuperscript{162} Huss suggested 100, 125, and 150 square feet, respectively, as minimum, adequate, and desirable for a junior high electricity laboratory. For a senior high electricity and radio laboratory he recommended 125, 150, and 175 square feet, respectively, as minimum, adequate, and desirable.\textsuperscript{163}

By converting room size and cubic feet into square feet, an average of 136 square feet was found to be the minimum square footage to be provided for the storage of materials and supplies in an electricity and electronics laboratory. Based upon this and other recommendations concerning the adequate and desirable amounts of square footage to be provided, the amount of space to be provided for the storage of materials and supplies in an electricity and electronics laboratory would be 125 square feet as a minimum, 150 square feet as adequate, and 175 square feet as desirable.

\textsuperscript{160}Illinois Board of Vocational Education and Rehabilitation, \textit{op. cit.}, p. 16.
\textsuperscript{161}Indiana State Department of Public Instruction, \textit{op. cit.}, p. 46.
\textsuperscript{162}Brant, \textit{op. cit.}, p. 37.
\textsuperscript{163}Huss, \textit{op. cit.}, p. 58.
Storage Space for Students' Projects and Personal Belongings

A study of the suggestions for the area of woodworking disclosed two sets of recommendations. The first set of suggestions was for the storage of small projects, aprons, etc., while the other set was for the storage of large projects. The recommendations presented in the woodworking area will also apply to the electricity and electronics laboratory. However, space utilized for the storage of large projects in the woodworking laboratory will be for the storage of radios, televisions, stereos, etc., in the electricity and electronics laboratory.

Special Facilities

Adequate space for test booths should be provided if the electricity and electronics industry is to be assimilated. Huss recommended 60 square feet as a minimum, 70 square feet as adequate, and 80 square feet as desirable for one soundproof test booth in a junior high electricity laboratory. For the senior high electricity and radio laboratory, he suggested 180 square feet as a minimum, 210 square feet as adequate, and 240 square feet as desirable for three soundproof test booths.164 Indiana State Department of Public Instruction agreed with the above recommendation for the high school by suggesting 180 square feet as the minimum

164Huss, op. cit., p. 58.
amount of square footage for three test booths for an electricity and electronics laboratory.\textsuperscript{165} California State Department of Education suggested that a soundproof room nine feet six inches by fourteen feet be provided for either a junior or senior high school electricity course.\textsuperscript{166}

Based upon the above, it was found that three soundproof test booths would be needed in an electricity and electronics laboratory. It was also noted that the space to be provided for these booths would be 180 square feet as the minimum, 210 square feet as adequate, and 240 square feet as desirable.

Graphic Arts Area

Recommendations presented in the woodworking section of this chapter, which also apply to the graphic arts area, are as follows: height of ceiling, windows and window area, demonstration and/or instructional area, teacher's office and conference room, library and planning area, display area, and toilet facilities. Exits and outside doors for the graphic arts area will be the same as recommendations presented in the electricity and electronics area. Additional space for a photography laboratory will be considered in this section, and variations will be noted.

\textsuperscript{165}Indiana State Department of Public Instruction, \textit{op. cit.}, p. 46.

\textsuperscript{166}California State Department of Education, \textit{op. cit.}, p. 18.
Square Feet of Floor Area per Student

A comparison of the square feet of floor area to be allotted per student in the graphic arts and woodworking areas revealed that only two sources differed in the recommendations. Illinois Board of Vocational Education and Rehabilitation suggested sixty to eighty square feet per student,\textsuperscript{167} while Maine State Department of Education recommended approximately seventy-five square feet per student.\textsuperscript{168} These variations were twenty square feet and twenty-five square feet, respectively, per student. However, it was found that these differences, when compared to the overall recommendations, failed to alter the recommendations presented in the woodworking area. Therefore, the amount of square feet of floor area per student for the graphic arts area would be in accordance with the woodworking area.

Storage Space for Materials and Supplies

A study of the literature with respect to the space to be provided for the storage of materials and supplies in a graphic arts laboratory revealed that the suggestions were relatively close. Two of the sources suggested room sizes. Illinois Board of Vocational Education and Rehabilitation

\textsuperscript{167}Illinois Board of Vocational Education and Rehabilitation, \textit{op. cit.}, p. 7.

\textsuperscript{168}Maine State Department of Education, \textit{op. cit.}, p. 7.
suggested a storage room twelve feet by twelve feet,¹⁶⁹ and California State Department of Education recommended a space of fourteen feet by eighteen feet for a stock room.¹⁷⁰ Indiana State Department of Public Instruction suggested 225 square feet for material storage,¹⁷¹ while Huss recommended storage space of 200 square feet as a minimum, 225 square feet as adequate, and 250 square feet as desirable for a junior high school, and 225, 250, and 275 square feet, respectively, as minimum, adequate, and desirable square footage for the senior high graphic arts laboratory.¹⁷²

An average of the amount of floor space recommended indicated 225 square feet as the minimum square footage to be provided for the storage space for materials and supplies.

An examination of the recommended square footage in the woodworking area revealed that both areas, woodworking and graphic arts, required the same minimum square footage for the storage of materials and supplies, thereby indicating that the storage space required for materials and supplies in the graphic arts area would be the same as the recommendations presented in the woodworking section of this chapter.

¹⁶⁹ Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 23.
¹⁷¹ Indiana State Department of Public Instruction, op. cit., p. 46.
¹⁷² Huss, op. cit., p. 58.
**Storage Space for Students' Projects and Personal Belongings**

A study of the suggestions for the area of woodworking disclosed two sets of recommendations. The first was for the storage of small projects, aprons, etc., and the second was for the storage of large projects. Since the storage space for large projects is not indicated in a graphic arts laboratory, only provisions for the storage of students' personal belongings would be necessary. Therefore, locker space to be provided for a graphic arts laboratory would be the same as the space allocations derived for the woodworking area.

**Photography Room**

A separate room adjoining the open laboratory area should be provided for a photography laboratory in the graphic arts area. Indiana State Department of Public Instruction suggested 125 square feet as the minimum for a photography laboratory.\(^{173}\) Huss recommended 125 square feet as a minimum, 150 square feet as adequate, and 175 square feet as desirable for a photography laboratory in both junior and senior high schools.\(^{174}\) Two sources presented recommendations in the form of floor plans. California

\(^{173}\)Indiana State Department of Public Instruction, *op. cit.*, p. 46.

\(^{174}\)Huss, *op. cit.*, p. 58.
State Department of Education recommended a room size of ten feet by fourteen feet for a photography laboratory,\textsuperscript{175} while Illinois Board of Vocational Education and Rehabilitation referred to this area as a darkroom and suggested a room seven feet six inches by twelve feet.\textsuperscript{176}

Based upon the above-mentioned recommendations, it was found that two of the four sources recommended 125 square feet as the minimum for a photography laboratory. The remaining recommended amounts of floor space to be provided, calculated into square feet, were 140 square feet and 90 square feet. An average of the suggested amounts of floor space to be provided for a photography room revealed that the square footage would be 125 square feet as a minimum, 150 square feet as adequate, and 175 square feet as desirable.

Handicrafts Area

In the woodworking area recommendations were presented, which are apropos to various other areas. Those recommendations pertinent to the handicrafts area are height of ceiling, windows and window area, demonstration and/or instructional area, teacher's office and conference room,

\textsuperscript{175}California State Department of Education, \textit{op. cit.}, p. 24.

\textsuperscript{176}Illinois Board of Vocational Education and Rehabilitation, \textit{op. cit.}, no page number given.
storage space for students' projects and personal belongings, library and planning area, display area, and toilet facilities. Exits and outside doors for the handicrafts area will be the same as recommendations presented in the electricity and electronics area. Additional space to be provided for a glazing and finishing room will be treated in this section, and variations will be noted.

**Square Feet of Floor Area per Student**

An examination of the recommendations for the woodworking area and a comparison with the suggestions for the handicrafts area identified only one variation with respect to the square feet of floor area to be provided per student. Indiana State Department of Public Instruction suggested 1500 square feet for the laboratory area,\(^\text{177}\) or a difference of approximately twelve and one-half square feet per student. Due to the minuteness of this suggestion, the recommendations presented in the woodworking area should be the basis for determining the square feet of floor area per student in the handicrafts area.

**Storage Space for Materials and Supplies**

Based upon recommendations presented in the preceding areas of instruction, it was found that storage space for

\(^{177}\)Indiana State Department of Public Instruction, *op. cit.*, p. 46.
materials and supplies in a handicrafts area would be the same as the recommendations presented in the graphic arts section of this chapter. Huss recommended the same number of square feet of storage space for both the graphic arts and handicrafts areas. Indiana State Department of Public Instruction combined storage with glazing and finishing areas and recommended that 350 square feet be provided for these special rooms. Suggestions for a floor plan from California State Department of Education indicated that a supply and special tool room ten feet by fourteen feet be provided and that a fourteen foot by eighteen foot room be planned for bulk supply and glazing.

Based upon previous recommendations and additional suggestions, it was indicated that the storage space to be provided for materials and supplies would be the same as the recommendations presented in the graphic arts area.

**Glazing and Finishing Room**

A study of the literature with respect to provisions for a glazing and finishing room in the handicrafts area revealed recommendations from only three sources. Huss

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178 Huss, op. cit., p. 59.

179 Indiana State Department of Public Instruction, op. cit., p. 46.

suggested 100 square feet as a minimum, 125 square feet as adequate, and 150 square feet as desirable for a glazing and finishing room in the junior high handicrafts area. For the senior high glazing and finishing room in the handicrafts area, he suggested 125 square feet as a minimum, 150 square feet as adequate, and 175 square feet as desirable.\textsuperscript{181} As previously stated, California State Department of Education suggested that a room fourteen feet by eighteen feet be provided for bulk supply and glazing,\textsuperscript{182} and Indiana State Department of Public Instruction recommended 350 square feet for special rooms, such as needed for glazing, finishing, and storage.\textsuperscript{183}

Upon consideration of the combined square footage for the glazing, finishing, and supply rooms as suggested by the above sources, it is indicated that the recommendations for a glazing and finishing room would be 125 square feet as a minimum, 150 square feet as adequate, and 175 square feet as desirable.

Presented in Chapter III were space requirements found in professional literature and related materials for use in

\textsuperscript{181}Huss, op. cit., p. 59.


\textsuperscript{183}Indiana State Department of Public Instruction, op. cit., p. 46.
planning and building industrial arts laboratories for the seven basic areas of instruction, which were woodworking, metalworking, drafting, electricity and electronics, power mechanics, graphic arts, and handicrafts. Certain physical facilities of the industrial arts laboratory were studied, and recommendations pertinent to the following aspects were made. They were square feet of floor area per student, height of ceiling, windows and window area, demonstration and/or instructional area, and exits and outside doors; teacher's office and conference room, storage space for materials and supplies, and storage space for students' projects and personal belongings; finishing, assembling, and gluing facilities, library and planning area, display area, toilet facilities, and equipment storage (tools, auxiliary machine parts, etc.). The recommendations were made in terms of square feet to be provided for each basic area of instruction.

The data were obtained from various state departments of education and from various writers in the field, who were concerned with the physical facilities of industrial arts laboratories. Their opinions were synthesized and presented as recommendations.

In an effort to make the study as thorough as possible, a study of the literature pertaining to safety and health and special facilities will be made. These data, secured
from the literature concerning safety and health and special facilities for the seven basic areas of instruction in industrial arts, will be treated and presented in Chapter IV.
CHAPTER IV

STANDARDS OF SAFETY AND HEALTH AND SPECIAL FACILITIES
FOR USE IN PLANNING INDUSTRIAL ARTS
LABORATORIES IN PUBLIC SCHOOLS

A study of current literature was made to secure recommendations concerning the health and safety of students working in industrial arts laboratories for use in planning and building of industrial arts laboratories in public schools. Recommendations pertaining to special facilities needed for maintaining and promoting good health and safety practices in laboratories designed for the seven basic areas of instruction (woodworking, metalworking, drafting, electricity and electronics, power mechanics, graphic arts, and handicrafts) will be treated in this chapter. However, since the majority of the recommendations will pertain to all areas of instruction, these areas will not be treated separately.

The organization of this chapter is as follows: lighting, heating, ventilating and air conditioning, acoustics, exhaust systems, and electrical system; plumbing facilities, fire extinguishers, power equipment, construction requisites, material for walls, floors and ceiling, and chalkboards and bulletin boards. The special facilities
needed to maintain and encourage the safety and health of the students when planning an industrial arts laboratory are as follows:

**Lighting**

When determining the lighting to be provided for a laboratory, there are two factors which are important. The first factor is the quantity or number of foot-candles, and the second factor is the source or quality of illumination. With respect to lighting, Brant suggested the following:

1. Fluorescent lighting should be used to supplement natural light.
2. The general lighting system should be semi-direct (25 per cent upward, 75 per cent downward), and should be supplemented by additional local lighting on machines.
3. The lighting for mechanical drawing and other precision work should be 150 foot-candles or more on the work.
4. Artificial lighting in laboratories should produce 100 foot-candles of light on the work.
5. Artificial lighting should produce a uniform distribution of shadow-free and glare-free illumination.1

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1Herbert M. Brant, "Check Out Your Shop Planning," *Industrial Arts and Vocational Education*, LVI (March, 1967), 38.
Georgia State Department of Education recommended:

A minimum of 30 foot candles at bench height should be provided in shops and a minimum of 50 foot candles in drawing rooms. Local lighting should be provided where necessary.

Direct or semi-direct types of fixtures are best for shops. Diffused light is preferred. Incandescent light is generally not satisfactory. Fixture height should be at least 10 feet in shops.

Light switches should be located near the main entrance to shops and drawing rooms.

The lighting circuit should be separate from circuits for machines and wall convenience outlets.

Ceilings and wall should be painted with a flat, high reflection factor point. Ceilings should be white with a reflection factor of 85% or above. Upper walls should be of a suitable color and with a reflection factor of 60%. Wainscoting should have a reflection factor 40-60%. Equipment in the shop should be painted to carry out the color scheme. Color schemes are available from paint manufacturers.2

In a book from Rockwell Manufacturing Company the following was recommended:

As a rule of thumb, 25 foot candles would be the absolute minimum for any shop and 100 foot candles is highly recommended. In most cases, the use of indirect lighting to avoid glare and evenly diffuse the light is recommended. When needed, individual machines can be individually lighted by lamp attachments or through their own built-in lighting systems. Present day lighting engineers when working with architects, can provide proper lighting which is equal to daylight in almost every respect. They can eliminate many of the problems involved in shop and laboratory planning concerned with the natural light available through restricted window areas which oftentimes varies greatly in candle power.3


Mississippi State Department of Education suggested:

Sufficient artificial illumination is necessary so that at least 50 foot candles of light reach both vertical and horizontal surfaces at bench height throughout the room. Additional light, up to 100 foot candles and even more in special cases, is needed for such shop activities as handicrafts, graphic arts, machine operation and mechanical drawing. Individual supplementary lighting is economical for those areas. In all cases, the light provided should be adequate to take care of the illumination at night as well as during the day. It should approach the effect of daylight and be as free from shadows as possible.\(^4\)

Kentucky State Department of Education suggested,

"Artificial lighting should be of an approved type, indirect or semi-indirect, incandescent or fluorescent fixtures, and not less than 50 foot-candles on the location where accurate work is being done."\(^5\)

Ohio State Department of Education recommended:

Electrical lights should supplement natural light to the extent that the artificial light alone will provide illumination that conforms to good lighting practice. Good general lighting should be provided to the intensity of 30 to 50 foot candles at bench height in all areas, and this should be supplemented with additional local lighting of all machines and areas where precision work is carried on. In no case should a bare lamp be visible. Glare should be reduced to a minimum. For shop areas where dust is an important factor, the glass-steel diffuser type of fixture is perhaps best adapted. For the more dust-free areas such as drawing and planning and library rooms requiring a soft, but

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intense light, either the direct or filtered fluorescent type of fixture will be found satisfactory.\textsuperscript{6}

Maine State Department of Education suggested:

The shop must be well lighted. The light should be well diffused, eliminate glare at the line of vision and cast no shadows around the work. Sufficient artificial illumination is necessary so at least 50 foot candles of light is available for general room lighting and up to 100 foot candles for auxiliary lighting in special areas or for fine work.\textsuperscript{7}

California State Department of Education suggested the following concerning lighting:

Artificial lighting systems should produce a uniform distribution of shadow-free light, and equipment and walls should be glare free. Artificial lighting should be secured by the use of fixtures that produce indirect or semi-indirect light.

... Lighting for tasks that are difficult to see should provide as much as 100 foot candles or more. General lighting should be supplemented by special lighting for each machine and for areas where precision work is done.\textsuperscript{8}

Florida State Department of Education was in complete agreement with the above suggestions, and further suggested, "Consideration should be given to the overall light level, brightness ratios, brightness differences, etc. . . .

\textsuperscript{6}Ohio State Department of Education, "A Guide for Industrial Arts Shop Planning" (Columbus, Ohio, no date given), p. 7. (Mimeographed.)

\textsuperscript{7}Maine State Department of Education, "Planning and Equipping Industrial Arts Facilities" (Augusta, Maine, no date given), p. 15. (Mimeographed.)

\textsuperscript{8}California State Department of Education, Guide for Planning and Equipping Industrial Arts Shops in California Schools (Sacramento, California, 1956), p. 5.
Artificial lighting for shops in general should yield a minimum of 30 foot candles on the work."\(^9\) According to California State Department of Education, "artificial lighting for shops in general should yield a minimum of 50 foot candles on the work."\(^10\)

New York State Education Department recommended:

"Sufficient artificial illumination is necessary so at least 50-foot candles of light reach both vertical and horizontal surfaces at bench height throughout the room. Additional light, up to 60-foot candles and even more in special cases, is needed for such shop activities as: printing, textiles, machine operation and mechanical drawing. Individual supplementary lighting is economical for these areas. In all cases, the light provided should be adequate to take care of the illumination at night as well as during the day.

It should approach the effect of daylight and be as free from shadows as possible.

Switches that control all general lighting in the shop should be located convenient to each entrance. All lights for any given shop area should be controlled within the shop. Areas of control should be small and should parallel windows so that lights in the dark side of the room are separately controlled from those nearest the windows.

Lights in photographic dark rooms should be controlled independently of the other lights.

Light switches and convenience outlets in finishing rooms should be vaporproof for safety.\(^11\)

Illinois Board of Vocational Education and Rehabilitation suggested:

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\(^9\)Florida State Department of Education and Industrial Arts Teachers of Orange and Seminole Counties, "County Course of Study, Industrial Arts" (Leon, Florida, 1966), p. 15. (Mimeographed.)

\(^10\)California State Department of Education, op. cit., p. 5.

The quantity of light delivered on the working benches in the laboratory shall be 100 foot candles. The quantity of light delivered on the table tops in drafting rooms shall be 100 foot candles.

Local power companies or a qualified architect should be consulted for recommendations as to correct type and number of fixtures to be used. Avoid glare caused by either natural or artificial light.

Fluorescent type fixtures are most often used in drafting rooms. Diagonal mounting helps eliminate shadows.

Auxiliary lights may be needed on individual machines where concentrated light is necessary.

All light fixtures, switches, and devices located in the finishing or paint room must be explosion-proof type.12

Huss stated, "Artificial lighting should be of sufficient intensity and quality to meet accepted standards of fifty foot candles or above. One-hundred foot candles are sometimes needed."13

The Industrial Arts Consultants for the State of Georgia, with respect to visual comfort details, supplied suggestions as follows:

1. The artificial light source should be fluorescent.
2. The general lighting system should be semidirect (25 per cent upward, 75 per cent down), no direct lighting.


3. The light-reflection value of the ceiling should be a minimum of 80 per cent and a maximum of 90 per cent.

4. The light-reflection value of the wall should be a minimum of 50 per cent and a maximum of 70 per cent.

5. The light-reflection value of the chalkboard should be a minimum of 15 per cent and a maximum of 25 per cent.

6. The light-reflection value of the tackboard should be a minimum of 50 per cent and a maximum of 60 per cent.

7. The light-reflection value of the floor should be a minimum of 20 per cent and a maximum of 30 per cent.

8. The light-reflection value of wainscoting, work-bench tops, furniture, trim and doors, and machinery should be a minimum of 30 per cent and a maximum of 50 per cent.\(^\text{14}\)

Bateson was in complete agreement with the above suggestions and further suggested:

1. The illumination level in service at the wood bench, wood lathe, band saw, jig saw, machine-shop bench, drill press, metal lathe, shaper, miller, floor

\(^{14}\)Georgia State Industrial Arts Consultants' Office, "Industrial Arts Facilities, Check List of Standards," (Atlanta, January, 1965), p. 3. (Mimeographed.)
grinder, and drafting table should be 50 foot-candles.

2. The jointer, circular saw, sander, potter's wheel, sheetmetal bench, bending and forming machines, punching and shearing machines and reference room should have 30 foot-candles.

3. The power saw and ceramics' bench should have 40 foot-candles.

4. The general illumination level in service thirty inches from the floor should be 30 foot-candles.\textsuperscript{15}

An examination of the data pertaining to lighting revealed that six of the sources recommended 50 foot-candles as the minimum at bench height for lighting a laboratory. Six of the sources indicated 100 foot-candles as adequate lighting for a laboratory, while two other sources indicated 100 foot-candles as the maximum. Four sources recommended fluorescent lighting, and three of these sources suggested that the general lighting be semidirect (25 per cent upward, 75 per cent downward). Three sources suggested indirect or semi-indirect lighting for general lighting.

The majority of the sources agreed that more light was required for areas in which precision work and drawing were done. Most of the sources recommended that 100 foot-candles

be provided for these areas. Eight of the sources suggested that general lighting should be supplemented by additional local lighting on machines.

It was also found that two of the sources, with respect to standards for a laboratory, treated light-reflection values of various surfaces. In general, based upon the preceding data, it was found that recommendations, where reasonable agreement existed, concerning the various aspects of the lighting of a laboratory are as follows:

1. The general lighting system should be of the approved type—semidirect, indirect, or semi-indirect (25 per cent upward, 75 per cent downward).

2. It should be diffused light utilizing fluorescent type fixtures.

3. Individual supplementary lighting should be provided for precision or accurate work.

4. The light provided should be adequate to take care of illumination at night as well as during the day.

5. Artificial lighting should approach the effect of daylight and should produce a uniform distribution of shadow-free and glare-free illumination.

6. Light switches should be located near the main entrance to laboratories.

7. The lighting circuit should be separate from circuits for machines and wall convenience outlets.
8. Equipment and walls should be glare-free.

9. All light fixtures, switches, and devices located in the finishing or paint room must be explosion-proof type.

10. A minimum of 50 foot-candles of light should reach both vertical and horizontal surfaces at bench height throughout the laboratory (however, 100 foot-candles were recommended as desirable).

11. A minimum of 100 foot-candles of light should be delivered on the tabletops in drafting rooms.

12. A minimum of 100 foot-candles of light should be provided for precision or accurate work, which could include areas such as handicrafts, graphic arts, textiles, machine operations, library, and planning room.

13. Ceilings, walls, trim, and built-in equipment should be of a light color with a high reflection value.

Light-reflection values recommended were as follows:

1. Ceiling—minimum, 80 per cent; maximum 90 per cent.

2. Wall—minimum, 50 per cent; maximum, 70 per cent.

3. Chalkboard—minimum, 15 per cent; maximum, 25 per cent.

4. Tackboard—minimum, 50 per cent; maximum, 60 per cent.
5. Floor—minimum, 20 per cent; maximum, 30 per cent.

6. Wainscoting, workbench tops, furniture, trim and doors, and machinery—minimum, 30 per cent; maximum, 50 per cent.

Heating, Ventilating, and Air Conditioning

Controlling the climate, or climatic control, in an industrial arts laboratory is an important factor to consider when planning industrial arts facilities. Norman L. Rutgers stated:

Generating and distributing heat to the industrial-education areas of our schools is very important. We must consider, however, the total thermal environment of this area which includes much more than heat alone. The term "thermal environment" is a relatively recent addition to the educator's vocabulary. Included in thermal environment is heating, ventilation, air movement, air cooling, air cleaning, humidity control, and air freshening. Comfort or discomfort (as is too often the case) will have a marked effect on the students' learning receptivity, physical health, and mental welfare in addition to his relations with other students and his teachers.

The greatest single problem in maintaining comfort conditions in all areas of the school is one of reducing the heat gains within the room. Depending on the design of the building, heat from the students, lights, solar radiation, and the many heat-producing pieces of equipment, especially in the shop areas, is often great enough to require cooling, even though outdoor temperatures are as low as 25° and lower.

Introducing outdoor air into the room, when outside temperature is low enough to do some real cooling, is the most economical approach. But, proper consideration must be given as to how this air is circulated within the room.

If cool air is directed toward the occupant at excessive velocities, discomfort and hazardous health conditions will exist. Air as cool as 40° or 45° can
be brought into the room, provided this air is completely mixed with room air before it reaches the occupant. Also, the velocity must not exceed 45 feet per minute. Mechanical cooling is rapidly moving out of the luxury category and is being recognized as a requirement in an increasing number of schools.

In light assembly work which bears a closer relation to the activity in a school shop, accidents increase both above and below an optimum temperature of 67°. This indicates that too low a temperature leads to physical awkwardness resulting in possible accidents; and too warm an environment leads to mental sluggishness. The type of activity will demand its own optimum temperature.

The average student produces as much heat as a 100-w electric light bulb. This is a significant amount of heat; and if the human body cannot dissipate it fast enough or loses it too rapidly, discomfort and lower learning capacity will result.

Often the teacher establishes the temperature in the room to his satisfaction without realizing that the temperature requirements of the students, frequently many years younger than the teacher, are at a lower level. In the shop area, the student is often more active than an instructor. Therefore, the proper temperature for the student might create a slight feeling of discomfort for the instructor. Frequently the comfort levels of the student and teacher are separated by at least 5°.

While not always related directly to the heating system, exhaust ventilation is very important to the shop area. Woodworking, welding, and other activities produce air contaminants. Some method is needed to remove foul air and replace it with fresh air. Exhaust ventilation becomes a part of the thermal system. The capacity of the heating units in the shop area must be large enough to replace the heat that is exhausted, specially during the more severe cold periods.

The temperature control system for the industrial-education portion of the school frequently does not require the same complexity of design as academic classrooms (with perhaps the exception of the mechanical drawing rooms, electricity and electronics labs, etc.). This does not mean that extreme temperature fluctuations are permissible. For example, wide temperature swings
from 67° to 74° and back again can create more discomfort and poorer learning results than a slightly "too high" or "too low" temperature which is maintained within close limits.16

New York State Education Department recommended:

Heat thermostatically controlled, sufficient to maintain a temperature of 68 degrees five feet above the floor with a variation not to exceed five degrees between this level and the floor should be provided. Since the industrial arts department is likely to be used for night school programs, it is desirable to have the control of the heat designed and located so as to permit heating it independently of the rest of the building.17

Mississippi State Department of Education was in complete agreement with the above suggestions, and further suggested:

Unit blower heaters are recommended. . . .

... . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

It is recommended that the shop be air-conditioned and that adequate facilities be provided for dust elimination. If a shop is not air-conditioned, fans will become mandatory.

One or more exhaust fans of sufficient size should be placed at one end of the shop where there is not an air-conditioner, and they should have the capacity to exchange the air every three to five minutes. An exhaust fan must be installed in the finish room.18

New York State Education Department further recommended that "the ventilation system should provide a constant gentle...


17New York State Education Department, op. cit., p. 10.

18Mississippi State Department of Education, op. cit., p. 23.
flow of clean air at all times while the room is in use."  
Maine State Department of Education agreed with the above suggestions, and further suggested, "A heating system, thermostatically controlled, sufficient to maintain a temperature of 68 degrees should be provided."  

California State Department of Education suggested, "The heating and ventilating system should be adequate to maintain comfortable and healthful conditions at all times," and the heating system should be automatically controlled. "The temperature variations from floor to 60 inches above the floor should not exceed 5°." Further suggestions from the California State Department of Education were in agreement with the recommendations by Brant in that both recommended the laboratory temperature should be 68 degrees measured 60 inches above the floor and that the classroom temperature should be 70 degrees measured 30 inches above the floor. Brant further recommended that the temperature of the laboratory should be controlled from the room and that radiators should be floor level against the wall or recessed in the wall.

19New York State Education Department, op. cit., p. 11.  
21California State Department of Education, op. cit., p. 5.  
22Ibid.  
23Brant, op. cit., p. 36.  
24Ibid.
The Industrial Arts Consultants for the State of Georgia supplied the following suggestions:

1. The temperature of the laboratory sixty inches from the floor should be 68 degrees.

2. The heating system used in the laboratory should be a wall-unit ventilator with a fan, a split system (forced warm air and convectors), or radiant panel.

3. The temperature controls should be automatic room controls.

4. The location of radiators (if used) should be floor level, against the wall, or recessed in the wall.25

Bateson was in complete agreement with the above suggestions, and also suggested the following:

1. The minimum quantity of air per pupil supplied by the ventilating system should be fifteen cubic feet per minute.

2. The fresh outdoor air included in the air circulated should be 25 per cent to 30 per cent of the total air.

3. The air velocity past the occupant during the heating season should be twenty-five lineal feet per minute.

4. The air velocity past the occupant during the cooling season (outside air) should be eighty-five lineal feet per minute.

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5. The ventilating system used in the laboratory should be mechanical, either an integral or separate part of the main plant.

6. The relative humidity of the laboratory in the winter should be 40 per cent, and in the summer it should be 50 per cent.

7. The relative humidity of the storage area should be 40 per cent.\(^{26}\)

Georgia State Department of Education suggested:

The heating system should be so regulated as to maintain a suitable temperature. Sixty-eight degrees is recommended in a shop where students are working. Drafting rooms need to be maintained at the usual temperature for classrooms.

Heating and ventilating systems should be planned to use a minimum of space.\(^{27}\)

Illinois Board of Vocational Education and Rehabilitation suggested:

Heat should be thermostatically controlled. Temperatures in laboratory areas should be maintained at 65 degrees Fahrenheit five feet above the floor and measured in the center of the room.

Overhead heating units are satisfactory in most laboratories but not in classrooms or drafting laboratories.

Unit ventilators are best for classrooms and drafting rooms.

Heating should be planned so that the industrial arts department can be heated independently of the


\(^{27}\)Georgia State Department of Education, "Questions for Critique for General Shop Organization" (Atlanta, no date given), p. 22. (Mimeographed.)
rest of the building since it is likely to be used for adult evening classes during the heating season.28

Marshall L. Schmitt stated that the present trend in planning industrial arts laboratories was to provide air-conditioning,29 and Florida State Department of Education suggested, "If shop is not air-conditioned, special attention should be given to provide forced-cross ventilation."30

With respect to air-conditioning, a book from Rockwell Manufacturing Company contained the following recommendation:
"If air conditioning is to be installed, a complete dust control system is recommended due to the problems inherent in pulling undue amounts of dirt into the air conditioning system."31

The Texas Education Agency, with respect to air-conditioning, suggested:

There is a definite trend in this state toward the climate controlled or so-called "air-conditioned" school building. This is in keeping with the present mode of life since having our homes, offices, stores, cars, etc., air-conditioned has become an accepted practice.

28Illinois Board of Vocational Education and Rehabilitation, op. cit., p. 13.


30Florida State Department of Education, op. cit., p. 10.

It is recommended that careful consideration be given to this type of building since it offers an improved learning climate, eliminates the need to orient for breeze and sun control, greatly reduces or eliminates the need for windows with the necessary shades, roof overhangs, and sun shields and makes possible a more compact design with the resulting reduction in construction and maintenance costs.32

Upon studying the aforementioned recommendations, it was found that seven of the sources agreed that heat should be automatically or thermostatically controlled. Four of the sources agreed that the heating controls should be independent of the rest of the building. Seven of the sources agreed that a temperature of 68 degrees should be maintained in the laboratory. Seven of the sources agreed that the temperature should be measured sixty inches above the floor. Three of the sources agreed that the temperature variation from the floor to sixty inches above the floor should not exceed 5 degrees. Two of the sources agreed that the classroom temperature should be 70 degrees measured thirty inches above the floor. Two of the sources suggested that the type of heaters to be provided should be the wall-unit ventilators with fan or split systems (forced warm air and convectors) or radiant panel. One source suggested that unit blower heaters be provided, while another recommended the overhead type heater for the laboratory and unit ventilators for the

classroom and drafting laboratory. One source recommended that industrial arts laboratories be air-conditioned, two stated that the trend was toward air-conditioning, and three other sources indicated that air-conditioning should be provided.

Acoustics

When planning facilities for industrial arts, special consideration should be given to acoustics. Sound prohibits learning and can be detrimental to the human organism, the ear. Information and sources concerning this aspect of planning industrial arts laboratories are as follows:

Huss stated:

Maximum use should be made of modern advances in construction materials to provide for better sound absorption.

... Control of sound influences the safety of learners. Large industrial organizations have found that the control of sound has a pronounced influence on worker productivity, morale, efficiency, and safety. Machines should be mounted on sound absorbing bases to prevent the transmission or amplification of noise. 33

John W. Gilliland stated:

Unwanted sound or noise eats away at human energy and efficiency. Noise interferes with the efficiency of students and teachers, lessens attention, and makes concentration on tasks more difficult.

... The increased flexibility of modern school construction and the development of new construction techniques make it possible to go several steps further in

sound control. Aside from acoustical design, it is possible to use any of several noise-absorbing floor coverings. New acoustical tile is inexpensive and easily applied and maintained.

... Special wall-insulating products and perforated pulp ceiling tiles have also proved invaluable for this purpose.

The economy of purchase and installation leaves little excuse for failure to utilize acoustical materials where necessary. These same materials, used in the proper way in movable baffles, increase the potentiality of large, flexible, multi-purpose areas.

Acoustical products are esthetically pleasing, yet frequently do not compete successfully with the more dazzling ceramic tiles, chrome, aluminum sheeting, and glass, all three of which intensify and magnify the noise problem. Reduction in the use of hard-surfaced materials would result in less expensive, more efficient school construction and would be of considerable consequence in the reduction of high acoustical interference resulting from normal, in-school activities. If this were not significant enough, it might be well to note that these same sound bouncers constitute "light bouncers" and "glare producers" to add eye fatigue to sound fatigue.34

New York State Education Department recommended:

Materials which provide maximum sound absorption should be used on the ceiling. It is good to have the upper portion of the side walls treated with materials selected to satisfy the requirements of the room. Acoustical material should be capable of being stained and restained without losing its acoustical properties.35

Mississippi State Department of Education was in complete agreement with the above suggestions,36 while Ohio State Department of Education recommended:

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35New York State Education Department, op. cit., p. 10.

Treatment of walls and ceilings is considered a necessity in the noisy areas of the industrial arts laboratory. A minimum treatment would at least provide for ceiling absorption of not less than 50 per cent. Maximum absorption is deemed desirable especially if a ceiling treatment alone is used. In the finishing room and other less noisy areas, a conventional plaster treatment is perhaps more practical.

Walls to wainscot height, or about five feet, should be surfaced with some durable material easily cleaned and of pleasing texture and color. Mat glazed tile, ceramic block or salt glazed tile is satisfactory for this purpose. Above this point, walls should be plastered preferably with acoustical plaster in the more noisy areas.37

California State Department of Education suggested that "shops should be acoustically treated with material that will permit repeated refinishing,"38 while Florida State Department of Education suggested, "Walls and ceiling should have acoustical treatment in order to keep the noise level in the shop at a reasonable level."39 Bateson suggested that the sound-absorbing value of the ceiling should not be less than 50 per cent nor more than 70 per cent. He also suggested that the sound-absorbing value of the wall range from a minimum of 30 per cent to a maximum of 60 per cent.40 In the publication from Rockwell Manufacturing Company it was suggested:

37Ohio State Department of Education, op. cit., p. 6.
40Bateson, op. cit., p. 38.
... acoustical material or treatment is highly recommended for the ceiling. In addition, it is often possible to also use acoustical plaster on the walls, down to approximately five feet of the floor. The lower wall areas should be tile, ceramic block or other easily cleaned durable material. Certain epoxie paints are also excellent when used on normal construction block.41

A study of the preceding data revealed that all of the quoted sources agreed that industrial arts laboratories should be acoustically treated to subdue the noise level. The majority of the sources recommended acoustical treatment of the walls and ceilings, and one source recommended a further step in sound control by recommending noise-absorbing floor coverings. Two sources recommended that acoustical material should be capable of finishing and repeated refinishing without losing its acoustical properties. Two sources recommended that the upper walls down to wainscot height, or approximately five feet above the floor, should be acoustically treated with acoustical plaster and that the lower walls up to wainscot height, or about five feet, should be surfaced with some durable material easily cleaned. The materials suggested for the lower walls were mat glazed tile, ceramic block or salt glazed tile, and epoxie paint when used on normal construction blocks. Other suggestions were that the sound-absorbing value of the ceiling should range from a minimum of 30 per cent to a maximum of 50 per

cent, the sound-absorbing value of the wall should range from a minimum of 30 per cent to a maximum of 60 per cent, and machines should be mounted on sound-absorbing bases.

Exhaust Systems

Exhaust systems should be provided to remove gases, wood shavings, dust, fumes, odors, vapors and smoke, according to Wayne P. Hughes and William A. Williams. They had the following to say concerning exhaust systems:

... Shop planners must consider providing equipment from such systems in auto mechanics shops to remove exhaust fumes from running automobile engines, in wood shops to remove wood shavings and dust from woodworking machines, in finishing rooms to remove contaminants from paint spray booths, in welding shops to remove harmful fumes resulting from arc-welding operations, in machine shops to remove dust from grinding operations and to remove fumes from melting and hardening furnaces, and in numerous other types of shops where local exhaust is necessary to safeguard the health of the students. Such exhaust systems are also necessary to remove possible explosive fumes or gases.

Bateson was in complete agreement with the material received from the Industrial Arts Consultants for the State of Georgia by suggesting that each area served should be provided with separate exhaust systems and that the exhaust system ducts should be overhead. Georgia State Department

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43 Ibid.
44 Bateson, op. cit., p. 39.
of Education suggested, "Exhaust systems should be installed where smoke, gases, paint, fumes, or excessive dust are present. In most states, hoods with exhausts must be specified over forges, melting pots, and other open-flame equipment. A vacuum exhaust system is needed to remove shavings." In the book from Rockwell Manufacturing Company it was recommended:

It should be decided in the initial planning stage both from a health and physical point of view whether dust collection is desired. In initial planning, the duct work can be more easily run under the floor rather than overhead. This creates a less cluttered appearance in the shop but also, within reason, dictates the final positioning of the machines and makes difficult any future changes due to the outlets being in one specific spot. In this light, overhead duct work is more flexible. It should also be decided whether every machine is to be attached to this system or only those which create dust rather than chips, i.e., the Belt Sander, the Disc Sander and other abrasive tools. It is often possible to obtain individual dust collectors for machines of this type rather than install a complete system. A full dust collection system is, of course, the most desirable but also the most expensive.

If air conditioning is to be installed, a complete dust control system is recommended due to the problems inherent in pulling undue amounts of dirt into the air conditioning system. The exhaust volumes and transport volicity [sic] should be very carefully figured by a competent technician. At least one "floor sweep" duct should be included as a part of the system.

Huss stated:

Dust collection systems are needed in wood and metal areas, as well as fume exhaustion systems in hot metal areas, plating or where acids are used.


Adequate ventilation should be provided in accordance with the requirements of local building codes. Special ventilating facilities are needed for wood or metal finishing, hot metal furnaces, heat-treating equipment, welding booths and auto exhaust. A separate dust-proof finishing room equipped with an independent exhaust system should be provided for wood or metal finishing laboratories.\textsuperscript{48}

Ohio State Department of Education suggested:

Woodworking machines such as surfacers, jointers, circular saws, belt sanders, etc., require dust collecting systems for disposal of waste and dust. If planned prior to construction of the building, the pipes may be placed under the floor thus obviating the necessity of unsightly overhead pipes.

Foundry, forging, and welding areas should be equipped with hoods to exhaust fumes and smoke. Soldering furnaces in the sheet metal area should be provided with a hood for disposing of fumes.

The automotive area should be provided with a system for disposal of engine exhaust while engines are being tested inside the laboratory.

Finishing room exhaust systems should not be used for exhausting automotive and welding fumes, etc., because of the explosive nature of finishing materials.

. . . A forced ventilation system is required where spray guns will be used.\textsuperscript{49}

Florida State Department of Education suggested, "Adequate systems should be provided for the collection and disposal of dust and shavings,"\textsuperscript{50} while California State Department of Education recommended:

Dust, smoke, odors, fumes, vapors, and gases should be exhausted by mechanical means.

\textsuperscript{48}Huss, \textit{op. cit.}, pp. 60, 65.

\textsuperscript{49}Ohio State Department of Education, \textit{op. cit.}, p. 8.

\textsuperscript{50}Florida State Department of Education, \textit{op. cit.}, p. 15.
Provision should be made for all engines operated in the shops to be muffled and connected to exhaust pipes that discharge outside the building.\textsuperscript{51} New York State Education Department recommended:

A ceramic tile flue, suitable to conduct smoke and gas fumes to the outside, should be built in the wall near the gas outlets. If internal combustion engines will be operated, provision should be made to carry away the exhaust fumes. Likewise, hoods to collect and carry off injurious gases, vapors, fumes or dust should be installed over areas such as foundry units, spray painting, ceramic glazing and welding booths.\textsuperscript{52}

Brant stated that the finishing room should be dust-proof with an independent exhaust system and that exhaust systems should be provided in other areas where needed.\textsuperscript{53} Maine State Department of Education suggested, "Special facilities should be provided to remove fumes, odors, vapors and dust in areas of the shop where they are likely to be presented."\textsuperscript{54}

Indiana State Department of Public Instruction recommended the following:

All dust generating equipment should be exhausted to an outside dust collector. Self-contained dust collection equipment will suffice on some equipment such as portable sanders and some grinders and polishers. All areas wherein fumes or atomized liquid particles are created in the air should be equipped with an

\textsuperscript{51}California State Department of Education, \textit{op. cit.}, p. 5.

\textsuperscript{52}New York State Education Department, \textit{op. cit.}, p. 13.

\textsuperscript{53}Brant, \textit{op. cit.}, pp. 36, 38.

\textsuperscript{54}Maine State Department of Education, \textit{op. cit.}, p. 15.
exhaust system to the outside. All spray booths and the hot-metals areas should be equipped with a hood and exhaust fan. Forced ventilation in the finishing room should provide ten air changes per hour.55

Illinois Board of Vocational Education and Rehabilitation recommended:

All forges, furnaces, and engine exhausts shall be connected to outside vents or exhausts.

An exhaust system must be provided for each finishing and/or drying room.

A spray booth is recommended for each finishing room.

Air exhausted from each spray painting booth must be equal to: (a) 125 cfm. per square foot of booth face opening measured from top of work surface to top of opening; or (b) 125 cfm. per square foot of booth floor area; or (c) 1000 cfm. per booth, whichever is greater; or (d) 800 cfm. drawn from within 16 inches of each spray nozzle. Air to be drawn from above work location.

An exhaust system must be provided for each welding room or area.

A welding booth is recommended for each welding station.

Air exhausted from each welding booth must be equal to: (a) 100 cfm. per square foot of booth face measured from top of work surface to top of opening; or (b) 100 cfm. per square foot of booth floor area; or (c) 1000 cfm. per booth, whichever is the greater; or (d) 600 cfm. drawn from within 12 inches of each welding arc. Air to be drawn from above work location.

Air exhausted from each welding or painting overhead hood (over welder or painter) must be equal to: (a) 100 cfm. per square foot of net hood opening; or (b) 100 cfm. per lineal foot of exposed hood perimeter; or (c) 1200 cfm. per hood, whichever is the greater. Edge of hood must be as low as possible and not more than 6'6" above floor.

Air exhausted from each welding or painting location without hood or booth or local nozzle, must be at

least 1400 cfm. for welding and 1600 cfm. for painting. Air to be drawn from slightly above work location.

Special exhaust systems designed to prevent air pollution of all kinds shall be provided in each shop where five or more pieces of industrial equipment are in use.

All exhaust air shall be discharged through weatherproof wall louvers or roof hoods, both provided with removable bird screens.56

Upon studying the aforementioned data, it was found that the majority of the sources agreed that exhaust systems should be provided in an industrial arts laboratory to remove gases, fumes, odors, vapors, smoke, dust, and wood shavings. It was also found that each area served should be provided with separate exhaust systems which would include an independent exhaust system for finishing rooms. With respect to the location of the exhaust system ducts, it was found that although overhead ducts create a cluttered appearance in the laboratory, they are more flexible than duct work under the floor. Duct work under the floor creates a less cluttered appearance; however, future changes are difficult due to the final positioning of the machines and outlets. In general, it was found that exhaust systems should be provided in areas where needed to safeguard the health of the students and teachers. This would include areas such as auto mechanics, woodworking, finishing rooms, welding, machine shops, foundry, forging, sheetmetal, hot

56 Illinois Board of Vocational Education and Rehabilitation, op. cit., pp. 8-9.
metal, heat treating, ceramic glazing, blueprinting, photography, drying rooms, graphic arts, and handicrafts, where gases, wood shavings, dust, fumes, odors, vapors, and smoke are present. In essence, exhaust systems should be provided for all of the seven basic areas of instruction, which are woodworking, metalworking, drafting, electricity and electronics, power mechanics, graphic arts, and handicrafts.

Electrical System

Providing an adequate electrical system is of importance in the planning of an industrial arts laboratory. Factors, such as the proper voltage and current, single-phase or three-phase, flexibility, and convenience outlets, should be considered in the initial planning stages.

Illinois Board of Vocational Education and Rehabilitation recommended the following concerning electrical power services:

All power equipment in each laboratory should be controlled by one master power switch which can be locked and which is located within that laboratory. A starter and overload switch should be provided for each machine in the laboratory. Each power machine shall have a protective ground. Single-phase, 108-120 volt current satisfactory for small motors used intermittently; three-phase 208-220 volt current best for larger motors using greater amounts of power (1 H.P. and over). Some schools now use only 220 volt circuits which can be tapped for 110 volt current at each receptacle by using polarized plugs. Two-prong plugs provide 110 volt and three-prong plugs pull out the full 220 volt. This is recommended as it provides great flexibility of power choice.
Wall receptacles rather than floor outlets preferred except for specific machines.
Most welders require 220 or 440 volt power.
Future needs for power in the laboratory should be considered.

The service control panel should be mounted flush with the wall as near to the entrance door as possible.
Each laboratory should have a master switch through which all power circuits can be controlled.
This switch should be the remote control type with several remote control buttons located in strategic positions in the laboratory.
Each circuit should have an individual switch within the panel together with a circuit breaker or fuse.57

Indiana State Department of Public Instruction suggested:

The main electrical control panel should be centrally located in the shop and direct access to it should be provided. An overhead buss-duct system should be employed to provide 208-220 volt, three-phase current. Flexible, rubber-covered drops to the machinery are recommended. For maximum flexibility in the use of light machinery and portable power tools, 115 volt duplex outlets should be placed 12' to 15' apart around the perimeter of the main work area approximately 48" above the floor level.58

Florida State Department of Education suggested:

Electrical outlets and controls in shop classrooms should be located where they may be used with a minimum of teacher movement. The controls for room lights and the electrical outlet for a film projector should be at this same point.

Power controls should be centralized on a master control panel that can be locked, has a pilot light, and is located near the instructor's desk or office.

57Ibid., pp. 11-12, 14.

58Indiana State Department of Public Instruction, op. cit., p. 41.
Remote safety relay cutout switches controlling the main power supply are also excellent safety provisions. Shops using portable power tools should be provided with one double electric wall outlet for every 10 feet of wall space, with provision for grounding the cord.

Service outlet requirements in the majority of shops include gas for melting pots and furnaces, hot and cold water, drainage, compressed air, and 110 volt single phase and 220 volt three phase electric current. The new 208 volt provision should be carefully checked as to adequacy for kilns, motors, and ovens.

Individual electrical control panels should be provided for each shop. At least three master cut-off switches should be positioned in each shop.

All machines should be controlled by a master fuse and switch box conveniently located in the shop and near the entrance. Safety cutoff switches should be placed in at least 3 positions in the shop.

Locate convenient outlets in the walls of the shop at frequent intervals. Outlets should be at least 36" above the floor and not more than 10" [this probably should read 10 feet] apart. Outlets for soldering irons and other heating equipment should be equipped with pilot lights.\(^59\)

Ohio State Department of Education recommended:

Sufficient electrical service outlets should be provided for anticipated changes in the department and in keeping with the desirability of semi-portable equipment.

The installation of "wire ways" or "plug-in-strips" along certain walls, bench height, providing continuous receptacles for electrical tools, extension cords, etc., will further add to the flexibility of the shop. Electrical outlets should be provided for both 220 volts and 110 volts and of sufficient capacity to prevent damage from overloading.

Power and light controls should be centralized on a control panel conveniently located in each laboratory.

\(^{59}\)Florida State Department of Education, *op. cit.*, pp. 11, 14, 17, 18.
Master switches should be placed in convenient locations about the shop, so that all power can be turned off from any of these locations. All panels should be provided with locks.60

Maine State Department of Education recommended the following:

Power controls should be centralized on a master control panel that can be locked. This panel should have a pilot light and should be located near the instructor's desk or office. Provision should be made for one double electric outlet (110 volts) for every eight feet of wall length, with provision for ground cord. These outlets should be located approximately 42 inches above the floor.

Most shops can operate on 119-220 volts three phase electrical circuits. A buss system can be installed to take care of all machines not located near a wall.

Control buttons should be located at strategic parts of the shop so that the master control panel may be shut off immediately if the instructor sees a student in a hazardous position while working at a machine.61

Huss stated:

Power and other utility services should be based on a liberal rather than restricted estimate of future needs and placed to allow maximum flexibility in laboratory arrangement. Later changes in equipment and arrangement will require electric outlets uniformly spaced throughout the laboratory. Extra outlets are installed most economically at the time the building is constructed.

Power and light controls should be centralized on a locked master control panel with pilot light and located near the teaching center. Remote control safety switches should be placed in several convenient locations in case of emergency.62

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60Ohio State Department of Education, op. cit., pp. 4, 7.


62Huss, op. cit., pp. 63-64.
Brant suggested that all electrical switches be enclosed, that a center control electrical switch panel be accessible, that utilities be shut off upon entering the laboratory, that conduits be embedded in the floors and walls with adequate wiring, and that all electrical materials and workmanship be approved by the National Board of Fire Underwriters.  

Brant, Bateson, and the suggestions supplied by the Industrial Arts Consultants for the State of Georgia were in agreement concerning the following electrical details:

1. The power circuit system should be three-wire, three-phase.
2. There should be one branch power circuit per machine.
3. There should be one spare power circuit for every four active circuits.
4. The overload protection for the power circuits should be circuit breakers.
5. There should be one spare light circuit for every five active circuits.

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64 Ibid., p. 38.
65 Bateson, op. cit., p. 39.
6. The overload protection for the light circuits should be circuit breakers.

7. Convenience outlets should be installed on the walls at intervals of ten feet.

8. There should be one spare circuit for every four convenience outlets.

9. The power cut-out safety buttons should be installed on the wall at intervals of fifteen feet to twenty feet.

The suggestions contained in the material supplied by the Industrial Arts Consultants for the State of Georgia were in accord with Bateson's suggestions in that further recommendations were as follows:

1. The raceway system for power circuits should be wireways.

2. The installation of light circuit raceways should be concealed in the ceiling.

3. The fire-alarm system should be an integral part of the main system with the alarm system sounding station in the laboratory.

However, there was disagreement with respect to the installation of the power circuit raceways. In the material received from the Industrial Arts Consultants for the State of Georgia,

67Ibid.

68Bateson, op. cit., p. 39.
of Georgia, it was recommended that they be placed under the floor or in the wall, and Bateson suggested exposed installation on the ceiling. Bateson also suggested that the finishing room electrical system be equipped with spark-proof switches and fixtures.

Mississippi State Department of Education suggested the following:

Floor plans and equipment layouts should be made far enough in advance to determine the location for electrical outlets in the final building plans. Service for 110 and 220 volts is desirable as some equipment items require 110 volts and others operate more efficiently on 220 volts.

Vapor-proof outlets should be installed in the finishing room. Special heavy duty outlets should be provided for kilns and electric arc and spot welders. Wire of sufficient amperage capacity should be specified.

The switch panel should be mounted flush with the wall in a convenient place inside the shop. It should contain a master switch located in or near the instructor's office through which all the power circuits can be controlled. Each circuit should have an individual switch within the panel together with a circuit breaker or fuse.

New York State Education Department was in complete agreement with the above suggestions and further recommended:

Duplex wall outlets for 110 volts should be spaced at 15-foot intervals around the entire shop at a height of approximately 42 inches above the floor.


70Bateson, op. cit., p. 39. 71Ibid.

72Mississippi State Department of Education, op. cit., pp. 24-25.
Extra 110 and 220-volt outlets should be placed in the floor and along the wall where it would be logical to locate a machine in case the shop facilities were expanded or rearranged.

Electric wiring and other services should not be installed in cross-partitions. Electric outlets on cross-walls should be supplied through conduits or metal moldings placed on the face of the walls in order to facilitate the movement of partitions when desired.

Wall outlets should be equipped with red pilot lights. Brass, free standing, water-tight screw base outlet fittings should be used in the floor. . . .

. . . The master switch should be of the remote control type with a red pilot light and several control buttons located in strategic parts of the shop. Remote control of all circuits, except for lights, is recommended as a safety feature. 73

Further suggestions from the Mississippi State Department of Education were as follows:

There should be a 110 volt outlet every eight feet in the shop walls and one every ten feet in the mechanical drawing room. The 220 volt outlets should be single phase and located every 16 feet for machines and for whatever expansion may be done in the future. Three phase should be provided where needed.

Overhead cables should be run to machine areas not served by wall receptacles. 74

California State Department of Education suggested:

Power controls should be centralized on a master control panel that can be locked, has a pilot light, and is located near the instructor's desk or office. Remote safety relay cutout switches controlling the main power supply may also be provided.

Shops using portable power tools should be provided with one double electric wall outlet for every 10 feet of wall space, with provision for grounding cord. 75

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73 New York State Education Department, op. cit., pp. 11, 13.


75 California State Department of Education, op. cit., p. 3.
The data studied and presented emphasized strongly that consideration be given in planning the electrical power system for industrial arts laboratories to insure that the system will include the following features:

1. There should be an adequate source of power that will provide 110/220 voltage for both single-phase and three-phase motors, kilns, welders, heat treating ovens, and small electrical tools and appliances.

2. Branch power circuits from the main panel should be provided for each machine with at least one spare circuit for every four active circuits.

3. The overload protection for the power circuits and the light circuits should be circuit breakers with one spare light circuit for every five active circuits.

4. There should be convenience outlets installed on all walls approximately forty-two inches above floor level at intervals not greater than ten feet.

5. Duplex convenience outlets should be provided with provisions for a grounding cord, and there should be one spare circuit for every four convenience outlets.

6. Remote controlled power cut-out safety buttons should be installed on the walls at intervals of fifteen to twenty feet.

7. A remote controlled master switch with a red pilot light and provisions for locking should be located in each laboratory near the instructor's desk or office.
8. The raceway system for power circuits should be wireways installed in the floor or in the walls, and the light circuit raceways should be concealed in the ceiling.

9. The service control panel should be flush with the wall, provided with a lock, and conveniently located inside the laboratory.

10. The fire alarm system should be an integral part of the main system with the sounding station in the laboratory.

11. All finishing room electrical systems should be spark-proof switches and fixtures and vapor-proof outlets.

Plumbing Facilities

Consideration should be given to the location of such utilities as water, gas, compressed air, and drainage of waste disposal. Deliberation, in the initial planning stage, should be given to pipe sizes, drinking fountains, washing facilities, air outlets, gas outlets, sprinkler system, and toilet facilities. Failure to consider these facts may result in inadequate plumbing; thus, creating an inadequacy of needed facilities for the students. In the publication from Rockwell Manufacturing Company, the following was recommended concerning plumbing details:

Some thought in the initial planning stage should be given to locating the air and gas lines inside the walls rather than having exposed piping. Gas might normally be run only to the soldering bench in the shop or possibly to a forge, but air can be used in almost any area for operating air tools, air powered accessories, or for cleaning purposes. It is highly
recommended that this piping be installed in appropriate places and in the appropriate size of pipe, regardless of whether a compressor is initially purchased or not. This might be comparable to the original installation of phone lines in a home with conveniently located phone jacks.76

Hughes and Williams, with respect to plumbing facilities, stated:

A sanitary drinking fountain should be installed at a convenient location within every school-shop area. The American Standards Association specifications should be followed. If cooled by mechanical means, the temperature of the water should not be lower than 45°F., but below 60°F. In hot weather, it is advisable to provide containers of salt tablets at the fountains.

At least one wash basin, or 2' of trough, or a circular or semi-circular wash fountain, with hot and cold running water, preferably from a combination supply fixture, should be provided within the shop area for every 20 students. The proper type of soap in an adequate dispenser is important not only for ordinary hygiene, but as a protection against dermatitis. Individually dispensed paste, liquid, or powder—not bar soap—for common use should be provided. Paper towels in covered dispensers, with a closed disposal receptacle, should be close by the washing facility.77

Bateson suggested the following:

Drinking facilities—one station per 25 pupils; washing facilities—one station per 10 pupils; work (slop) sinks—one for each area of activity; (automatic sprinkler system (in each area indicated)—shop proper, tool cribs, storage rooms, finishing room; location of air compressor—outside of shop proper; distribution of compressed air outlets—on wall at 20' intervals; distribution of gas outlets—on wall at 20' intervals.78

Illinois Board of Vocational Education and Rehabilitation recommended:

76 Rockwell Manufacturing Company, op. cit., p. 10.
77 Hughes and Williams, op. cit., p. 43.
78 Bateson, op. cit., p. 38.
A drinking fountain should be provided in each laboratory.

One hand washing facility which will accommodate several students at one time should be provided in each laboratory.

Hand washing facility should be mounted on the wall rather than standing free in the center of the room.

A lavatory is recommended in each unit drawing room.

One floor drain with grease trap needed in auto laboratory.

A service sink with acid-resisting drain and supplied with hot and cold water is a necessity in or near the finish room.

In some laboratories, a water faucet should be provided near the outside entrance.

Gas outlets should be available for the foundry unit, heat-treating, forging, and soldering areas.

Compressed air may be piped from one large central compressor in the department. Connections for air hose should be provided for the finish room, foundry bench, metalwork bench, and power mechanics areas. One extra connection on each side of each laboratory will be helpful for cleaning purposes.79

Mississippi State Department of Education suggested:

At least two gas outlets should be provided in the shop by a gas line brought through the floor or through the wall near the place where the furnace units and other equipment requiring gas are to be installed. The main supply pipe must be adequate for maximum consumption. A gas connection installed on the wall provides more flexibility than one located in open shop areas.

Where the shop is large, the sink should be a minimum of five feet long and should have three faucets. It is advisable to install the sink on the wall to preserve floor space. Additional sinks should be provided for areas of work requiring the use of water. An extra large trap should be installed under each sink in order to prevent wax, grease, paint, plaster of paris, cement and other injurious materials from being washed into the drain pipe.

79 Illinois Board of Vocational Education and Rehabilitation, op. cit., pp. 11-12.
A drinking fountain is standard equipment in every shop. The most suitable place for installation is near the sink.\textsuperscript{80}

New York State Education Department recommended the following:

Installing gas, water and compressed air supply outlets through or along the wall rather than through the floor in central portions of the shop. Note: This statement does not apply to highly specialized shops requiring numerous outlets of one sort.

A gas line should be brought into the shop through the floor or through the wall near the place where the furnace units and other equipment requiring gas are to be installed. The main supply pipe must be adequate for maximum consumption. Attention should be given to the kind of gas available: natural, mixed, artificial or bottled. A gas connection installed on the wall provides more flexibility than one in the middle of the room. . . .

Both hot and cold water should be piped to the sink. Where the shop is large, the sink should be long enough to provide wash stations for five or six pupils. It is advisable to install the sink on the wall because wall sinks require less floor space than those in the center of the room. Additional sinks should be provided for areas of work such as ceramics, automobile mechanics, and textiles, if the size and scope of the activity warrants them.

An extra large trap should be installed under each sink in order to prevent wax, grease, paint, plaster of paris, cement and other injurious materials from being washed into the drain pipe.

If automobiles are to be driven into the shop for repairs, a floor drain should be provided in the middle of the concrete area to carry off water and grease.

A drinking fountain is standard equipment in every shop. The most suitable place for installation is near the sink. In small shops, a cold water fountain may be placed in the sink to conserve space.

Compressed air should be supplied from a central source and outlets placed convenient to metalworking

\textsuperscript{80}\textit{Mississippi State Department of Education, op. cit.}, p. 25.
benches, paint and ceramics glaze spraying equipment
foundry bench, soldering bench and automobile area. 81

California State Department of Education suggested:

Adequate washing facilities should be provided in
each shop.
Hot water should be available in each shop.
Each shop should have a drinking fountain located
where it will not cause congestion and, for purposes of
supervision, can be seen from any point in the shop.

Toilet facilities for all shops should be located
at a central point in the shop building.
An air compressor unit should be located where all
shops requiring compressed air may use it.
The air compressor unit should be located so that
it can be conveniently serviced, and noise from its
operation will not disturb classes. 82

Ohio State Department of Education suggested the fol-
lowing:

Washing facilities should be provided in the labo-
rary in the ratio of one washing position to ten
pupils.
Gas, water, electricity, and compressed air should
be considered as essential utilities for every indus-
trial arts laboratory. An adequate provision of out-
lets with a liberal allowance for expansion and revision
of the program will obviate the necessity of expensive
and unsightly extension of utilities later. 83

Maine State Department of Education suggested:

A toilet facility should be located in the shop or
in close proximity and should include one urinal, one
flush and one electric hand dryer.
There should be a wash-up facility located near an
entrance-exit. A Bradley semi-circular type washing

81New York State Education Department, op. cit.,
pp. 11, 13, 14.

82California State Department of Education, op. cit.,
pp. 3-4.

83Ohio State Department of Education, op. cit., p. 7.
sink is very satisfactory. A paper towel dispenser should be located nearby the wash-up facility.

A sink with an acid resistant trap should be installed in the metals area. A drinking fountain should be installed as a separate installation and properly located in the shop. A floor drain and an auxiliary water outlet should be located in the power mechanics area. An ample supply of hot and cold water should be supplied where needed in any facility.

Artificial gas should be available in the soldering, forging, heat treating and art metals areas of the shop. 84

Huss had the following to say concerning plumbing facilities:

Provision should be made for such utilities as water, gas, compressed air, electric outlets and drainage of waste disposal. A washing station should be provided for every five students in such laboratories as wood, metal, and graphic arts. Hot water should be available in all laboratories.

Compressed air should be made available at convenient locations in the laboratory with diaphragm valves to control the pressure. The air compressor should be outside the laboratory.

A drinking fountain should be located with the wash sink, or adjacent to it, to eliminate congestion. 85

Georgia State Department of Education suggested, "Provide sinks with hot and cold running water. Washing facilities and drinking fountains should be provided in the shop. Toilet facilities, adequate chalkboard and bulletin board space, water, gas, and compressed air should also be provided." 86 Suggestions contained in the material supplied by

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84 Maine State Department of Education, op. cit., pp. 16-17.

85 Huss, op. cit., pp. 60, 65.

the Industrial Arts Consultants for the State of Georgia were as follows:

1. There should be one drinking facility per twenty-five pupils.
2. There should be one washing facility per ten pupils.
3. There should be one work sink for each area of activity.
4. The air compressor should be located outside of the laboratory proper.
5. There should be two compressed air outlets per laboratory.
6. There should be one gas outlet per laboratory.87

Brant recommended that there should be one washing facility per ten pupils and one sink for each area of activity. The sinks should be provided with traps to collect dirt, grease, etc., which can be easily cleaned, and every shop and classroom should have a drinking fountain located in view of the instructor.88

A study of the literature pertaining to plumbing facilities revealed the following:

1. One drinking fountain located near the washing facility should be provided in each laboratory.

87Georgia State Industrial Arts Consultants' Office, "Check List of Standards," p. 3.
88Brant, op. cit., p. 38.
2. One washing station per ten students, of the semi-circular or sink type mounted on the wall, should be provided.

3. Air and gas outlets on the wall at twenty-foot intervals should be provided.

4. Hot and cold water should be provided in each laboratory.

5. An extra large trap should be installed under each sink in order to prevent wax, grease, paint, plaster of paris, cement and other injurious materials from being washed into the drain pipe.

6. A floor drain with a grease trap should be provided in the power mechanics laboratory.

7. One work (slop) sink should be provided for each area of activity.

8. Each service sink should be equipped with an acid-resisting drain.

9. The air compressor should be located outside the shop proper.

10. The piping can be located inside or along the wall. Although only one source presented recommendations pertaining to an automatic sprinkler system, it should be noted that this recommendation was that an automatic sprinkler system should be provided in each area indicated (shop proper, tool cribs, storage rooms, and finishing room).
Fire Extinguishers

Fire extinguishers should be provided for each of the various types of fires, namely, class A, B, and C; and they should be located in prominent places, according to the Kentucky State Department of Education.89 In the material received from the Industrial Arts Consultants for the State of Georgia, it was suggested that the fire-extinguishing agents to be provided for the laboratory should be one unit per shop.90 Bateson, being more specific, stated that the fire-extinguishing agents for the shop should be a fire blanket and vaporizing liquid (carbon tetrachloride).91

Brant,92 Mississippi State Department of Education,93 New York State Education Department,94 Florida State Department of Education,95 California State Department of Education,96 and Illinois Board of Vocational Education and

89Kentucky State Department of Education, op. cit., p. 44.


91Bateson, op. cit., p. 39.


93Mississippi State Department of Education, op. cit., p. 28.

94New York State Education Department, op. cit., p. 26.


96California State Department of Education, op. cit., p. 3.
Rehabilitation\textsuperscript{97} recommended that fire extinguishers of sufficient size and in accord with fire regulations should be located on the wall conveniently to the area where fire hazards exist and should be marked and labeled conspicuously. Illinois Board of Vocational Education and Rehabilitation further suggested, "Extinguishers using toxic chemicals, such as tetrachloride, are prohibited. Place fire extinguishers near finish room, not in them."\textsuperscript{98}

Huss stated, "Fire extinguishers must be located near danger points and labeled conspicuously. Carbon-dioxide extinguishers seem best for all around use. However, each fire extinguisher should be planned for a specific use, according to the fires likely to occur in the area."\textsuperscript{99}

Hughes and Williams, with respect to fire extinguishers, stated the following:

> Even though the school plant may be equipped with fixed systems of fire protection, portable fire-protection appliances should also be available and ready for emergency use. If portable extinguishers are to be effective, the following rules must be applied:
> 1. The right type of extinguisher must be available for each exposure.
> 2. Extinguishers must be located where they will be readily accessible, and there must be ample units to cover the exposure in any given area.

\textsuperscript{97}Illinois Board of Vocational Education and Rehabilitation, \textit{op. cit.}, p. 14.

\textsuperscript{98}Ibid.

\textsuperscript{99}Huss, \textit{op. cit.}, p. 64.
3. Extinguishers must be ready for immediate use.
4. The right chemicals of correct strength must be used, and the extinguishers must be maintained in perfect operating condition.
5. Extinguishers must be inspected frequently for good operating condition, checked against tampering, and they must be recharged.
6. Persons must know the location of extinguishers and be trained to use them effectively and promptly.
   (Training extinguishers should be provided for this purpose.)

Operating characteristics which make one type of portable fire extinguisher suitable for certain fire hazards may make the same type dangerous for others. The school-shop planner should, therefore, secure on-the-job advice from local fire equipment experts to determine: (1) types of extinguishers needed; (2) number of units required for each exposure area; and (3) kind and quantity of recharging materials necessary for maintenance purposes.\(^{100}\)

Based upon the preceding data, it was found that fire extinguishers should be provided for industrial arts laboratories. The right type of extinguisher must be available for each exposure, i.e., class A, B, or C type fires. The extinguishers should be of sufficient size and in accord with fire regulations. The extinguishers should be located on the wall convenient to the fire hazard area and should be marked and labeled conspicuously. The extinguishers should be inspected frequently and recharged when necessary.

Power Equipment

When planning and equipping an industrial arts laboratory, safety should be given first consideration. Factors such as the location of the machinery and providing wide

\(^{100}\) Hughes and Williams, op. cit., p. 43.
aisles of travel are of utmost importance. A well designed laboratory will not prevent all accidents, but it can contribute to minimizing them. Brant stated the following:

Spacing between benches, machinery, and equipment should be sufficient for safety and free passage, preferably 4 feet, no less than 3 feet.

- Machines located for best light, day or night.
- Have machines color schemed.
- Machines for roughing stock should be placed near the storage rooms.

- Machines located for safe operation.
- Ground all power machines.
- High visibility color should be used on control levers and switch boxes.
- On machines such as a radial arm saw there should be a braking device.
- Enclose all belts and moving parts on machines.
- Operating parts should be painted a contrasting color from the nonoperating machine body.
- Well-defined safety zones should be placed around machines.
- Nonskid paint should be placed on the floor around machines (Ferrox).

Georgia State Department of Education suggested the following:

- Provide aisles of travel to commonly used areas.
- Insure that ample space exists around equipment.
- Equipment used in sequential order should be located in the order of their operation.
- Utilize naturally lighted areas for precision equipment such as lathes, drawing tables, grinders, saws, etc., and consider direction of light in locating equipment.
- Locate machines to accommodate largest sizes of materials commonly handled. Do not distort the most effective arrangement for the occasional extra large piece.

101Brant, op. cit., pp. 36-37.
Locate the most frequently used equipment near the center of operation.102

Huss had the following to say about machinery:

Adequate clearance should be allowed between machines. Usually a minimum working space of three feet is needed, and working space should be provided for the operator.

Dangerous parts and machines must be marked with a color coding similar to that recommended by the National Safety Council. Dangerous areas around machines should be marked off with color coding.

A scientifically arranged color scheme should be planned for the entire laboratory. Such plans as those developed by Dupont or Pittsburgh Paint companies are suitable. It has been demonstrated in industrial shops and school laboratories that the use of color improves the efficiency of the worker.

A uniform color for denoting electrical outlets and switches should be used to indicate caution.103

Kentucky State Department of Education suggested:

Machines that are usually considered dangerous should be located in an isolated area away from the passage of students. The table saw and jointer are machines that can be extremely dangerous. Student work stations should not be located behind the table saw since those working may be endangered by "kickbacks." Welding and other hot metals are likewise areas that should be located away from students who are not working in these activities.

Aisles of travel should be kept open for student passage. Students should not pass through machine or other work areas where workers will be distracted or safety practices violated. The aisles should be not less than four feet in width, and, if greatly traveled, a foot should be added. The aisles may be painted a prominent color to indicate their location.


Safety mats should be placed around all hazardous equipment where there is a danger of slipping.¹⁰⁴

California State Department of Education suggested the following:

Arrangement of equipment, machines, and work stations should be determined by considerations of safety, work procedures, flow of materials, and instructional efficiency.

Aisles of travel should be provided for free flow of traffic between all areas and points of common use such as auxiliary rooms, tool panels, and common machine areas. Such aisles should be at least 4 feet in width.

Spacing between benches, machinery, and other equipment should be sufficient for students' safety and for free passage. The amount of such space between benches, machinery, and equipment is determined by the nature of the shop work and the equipment, but in all instances should be at least 3 feet.

Machines that are used for roughing out stock should be placed near the storage areas.¹⁰⁵

Florida State Department of Education was in complete agreement with the above suggestions, and further suggested:

Furniture and other shop equipment should be finished in light colors.
Machinery and equipment should be painted in colors that will minimize eye fatigue and contribute to safe operating procedures.
Certain operating parts should be finished in colors which will create a visual working area that minimizes eye fatigue.
High visibility colors should be used on control levers and switch boxes, with black for starting button and red for stop button.

¹⁰⁴Kentucky State Department of Education, op. cit., pp. 40, 44.

Locate machines to accommodate largest sizes of materials commonly handled. Do not distort the most effective arrangement for the occasional extra large piece.

Arrange pieces of equipment in order of their operation.

Paint safety zones on the floor around dangerous equipment. 106

Ohio State Department of Education recommended the following concerning the placement of equipment:

Safety factors become paramount in the placing of equipment. Machines such as: circular saws, jointers, band saws and lathes, around which zones of danger exist, should be placed in such a manner as to reduce the possibility of any pupil being needlessly exposed to danger. The location of aisles of travel should be carefully planned so that traffic will be minimized in the danger zones.

Distinct aisles of travel should be provided between all areas and points of common usage such as storage rooms, tool rooms, and common machine areas. Areas should be so spaced in relation to one another that a maximum working relationship exists. For example, areas of foundry, forging, and welding have processes and materials in common and should be placed in close proximity to one another with ample ventilation. The same might be said of machine metal work, sheet metal work, automotives, and electricity.

Certain machines should be arranged with reference to a sequence of operations and their relationship to other areas. The jointer is usually placed to the right and rear of the circular saw, since these machines are frequently used alternately. The circular saw should be placed near the lumber storage space to reduce the disturbance and danger of handling long lengths in the shop. In no case, however, would any of these particular machines be placed at or near the

principal exit. Attention should be given in the placement of any machine to assure adequate clearance for the work to be done.\textsuperscript{107}

New York State Education Department suggested that "equipment should be located to provide clear aisle space 3 to 4 feet wide. . . . Machine tools should be placed so that their operators are isolated, as much as possible, from traffic and distracting influences."\textsuperscript{108}

Illinois Board of Vocational Education and Rehabilitation suggested:

Belts, drives, pulleys, shaft couplings, etc., shall have rigid steel or steel bound steel mesh removable guards, arranged to cover all moving belts, parts, shafts, etc.
Fans of every type drawing directly from any room or space shall have wire mesh or equivalent removable guards in all inlets; fan outlets discharging directly into rooms or spaces shall have similar guards.

Select only machines that provide adequate and effective guards for maximum protection to the operator and other individuals.

Arrange the equipment to permit free use of the safety aisles.
Place machines in the normal sequential order of their operation for most work to be performed.
Avoid placing machines against columns or pipes which will transmit sound to other rooms.
Locate machines so as to accommodate maximum sized materials.
Tools used most frequently should be placed in the most convenient location.
Precision machines should be protected from damage due to natural dampness, dust, or grit.
Arrange machines for maximum safety.

\textsuperscript{107}Ohio State Board of Education, \textit{op. cit.}, pp. 4-5.

\textsuperscript{108}New York State Education Department, \textit{op. cit.}, p. 61.
Heavy machines should have soundproof foundations.

Aisles or lanes should be provided in every laboratory to permit student movements without crowding or interference while the work is progressing.

Provide safety zones around dangerous machines.

Plastic tape is now available for marking safety zones. It is pressure sensitive and requires no cement.

Non-skid areas should be provided on floor for machine operators to stand on while operating dangerous machines. Non-slip surfacing material is now available in either cleat or strip form to be cemented to floor in dangerous areas. Rubber mats offer both traction and insulation. Non-skid paint is also available.109

Mississippi State Department of Education recommended the following:

Power machines should be so placed that students are not in the line of danger. Added protection is given by enclosing these machines in a safety zone painted on the floor.

Wide aisles of travel should be provided between benches, machines, and in areas in front of tool panels and storage lockers. Special safe space should be allotted to areas where molten metal, welding, heat treating, etc., are handled.

Placement of machines with regard to sequence or association of operations is necessary.110

Suggestions contained in the publication from Rockwell Manufacturing Company were in complete agreement with the above suggestions, and it was further suggested:

Aisles of travel may be designated by painted lines similar to those used in industry. These aisles should be a minimum of 3 to 4 feet in width.

109 Illinois Board of Vocational Education and Rehabilitation, op. cit., pp. 15-17, 19.

110 Mississippi State Department of Education, op. cit., p. 28.
Non-skid surfaces such as Ferrox or sand on shellac should be applied to the floor at machines to minimize danger of slipping. Moisture absorbing material should be regularly stocked for use on oily or wet areas.

Placement of machines with regard to sequence or association of operation is necessary particularly with the circular saw and jointer; spinning lathe and buffing machine; forge and anvil; cut-off saw and lumber rack; power hack saw and metal storage rack.\textsuperscript{111}

Bateson stated that the width of the main aisle of travel should be four feet,\textsuperscript{112} and Hughes and Williams stated:

A guarded machine is a safe machine, and when the shop student's fear of the machine is dispelled, this contributes to the instructional process.

Mechanical guarding must be considered when equipping a school shop. School administrators, supervisors, and shop teachers should acquaint themselves with the standards established by the American Standards Association (New York, N. Y.) safety code for the guarding of transmission machinery. They should also be familiar with Bulletin No. 197 of the U. S. Department of Labor, The Principles and Techniques of Mechanical Guarding.\textsuperscript{113}

Findings based upon the aforementioned recommendations are as follows:

1. The aisle of travel should be no less than four feet.
2. Space between machines and equipment should be no less than three feet.
3. Entire laboratory should be color schemed.

\textsuperscript{111}Rockwell Manufacturing Company, \textit{op. cit.}, p. 8.
\textsuperscript{112}Bateson, \textit{op. cit.}, p. 37.
\textsuperscript{113}Hughes and Williams, \textit{op. cit.}, pp. 40-41.
4. Machines should be located to accommodate the largest sizes of materials commonly handled.

5. Equipment used in sequential order should be located in the order of their operations.

6. Machines for roughing stock should be placed near the storage rooms.

7. Machines that are considered dangerous should be isolated away from the passage of students.

8. All belts, pulleys, shaft couplings, and moving parts should be guarded.

9. Safety zones should be painted around machines.

10. Main aisle of travel should be designated by painted lines.

11. Nonskid surface should be provided on the floor around dangerous machines to prevent slipping (Ferrox, safety mats, sand on shellac or other nonskid paints).

Construction Requisites

Consideration should be given to the size, location, and shape of industrial arts buildings when planning new facilities or adding to existing facilities. Concerning the shape of a laboratory, Indiana State Board of Public Instruction,\textsuperscript{114} as well as the Ohio State Department of

\begin{footnote}
\textsuperscript{114}Indiana State Department of Public Instruction, \textit{op. cit.}, p. 40.
\end{footnote}
Education,\textsuperscript{115} suggested that the laboratory be rectangular in shape and that the ratio of width to length should be between one to one and one-half and one to two. Ohio State Department of Education also recommended that "irregular shaped laboratories such as "U" and "L" are undesirable because of lack of visibility and ease of supervision."\textsuperscript{116}

Requisites with respect to the size, location, and shape of industrial arts buildings, as suggested by Bateson\textsuperscript{117} and by the Industrial Arts Consultants for the State of Georgia,\textsuperscript{118} were as follows: The minimum width of the laboratory should be thirty feet. The minimum ratio of the width to the length should be one to one and one-half. The maximum ratio of the width to the length should be one to two. The location of the laboratory in relation to the grade level should be grade level.

Georgia State Department of Education suggested that the laboratories should be on or above ground level and located where noise will cause the least interference to the rest of the school. A wing of the building or a separate building near the main building is preferred. All floor space of a laboratory should be on one level and square or

\begin{itemize}
\item \textsuperscript{115}Ohio State Department of Education, \textit{op. cit.}, p. 5.
\item \textsuperscript{116}Ibid.
\item \textsuperscript{117}Bateson, \textit{op. cit.}, p. 36.
\item \textsuperscript{118}Georgia State Industrial Arts Consultants' Office, "Check List of Standards," p. 1.
\end{itemize}
rectangular in shape. Recessed or "L" and "T" shapes should be avoided.\textsuperscript{119}

The Kentucky State Department of Education suggested the following:

The industrial arts laboratory should be located in a first floor wing of the school building, preferably at the end. In the campus type plant, it may be located adjacent to other subject matter facilities having some common characteristics. Often the practical arts are located in the same unit of a plan. The industrial arts laboratory should never be located separate and apart from other school activities. Under no circumstances should it be placed in a basement room.

The physical plant should conform to the existing school building code.

A dimensional relationship of one to two is recognized as a desirable proportion with a size of 30 x 60 feet, plus auxiliary rooms, being considered as minimum for the average laboratory. An even better size is 40 x 60 or 70 feet. Certain specialized laboratories require a larger space.

A rectangular shape is imperative. No form of irregular shape is satisfactory.\textsuperscript{120}

Illinois Board of Vocational Education and Rehabilitation recommended:

In locating the place for the Industrial Arts laboratories, the following locations are suggested in preferential order:

a. Wing of building.
b. Separate building attached to main plant.
c. Separate building.


\textsuperscript{120}Kentucky State Department of Education, \textit{op. cit.}, p. 35.
Laboratories should be planned so they are easily accessible to adult education groups without opening the entire building.

Should be rectangular in shape with a ratio of width to length of 2:3 or less desirable 1:2. Width should not be less than thirty-two (32), or better still thirty-four (34) feet. These ratios lend themselves to better lighting and arrangement of equipment. Any shape which does not allow the instructor complete visibility at all times should be avoided (such as L-shape, U-shape, or T-shape).121

Maine State Department of Education recommended the following:

To promote efficiency, the aim should be to utilize a shape which would give the largest amount of area in the most compact shape. However, when this is done, such as in a square shop, valuable wall space is lost. As a compromise, therefore, the rectangular shape is recommended.

A ratio of width to length of 1 to 1 1/2 as a minimum (most desirable) and 1 to 2 as a maximum is recommended. This pertains to the work area and does not include auxiliary rooms.

It is recommended that the width of a shop should never be less than 30 feet.

All irregular shapes of shops should be avoided.

It is recommended that the shop should be located in a special wing in a new building and an attached wing in an existing building.122

Mississippi State Department of Education123 and New York State Education Department124 agreed that the shape of the laboratory was important. However, they differed with

121Illinois Board of Vocational Education and Rehabilitation, op. cit., pp. 6-7.


124New York State Education Department, op. cit., p. 7.
respect to the ratio of length to width. Mississippi State Department of Education suggested that the ratio of length to width should range from one and one-half to one to not more than two to one, and New York State Education Department recommended a range from one to one to not more than two to one.

Further suggestions from New York State Education Department were as follows:

Long narrow shops should be avoided as they do not lend themselves to effective orientation of machine tool equipment or to efficient space utilization. In schools housing only one shop this situation can be avoided by placing the shop at the end of a wing where it is possible to take advantage of the width of the entire wing. Any shape which does not allow an instructor full visibility of the entire area at all times should be avoided.

Industrial arts shops should be located on the ground level whenever possible. This makes it convenient to have an outside entrance through which to move large items of equipment, supplies, automobiles, boats, etc. It is desirable, too, since noise in rooms on the ground level will not penetrate to other classrooms which might otherwise be located below.

In large schools it is recommended that a separate wing or the end of a wing of the main building be used for shops and related subjects. Experience has shown that shop facilities are constantly being enlarged to accommodate unforeseen increases in enrollment. Shops should, therefore, be located so that future expansion may be made with a minimum of alterations and without destroying the harmony with building design and fenestration. Consideration should also be given to the position of the shops in relation to the mechanical drawing and art rooms. This is particularly important in a large school having several shops.


126 New York State Education Department, op. cit., p. 7.
Another important consideration in the location of a shop or shops is whether or not they are conveniently accessible for adult education classes in the evening.\footnote{Ibid., pp. 7, 9.}

Mississippi State Department of Education\footnote{Mississippi State Department of Education, op. cit., p. 21.} was in complete agreement with the above suggestions, while Florida State Department of Education recommended:

The site area devoted to shops or laboratories for junior high schools should be large enough to allow for future expansion; it should not be isolated but should be adjacent to or connected with other areas used for educational purposes; it should be easily accessible by automobile and truck for delivery of supplies and for adult and evening school use.

Building units should be connected by covered walkways.

School shops should be housed in one or more separate buildings or in wings of school buildings that are designed for shop use.

Building units should be of one story structure.

The open shop area should be rectangular in shape and width-to-length ratio of the open shop area should be approximately 2-3.\footnote{Florida State Department of Education, op. cit., p. 10.}

California State Department of Education was in agreement with the above suggestions, and further suggested:

Shops in which noisy activities are conducted should be located so that the noise will not disturb other school activities. This does not mean isolation. Auto shops and other shops that must be accessible to automobiles or trucks should have entrances and exits located on driveways.

School shops should not be located in basements.
The entire shop area should be visible from any point.130

A study of preceding data revealed that the majority of the sources agreed on the following:

1. The minimum width of a laboratory should be thirty feet.
2. The ratio of width to length should be a minimum of one to one and one-half and a maximum of one to two.
3. The location of a laboratory should be grade level.
4. The laboratory should be in a wing of the building or a separate wing attached to the main building or a separate building located near the main building.
5. The laboratory should be rectangular in shape, and irregular shapes, such as "U," "L," and "T" should be avoided.
6. The laboratory should be located where noise will cause the least interference to the rest of the school.
7. All laboratories should be one-story structures.
8. The laboratory should be accessible for adult and evening school use.
9. Building units should be connected by covered walkways where climatic conditions make it necessary.

Material for Walls, Floors, and Ceilings

The floor material in a laboratory and auxiliary (storage) area should be concrete, and for a drafting-planning area it should be tile over concrete. Partition walls in a laboratory should be nonweight bearing, and the walls in a laboratory should be wainscoted from four to seven feet high, according to the suggestions contained in the material supplied by the Industrial Arts Consultants for the State of Georgia.\textsuperscript{131} Georgia State Department of Education recommended the following:

- Concrete floors—drafting rooms and planning rooms should be covered with tile.
  - Where concrete floors are used and color is desired, the color should be added at the time the floor is poured and all exposed concrete floors should be finished smooth and dust-proofed.
  - Walls should have a smooth finish. A wainscoting 48" to 72" high and of durable nature should be provided. Higher wainscoting permit more effective use of wall space. Acoustical glazed tile is recommended.
  - Partition walls should be non-bearing walls ceiling height, and of a semi-permanent construction to permit future alterations in floor plan.
  - Ceilings should be acoustically treated.\textsuperscript{132}

Bateson recommended that the floor material in the woodworking, sheetmetal, ceramics, and drafting areas be wood and that the floor material in the machine shop area be concrete. The movable partitions in the laboratory


proper should be constructed of metal, and the walls to wainscot height (four feet) should be finished with a hard plaster (painted or glazed material).133

Mississippi State Department of Education suggested the following concerning construction materials:

Floor materials are recommended as follows: trowel-finished concrete floor with hardener and color added. Ceramic tile is recommended for rest rooms. The lower portion of shop walls, up to a height of five feet, should be made of a durable hard-surfaced material which can be easily cleaned. It should have a pleasing color and texture. Glazed brick, glazed tile, liquid plastic, or Epoxy enamel are satisfactory materials for this purpose.

In situations where a separate wing of the building is devoted to shopwork, good quality, carefully laid cinder blocks are satisfactory providing they are properly sealed and painted. The walls above a wainscot or wainscotton height should be treated with a non-glare material. The lower portion of the wall should be free from obstructions and projections to allow efficient placement of benches, machines and cabinets. At least one, or preferably two, full height walls should be reserved for the mounting of chalkboard, tool panels, bulletin boards and display shelves. . . . Materials with high sound absorption characteristics and light reflection qualities should be used for ceilings.

If partitions are necessary, they should be non-bearing and constructed so that they may be readily removed or rearranged if necessary.134

Maine State Department of Education suggested:

Hardwood flooring, treated with a nonslip finish, is suggested for wood areas. In the areas of metals and transportation where the floors are subjected to

133Bateson, op. cit., p. 36.

considerable oil, grease, dirt and water, concrete floors are recommended. All other areas of work, wood or tile may be used.

The materials used for the ceiling should be of the acoustical type and light in color. . . .

Partitions between shops should be soundproof and non-bearing so they may be easily moved to provide for expansion or changing conditions. . . .

The lower part of shop walls, up to a height of five or six feet, should be made of impervious materials which can be easily cleaned.135

Florida State Department of Education recommended the following:

The floors should have a pleasing appearance, be easy to clean, be of a material that will require a minimum of repairs, and be finished to reduce the danger of slipping. If cement floors are used they should be sealed to prevent dust or covered with a non-slip mastic. Asphalt floors are generally not satisfactory. End grain wooden blocks are good in some locations.

The flooring materials will differ from shop to shop and within a particular shop according to the activities that are carried on in them.

The floor areas where machine operators stand should be covered with rubber mats, garnet cloth, or sand sprinkled on a three-coat film of shellac or other non-slip material as a safety precaution for the operator.136

Ohio State Department of Education recommended the following with respect to materials for walls, floors, and ceilings:

Floor materials should meet the needs of the areas in operation. The automotives, forge, foundry and welding should be concrete.


For the woods, metals, and electrical areas, maple or end grain wood block floor is recommended. Quarry tile is sometimes used for the ceramics and photography areas. Battleship linoleum is very practical for the graphic arts area, library and office. The use of concrete floors, other than specified, is not recommended.

Treatment of walls and ceilings is considered a necessity in the noisy areas of the industrial arts laboratory. A minimum treatment would at least provide for ceiling absorption of not less than 50 per cent. Maximum absorption is deemed desirable especially if a ceiling treatment alone is used. In the finishing room and other less noisy areas, a conventional plaster treatment is perhaps more practical.

Walls to wainscot height, or about five feet, should be surfaced with some durable material easily cleaned and of pleasing texture and color. Mat glazed tile, ceramic block or salt glazed tile is satisfactory for this purpose. Above this point, walls should be plastered preferably with acoustical plaster in the more noisy areas. . . .

Partitions, preferably of glass and steel, are desirable and essential for certain areas in the laboratory. Ideally, the maximum integration takes place where no partitions exist; therefore, in practice, partitions when used should be such as to preserve, as far as possible, the unity of the laboratory by maintaining maximum visibility between the areas. A forty-two inch steel partition with the remainder being glazed to the ceiling best serves this purpose. Movable partitions if possible.137

Illinois Board of Vocational Education and Rehabilitation suggested:

Floors should be adapted to the type of activity to be carried on, and made of a material that will not become slippery. Hardwood or wood blocks on end are desirable. Concrete is best for hot metal and power mechanics. Concrete floors are satisfactory when covered with grease-proof asphalt tile. Floors for Industrial Arts laboratories should not have slopes, sumps or drains except in automotive and power mechanics laboratories. Automotive laboratories should have a floor drain with grease trap.

137Ohio State Department of Education, op. cit., p. 6.
In floor surface maintenance, no preparation should ever be used which will become slippery from use. Floor seals, waxes, and polishing materials may produce this effect.

Concrete block walls painted in an attractive color are frequently used in laboratories and drawing rooms.

Bearing and non-bearing walls including inside partitions should be of non-combustible construction.

Walls and ceilings should be light in color.

Leading paint companies now make excellent recommendations as to colors.

Interior partitions should be so constructed that they may be removed or changed without affecting the building support.138

Kentucky State Department of Education suggested the following construction materials:

Most modern school buildings are constructed using reinforced concrete, and for that reason there will usually be a base or sub-floor of concrete. However, most laboratories should have a covering over the concrete. Several excellent types of floors are available and appropriate. Asphalt and rubber tile, cork, and several composition materials are satisfactory. But certain heavy shops require a different treatment. . . .

All walls should be treated with glazed tile or epoxy resin to a height of four or five feet.139

New York State Education Department recommended:

Matched maple flooring, treated with a nonslip finish, is the best for most school shops. In the areas where hot metals are worked or where the floor is subjected to considerable oil, grease, dirt and water, concrete floors are recommended. In all cases, a suitable subflooring is necessary for anchoring and supporting heavy items of equipment.

If mastic or nonceramic tile is desired for floor treatment, the following requirements govern its

138Illinois Board of Vocational Education and Rehabilitation, op. cit., pp. 7-8, 10.

selection. It must have high impact strength to resist denting by falling objects and from heavy objects resting on small surfaces; it should be impervious to acids, water, oil and other materials to which it may be subjected; it must be slipproof and for some situations, fireproof.

The lower portion of shop walls, up to a height of four or five feet, should be made of a durable hard-surfaced material which can be easily cleaned. It should have a pleasing color and texture. Glazed brick, glazed tile or Keene cement are satisfactory materials for this purpose. In situations where a separate wing of the building is devoted to shopwork, good quality, carefully laid cinder blocks are satisfactory providing they are properly sealed and painted. The walls above a wainscot or wainscot height should be treated with a nonglare material. 140

In the book from Rockwell Manufacturing Company, the following was suggested:

Although concrete today is the most used floor material, it is possibly the most unsatisfactory. In general, concrete should be used only in the "hot metal" area or other similar areas where a fireproof floor is absolutely necessary. Concrete floors, unless properly treated, may cause both a safety and health hazard. Even when sealed or painted to eliminate the dust problem, they are still hard and, in addition, slippery. The actual floor material used should depend on the activity involved for that specific area. Wood flooring is generally recommended. Probably the most expensive flooring and the best is either end grain wood block or a "parkay type." With this type of floor, it is much easier to replace a damaged section than with a normal hardwood floor. Maple is generally recommended over oak because of its ability to resist splitting. Tile floors have recently become popular due to the ease of replacing individual tiles, and because of their low initial cost. Some caution should be exercised in specifying the exact type of tile due to solvents and other inherent damaging effects when used in a shop or laboratory. . . .

Although cost is a definite factor, acoustical material or treatment is highly recommended for the

140New York State Education Department, op. cit., p. 9.
ceiling. In addition, it is often possible to also use acoustical plaster on the walls, down to approximately five feet of the floor.

The lower wall areas should be tile, ceramic block or other easily cleaned durable material. Certain epoxide paints are also excellent when used on normal construction block.\(^{141}\)

A study of the literature pertaining to the materials to be used for walls, floors, and ceilings disclosed the following:

1. Floor material for areas such as power mechanics, metalworking, foundry, welding, or any area where the floors are subjected to oil, grease, dirt and water should be concrete.

2. Floor material for all other areas should be hardwood, end-grain wooden blocks (maple wood preferred), or tile over concrete.

3. Ceilings should be acoustically treated.

4. Partition walls should be nonweight bearing.

5. Walls to wainscot height, approximately four or five feet, should be surfaced with some durable material easily cleaned and of pleasing texture and color. Materials for this purpose may be mat glazed tile, ceramic block or salt glazed tile, glazed brick or epoxy paint.

6. Upper walls should be treated with a nonglare acoustical plaster.

Chalkboards and Bulletin Boards

Chalkboards and general bulletin boards should be provided in all laboratories, according to New York State Education Department\textsuperscript{142} and Mississippi State Department of Education.\textsuperscript{143} Suggestions from Mississippi State Department of Education concerning bulletin boards were that "a general bulletin board with an area of approximately twenty-four square feet should be placed near the entrance of the shop, the tool center, drinking fountain or wash sink. Additional smaller bulletin boards convenient to various work centers are desirable."\textsuperscript{144} New York State Education Department agreed with the above; however, they recommended an area of approximately sixteen square feet for a bulletin board.\textsuperscript{145}

With respect to chalkboards, New York State Education Department suggested:

Chalkboards should be provided in the teaching center of all shops. It is recommended that a minimum of thirty-six square feet of chalkboard that is more highly reflective than slate blackboard be installed. When thirty-six square feet of surface is inadequate, vertical sliding panels or book-type boards should be considered.\textsuperscript{146}

\textsuperscript{142}New York State Education Department, \textit{op. cit.}, p. 25.
\textsuperscript{143}Mississippi State Department of Education, \textit{op. cit.}, p. 27.
\textsuperscript{144}Ibid.
\textsuperscript{145}New York State Education Department, \textit{op. cit.}, p. 25.
\textsuperscript{146}Ibid.
Mississippi State Department of Education's recommendation varied from the above in that it was suggested that the chalkboards be portable and that they should also be provided in classrooms. It was also suggested that a minimum of twenty square feet of chalkboard be provided.  

Bateson was in complete agreement with the suggestions contained in the material supplied by the Industrial Arts Consultants for the State of Georgia by suggesting approximately thirty to thirty-five square feet for a chalkboard area. For the tackboard area approximately twenty-five square feet was suggested.

Florida State Department of Education suggested, "Tack boards and chalkboards should be placed at strategic locations in each shop with at least four lineal feet of tack board and eight lineal feet of chalkboard at proper heights."

Illinois Board of Vocational Education and Rehabilitation recommended the following concerning chalkboards and bulletin boards:

---

147 Mississippi State Department of Education, *op. cit.*, p. 27.


Chalkboards and bulletin boards should face the light source.
Minimum or eight (8) linear feet of chalkboard per laboratory.
Minimum or twelve (12) linear feet of chalkboard in each drawing room.
Chalkboard should be at least three and one-half feet wide.
Minimum size of bulletin board thirty-two (32) square feet.
A separate bulletin board should be provided in each laboratory.151

West Virginia Department of Education suggested that four to six linear feet each of chalkboard and tackboard be provided for the laboratory (general shop). For the planning-conference room, it was suggested that ten to fifteen linear feet each of chalkboard and tackboard with map and display rail above be provided. For the mechanical drawing (drafting) room fifteen to twenty linear feet each of chalkboard and tackboard with display and map rail above was suggested.152

Based upon the preceding data, it was found that all of the sources presented recommendations for chalkboards. Four sources gave recommendations for tackboards, while the remaining three suggested bulletin boards. Since bulletin boards and tackboards are synonymous, ensuing recommendations will refer to bulletin boards.

151 Illinois Board of Vocational Education and Rehabilitation, op. cit., pp. 10-11.
A study of the preceding data also revealed that the space to be provided for chalkboards and bulletin boards was recommended in terms of square feet and linear feet. Therefore, approximate calculations were made so that the following recommendations could be presented in square feet.

After considering the above-mentioned facts, findings were as follows:

1. A minimum of thirty square feet of chalkboard should be provided in each laboratory and classroom.
2. Approximately thirty to fifty square feet of chalkboard with a map and display rail above should be provided in the planning-conference room.
3. Approximately fifty to seventy square feet of chalkboard with a map and display rail should be provided in the drafting room.
4. Chalkboard rather than slate blackboard should be installed.
5. Chalkboard should be at least three and one-half feet wide.
6. A minimum of twenty square feet of bulletin board should be provided in each laboratory and classroom.
7. Additional smaller bulletin boards, strategically located, should be provided in each laboratory.
8. Approximately thirty to fifty square feet of bulletin board should be provided in the planning-conference room.
9. Approximately fifty to seventy square feet of bulletin board should be provided in the drafting room.

Data secured from current literature concerning the safety and health and special facilities areas were presented in this chapter. The data were synthesized and recommendations were presented after each section. The sections included in this chapter were as follows: lighting, heating, ventilating and air conditioning, acoustics, exhaust system, electrical system, plumbing facilities, fire extinguishers, power equipment, construction requisites, material for walls, floors and ceilings, and chalkboards and bulletin boards.

Through a synthesis and analysis of the recommendations presented in Chapters III and IV, tentative standards for use in planning and equipping new industrial arts laboratories or renovating existing industrial arts laboratories were ascertained. The tentative standards were formulated, and the data are presented in the Appendix of this study.
CHAPTER V

SUMMARY, FINDINGS, AND RECOMMENDATIONS

Summary

This study was made to determine what constitutes adequate or desirable physical facilities for industrial arts laboratories in public schools, and to develop standards that may be used by school administrators, teachers, and architects when planning, equipping or renovating industrial arts laboratories. Recommendations concerning the planning and equipping of industrial arts laboratories were secured from professional literature and from publications available or supplied by eleven State Departments of Education.

Chapter I introduced the study, and presented a statement of the problem and the need for the study. The purpose of the study, basic assumptions, delimitations of the study, definition of terms, sources of data, procedure, and a review of recent and related studies were also presented.

Chapter II was concerned with an analysis of the approved curriculum for industrial arts offered in Texas schools to identify the types of learning activities and facilities needed in the industrial arts program to provide optimum teaching-learning situations.
Chapter III presented suggestions and recommendations found in professional literature and related materials concerning space requirements. The recommendations and suggestions concerning space requirements as a factor in planning and equipping of industrial arts laboratories were synthesized. Where a reasonable degree of agreement was found to exist between the recommendations and suggestions presented, they were restated and presented as tentative standards.

In Chapter IV a study was made of the literature concerning safety, health, and other special facilities unique to industrial arts laboratories. Some of these areas were lighting, heating, ventilating, exhaust systems, electrical power and plumbing. The data were synthesized and tentative standards were developed and presented.

Included in Chapter V are a summary of the study, findings based upon the results of the study, and recommendations.

The Appendix of the study contains the standards that were developed from the data presented in Chapters III and IV of the study. The standards are presented in the form of a check list and can be used by school administrators, teachers, and architects in planning and equipping or renovating industrial arts laboratories.
Findings

Findings, based upon the suggestions and recommendations, concerning the planning and equipping of industrial arts laboratories, secured from professional literature and publications from eleven State Departments of Education, are as follows:

1. Based upon the data presented in this study, it was found that there was close, but not complete, agreement between the eleven State Departments of Education concerning the recommended standards to be used in planning and equipping industrial arts laboratories.

2. It was found from the data presented in this study that there was close, but not complete, agreement between authors of the articles found in professional literature concerning planning and building industrial arts laboratories.

3. From the data presented in this study, it was found that there was close, but not complete, agreement between the eleven publications from the State Departments of Education and the authors of articles found in professional literature concerning the recommendations for planning and equipping industrial arts laboratories.

Recommendations

Based upon the results of this study, the following recommendations are presented:
1. Because of changing curriculums and the improvements of building materials and processes, it is recommended that research be conducted periodically with respect to all of the various aspects involved in the planning and equipping of industrial arts laboratories.

2. Due to the trend toward climatic control within school buildings, it is recommended that further research be conducted with respect to design and installation of adequate exhaust systems, central air conditioning, and central heating in industrial arts laboratories.

3. Based upon the data presented in this study, it is recommended that further research be conducted concerning exhaust systems. More specifically, what are the types of exhaust systems needed in the various instructional areas of industrial arts laboratories and the recommended amount of air needed to remove gases, wood shavings, dust, fumes, odors, vapors, and smoke from the different work locations.

4. It is recommended that further research be conducted involving individual pieces of power equipment with respect to the space needed on all sides of the equipment to insure safe operating conditions and adequate space to accommodate the largest piece of material commonly handled.
## APPENDIX

### STANDARDS FOR USE IN PLANNING PHYSICAL FACILITIES FOR INDUSTRIAL ARTS

<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Laboratory Construction:</strong></td>
<td></td>
</tr>
<tr>
<td>1. Width of laboratory</td>
<td>Minimum--30 feet</td>
</tr>
<tr>
<td>2. Ratio of width to length of laboratory</td>
<td>Minimum--1:1 1/2</td>
</tr>
<tr>
<td></td>
<td>Maximum--1:2</td>
</tr>
<tr>
<td>3. Location of laboratory in relation to grade level</td>
<td>Grade level</td>
</tr>
<tr>
<td>4. Location of laboratory in relation to main plant (in preference order)</td>
<td>In a wing</td>
</tr>
<tr>
<td></td>
<td>In a separate wing attached to the main building</td>
</tr>
<tr>
<td></td>
<td>In a separate building with a covered walkway connecting the two buildings</td>
</tr>
<tr>
<td>5. Shape of laboratory</td>
<td>Rectangular (avoid irregular shapes, such as &quot;U,&quot; &quot;L,&quot; and &quot;T&quot;)</td>
</tr>
<tr>
<td>6. Location of laboratory with respect to noise</td>
<td>Where it will cause the least interference to the rest of the school</td>
</tr>
<tr>
<td>7. Height of laboratory</td>
<td>One-story structure</td>
</tr>
<tr>
<td>8. Accessibility of laboratory</td>
<td>Accessible for adult and evening school use</td>
</tr>
</tbody>
</table>

**B. Laboratory Space:**

1. Square feet of floor area per student
### Facility and/or Feature

**Standard**

<table>
<thead>
<tr>
<th>Exclusive of storage, planning area, etc.</th>
<th>Minimum</th>
<th>Adequate</th>
<th>Desirable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Woodworking, metalworking, electricity and electronics, graphic arts, and handicrafts laboratories</strong></td>
<td>75 square feet</td>
<td>100 square feet</td>
<td>125 square feet</td>
</tr>
<tr>
<td><strong>b. Drafting laboratory</strong></td>
<td>50 square feet</td>
<td>75 square feet</td>
<td>100 square feet</td>
</tr>
<tr>
<td><strong>c. Power mechanics laboratory</strong></td>
<td>100 square feet</td>
<td>125 square feet</td>
<td>150 square feet</td>
</tr>
</tbody>
</table>

### Storage Space

1. Storage space for materials and supplies

<table>
<thead>
<tr>
<th>Minimum</th>
<th>Adequate</th>
<th>Desirable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Woodworking, metalworking, power mechanics, graphic arts, and handicrafts laboratories</strong></td>
<td>225 square feet</td>
<td>275 square feet</td>
</tr>
<tr>
<td><strong>b. Drafting laboratory</strong></td>
<td>150 square feet</td>
<td>175 square feet</td>
</tr>
<tr>
<td><strong>c. Electricity and electronics laboratory</strong></td>
<td>125 square feet</td>
<td>150 square feet</td>
</tr>
</tbody>
</table>

2. Storage space for pupils' property (small projects, aprons, etc.)
<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Woodworking, metalworking, electricity and electronics, power mechanics, graphic arts, and handicrafts laboratories</td>
<td>75 to 100 square feet per laboratory</td>
</tr>
<tr>
<td>b. Drafting laboratory</td>
<td>Coat rack with shelf above</td>
</tr>
</tbody>
</table>

3. Storage space for students' large projects

<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Woodworking, metalworking, electricity and electronics, and handicrafts laboratories</td>
<td>Minimum: 200 square feet Adequate: 225 square feet Desirable: 250 square feet</td>
</tr>
</tbody>
</table>

4. Storage space for equipment (tools, auxiliary machine parts, etc.)

<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Woodworking, metalworking, and electricity and electronics laboratories</td>
<td>Minimum: 50 square feet Adequate: 75 square feet Desirable: 100 square feet</td>
</tr>
<tr>
<td>b. Power mechanics laboratory</td>
<td>Minimum: 100 square feet Adequate: 125 square feet Desirable: 150 square feet</td>
</tr>
</tbody>
</table>

D. Special Rooms or Space:

1. Space for demonstration and/or instructional area inclusive of library and planning area

<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Woodworking, metalworking, electricity and electronics</td>
<td>Minimum: 400 square feet Adequate: 450 square feet Desirable: 500 square feet</td>
</tr>
<tr>
<td>Facility and/or Feature</td>
<td>Standard</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>power mechanics, graphic arts, and handicrafts laboratories</td>
<td></td>
</tr>
<tr>
<td>2. Space for teacher's office and conference room</td>
<td>Minimum: 100 square feet</td>
</tr>
<tr>
<td></td>
<td>Adequate: 125 square feet</td>
</tr>
<tr>
<td></td>
<td>Desirable: 150 square feet</td>
</tr>
<tr>
<td>3. Space for finishing room</td>
<td></td>
</tr>
<tr>
<td>a. Woodworking and metalworking laboratories</td>
<td>Minimum: 125 square feet</td>
</tr>
<tr>
<td></td>
<td>Adequate: 150 square feet</td>
</tr>
<tr>
<td></td>
<td>Desirable: 175 square feet</td>
</tr>
<tr>
<td>4. Space for assembling and gluing room or assembling area</td>
<td></td>
</tr>
<tr>
<td>a. Woodworking and metalworking laboratories</td>
<td>Minimum: 150 square feet</td>
</tr>
<tr>
<td></td>
<td>Adequate: 175 square feet</td>
</tr>
<tr>
<td></td>
<td>Desirable: 200 square feet</td>
</tr>
<tr>
<td>5. Space for blueprint or reproduction room</td>
<td></td>
</tr>
<tr>
<td>a. Drafting laboratory</td>
<td>Minimum: 125 square feet</td>
</tr>
<tr>
<td></td>
<td>Adequate: 150 square feet</td>
</tr>
<tr>
<td></td>
<td>Desirable: 175 square feet</td>
</tr>
<tr>
<td>6. Space for soundproof test booths</td>
<td></td>
</tr>
<tr>
<td>a. Electricity and electronics laboratory</td>
<td>Minimum: 180 square feet</td>
</tr>
<tr>
<td></td>
<td>Adequate: 210 square feet</td>
</tr>
<tr>
<td></td>
<td>Desirable: 240 square feet</td>
</tr>
<tr>
<td>7. Space for photography room</td>
<td></td>
</tr>
<tr>
<td>a. Graphic arts laboratory</td>
<td>Minimum: 125 square feet</td>
</tr>
<tr>
<td></td>
<td>Adequate: 150 square feet</td>
</tr>
<tr>
<td></td>
<td>Desirable: 175 square feet</td>
</tr>
</tbody>
</table>
Facility and/or Feature | Standard
---|---
8. Space for toilet facilities (if not accessible nearby) | Minimum: 100 square feet Adequate: 125 square feet Desirable: 150 square feet

E. Exits and Outside Doors:

1. Width of corridor door to laboratory
   a. Woodworking, metalworking, and power mechanics laboratories | 60 inches
   b. Drafting laboratory | Minimum: 30 inches
   c. Electricity and electronics, graphic arts, and handicrafts laboratories | Minimum: 48 inches

2. Width of service door
   a. Woodworking, metalworking, and power mechanics laboratories | 8 to 10 feet

3. Type of service door
   a. Woodworking and metalworking laboratories | Overhead or hinged double door with removable center mullion
   b. Power mechanics laboratory | Overhead

4. Additional doors for an outside entrance if overhead doors are installed | Minimum: 30 inches

F. Walls, Floors, and Ceilings:
<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Height of ceiling*</td>
<td>Minimum: 12 feet</td>
</tr>
<tr>
<td>2. Floor material</td>
<td></td>
</tr>
<tr>
<td>a. Power mechanics and metalworking or any area where the floors are subjected to oil, grease, dirt, and water</td>
<td>Concrete</td>
</tr>
<tr>
<td>b. All other areas</td>
<td>Hardwood, end-grain wooden blocks (maple wood preferred) or tile over concrete</td>
</tr>
<tr>
<td>3. Type of partition walls</td>
<td>Nonweight bearing</td>
</tr>
<tr>
<td>4. Height of wainscot</td>
<td>4 to 5 feet</td>
</tr>
<tr>
<td>5. Material or treatment of walls from floor to wainscot height</td>
<td>Durable material easily cleaned and of pleasing texture and color</td>
</tr>
<tr>
<td>6. Material for lower walls or wainscot</td>
<td>Mat glazed tile, ceramic block or salt glazed tile, glazed brick or epoxy paint</td>
</tr>
<tr>
<td>7. Material for upper walls</td>
<td>Nonglare acoustical plaster</td>
</tr>
</tbody>
</table>

**G. Visual Comfort:**

1. Ratio of window area to floor area in a laboratory  
25 per cent

2. Height of window sills

*If an auto lift is to be installed in power mechanics, the manufacturer of the auto lift should be consulted to ascertain if additional ceiling height will be needed.*
<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Woodworking, metalworking, electricity and electronics, power mechanics, graphic arts, and handicrafts laboratories</td>
<td>72 inches above the floor</td>
</tr>
<tr>
<td>b. Drafting laboratory</td>
<td>36 to 42 inches above the floor</td>
</tr>
<tr>
<td>3. Height of window tops</td>
<td>Ceiling height</td>
</tr>
<tr>
<td>4. General lighting system</td>
<td>Semi-direct, indirect, or semi-indirect (25 per cent upward, 75 per cent downward)</td>
</tr>
<tr>
<td>5. Artificial light source</td>
<td>Diffused of the fluorescent type fixtures</td>
</tr>
<tr>
<td>6. Lighting for precision or accurate work</td>
<td>Individual supplementary lighting</td>
</tr>
<tr>
<td>7. Illumination level</td>
<td>Adequate for night as well as during the day</td>
</tr>
<tr>
<td>8. Illumination effectiveness</td>
<td>Approach effect of daylight and produce a uniform distribution of shadow-free and glare-free illumination</td>
</tr>
<tr>
<td>9. Equipment and walls</td>
<td>Glare-free</td>
</tr>
<tr>
<td>10. Illumination level throughout laboratory on vertical and horizontal surfaces at bench height</td>
<td>Minimum: 50 foot-candles Desirable: 100 foot-candles</td>
</tr>
<tr>
<td>11. Illumination level on tabletop</td>
<td>Minimum: 100 foot-candles</td>
</tr>
<tr>
<td>a. Drafting laboratory</td>
<td>Minimum: 100 foot-candles</td>
</tr>
</tbody>
</table>
Facility and/or Feature ............................................. Standard

12. Illumination level for precision or accurate work areas
   a. Handicrafts, graphic arts, machine operations, and library and planning area
      Minimum: 100 foot-candles

13. Ceilings, walls, trim, and built-in equipment
      Light color with high reflection value

14. Light-reflection value of ceiling
      Minimum: 80 per cent
      Maximum: 90 per cent

15. Light-reflection value of walls
      Minimum: 50 per cent
      Maximum: 70 per cent

16. Light-reflection value of floor
      Minimum: 20 per cent
      Maximum: 30 per cent

17. Light-reflection value of wainscoting, workbench tops, furniture, trim and doors, and machinery
      Minimum: 30 per cent
      Maximum: 50 per cent

18. Light-reflection value of chalkboard
      Minimum: 15 per cent
      Maximum: 25 per cent

19. Light-reflection value of tackboard
      Minimum: 50 per cent
      Maximum: 60 per cent

H. Climatic Control:

1. Temperature controls
   Automatic individual room control

2. Temperature of laboratory 60 inches from floor
   68 degrees

3. Temperature variation from floor to 60 inches above the floor
   Not to exceed 5 degrees
<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Classroom temperature measured 30 inches above the floor</td>
<td>70 degrees</td>
</tr>
<tr>
<td>5. Heating system used in laboratory</td>
<td>Wall-unit ventilators with fan or split system (forced warm air and convectors) or radiant panel</td>
</tr>
<tr>
<td>6. Type of air cooling in laboratory</td>
<td>Air-conditioning with a complete dust control system</td>
</tr>
<tr>
<td>7. Location of radiators (if used)</td>
<td>Floor level, against wall, or recessed in wall</td>
</tr>
<tr>
<td>8. Ventilating system</td>
<td>Adequate to maintain healthful conditions while laboratory is in use</td>
</tr>
<tr>
<td>9. Minimum quantity of air per pupil supplied by ventilating system</td>
<td>15 cubic feet per minute</td>
</tr>
<tr>
<td>10. Fresh outdoor air included in air circulated</td>
<td>25 per cent to 30 per cent of total air</td>
</tr>
<tr>
<td>11. Air velocity past occupant during cooling season (outside air)</td>
<td>85 lineal feet per minute</td>
</tr>
<tr>
<td>12. Air velocity past occupant during heating season</td>
<td>25 lineal feet per minute</td>
</tr>
<tr>
<td>13. Ventilating system used in laboratory</td>
<td>Mechanical, either integral or separate part of main plant</td>
</tr>
<tr>
<td>14. Relative humidity of laboratory</td>
<td>Winter: 40 per cent, Summer: 50 per cent</td>
</tr>
<tr>
<td>Facility and/or Feature</td>
<td>Standard</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>15. Relative humidity of storage area</td>
<td>40 per cent</td>
</tr>
</tbody>
</table>

**I. Exhaust Systems:**

1. Installation of exhaust system                           | Each area served by a separate system                                    |
2. Finishing room exhaust system                             | Independent from other exhaust systems                                  |
3. Installation of exhaust system ducts                      | Overhead                                                                |
4. Facilities and equipment to be exhausted                  | Adequate exhaust system to remove gases, wood shavings, dust, fumes, odors, vapors, and smoke |

   a. Engine exhaust fumes, surfacer, belt sander, jointer, circular saw, disc sander, lathe, shaper, radial arm saw, oxy-acetylene and arc welding, electroplating, bluing, furnaces, blueprint or reproduction machine, photography (dark-room), glazing and finishing room, drying room, ovens, and cleaning and etching of art metals

5. Air exhausted from each spray painting booth             | (A) 125 cfm. per square foot of booth face opening measured from top of work surface to top of opening; or (B) 125 cfm. per square foot of booth floor area; (C) 1000 cfm. per booth,
<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Air exhausted from each welding booth</td>
<td>whichever is greater; or (D) 800 cfm. drawn from within 16 inches of each spray nozzle. Air to be drawn from above work location.</td>
</tr>
<tr>
<td></td>
<td>(A) 100 cfm. per square foot of booth face measured from top of work surface to top of opening; or (B) 100 cfm. per square foot of booth floor area; or (C) 1000 cfm. per booth, whichever is the greater; or (D) 600 cfm. drawn from within 12 inches of each welding arc. Air to be drawn from above work location.</td>
</tr>
<tr>
<td>J. Auditory Comfort:</td>
<td></td>
</tr>
<tr>
<td>1. Treatment of ceiling</td>
<td>Sound-absorbing materials</td>
</tr>
<tr>
<td>2. Treatment of floor</td>
<td>Noise-absorbing floor covering (if possible)</td>
</tr>
<tr>
<td>3. Treatment of upper walls down to wainscot height</td>
<td>Acoustical plaster</td>
</tr>
<tr>
<td>4. Treatment of lower walls up to wainscot height</td>
<td>Durable material easily cleaned</td>
</tr>
<tr>
<td>5. Material for lower walls</td>
<td>Mat glazed tile, ceramic block or salt glazed tile, and epoxy paint when used on normal construction blocks</td>
</tr>
<tr>
<td>6. Acoustical properties of materials</td>
<td>Capable of finishing and refinishing without losing acoustical properties</td>
</tr>
<tr>
<td>Facility and/or Feature</td>
<td>Standard</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>7. Mounting of machinery</td>
<td>Sound-absorbing bases</td>
</tr>
</tbody>
</table>
| 8. Sound-absorbing value of ceiling | Minimum: 50 per cent  
                                 | Maximum: 70 per cent |
| 9. Sound-absorbing value of wall | Minimum: 30 per cent  
                                 | Maximum: 60 per cent |

K. **Electrical Circuit:**

<table>
<thead>
<tr>
<th>1. Available voltage</th>
<th>110 and 220/440 volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Power circuit system</td>
<td>Three-wire, three-phase and single-phase</td>
</tr>
<tr>
<td>3. Branch power circuits</td>
<td>One per machine</td>
</tr>
<tr>
<td>4. Spare power circuit</td>
<td>One for every four active circuits</td>
</tr>
<tr>
<td>5. Overload protection on power circuits</td>
<td>Circuit breakers</td>
</tr>
<tr>
<td>6. Spare light circuits</td>
<td>One for every five active circuits</td>
</tr>
<tr>
<td>7. Overload protection for light circuits</td>
<td>Circuit breakers</td>
</tr>
<tr>
<td>8. Lighting circuit</td>
<td>Separate from circuits for machines and wall convenience outlets</td>
</tr>
<tr>
<td>9. Location of light switches</td>
<td>Near main entrance to laboratory</td>
</tr>
<tr>
<td>10. Convenience outlets</td>
<td>Installed on walls at intervals of 10 feet</td>
</tr>
<tr>
<td>11. Height of convenience outlets</td>
<td>Approximately 42 inches</td>
</tr>
<tr>
<td>12. Type of convenience outlets</td>
<td>Duplex with provisions for grounding cord</td>
</tr>
<tr>
<td>Facility and/or Feature</td>
<td>Standard</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>13. Spare circuits for convenience outlets</td>
<td>One for every four outlets</td>
</tr>
<tr>
<td>14. Power cut-off safety buttons</td>
<td>Remote control type installed on walls at intervals of 15 to 20 feet</td>
</tr>
<tr>
<td>15. Master switch</td>
<td>Remote control type with a red pilot light and provisions for locking</td>
</tr>
<tr>
<td>16. Location of master switch in each laboratory</td>
<td>Near instructor's desk or office</td>
</tr>
<tr>
<td>17. Raceway system for power circuits</td>
<td>Wireways</td>
</tr>
<tr>
<td>18. Installation of light circuit raceways</td>
<td>Concealed in ceiling</td>
</tr>
<tr>
<td>19. Fire alarm system</td>
<td>Integral part of main system, alarm system sounding station in laboratory</td>
</tr>
<tr>
<td>20. Service control panel</td>
<td>Flush with wall, provided with lock and conveniently located inside the laboratory</td>
</tr>
<tr>
<td>21. Installation of power circuit raceways</td>
<td>In floor or wall</td>
</tr>
<tr>
<td>22. Type of light fixtures, switches and devices in finishing or paint rooms</td>
<td>Explosion-proof (spark-proof switches and fixtures and vapor-proof outlets)</td>
</tr>
</tbody>
</table>

L. Plumbing to Accommodate Facilities:

1. Drinking facilities | One per laboratory located near the washing facility |
<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Washing facilities</td>
<td>One station per 10 students</td>
</tr>
<tr>
<td>3. Type and location of washing facilities</td>
<td>Semi-circular or sink mounted on the wall</td>
</tr>
<tr>
<td>4. Distribution of air and gas outlets</td>
<td>Located on the wall at 20-foot intervals</td>
</tr>
<tr>
<td>5. Water facilities</td>
<td>Hot and cold water in each laboratory</td>
</tr>
<tr>
<td>6. Traps for sinks</td>
<td>One extra large trap per sink to prevent wax, grease, paint, plaster of paris, cement, and other injurious materials from being washed into the drain pipe</td>
</tr>
<tr>
<td>7. Floor drain for power mechanics</td>
<td>One with grease trap</td>
</tr>
<tr>
<td>8. Work (slop) sink</td>
<td>One for each area of activity</td>
</tr>
<tr>
<td>9. Service sink</td>
<td>Each sink provided with an acid-resisting drain</td>
</tr>
<tr>
<td>10. Location of air compressor</td>
<td>Outside the laboratory proper</td>
</tr>
<tr>
<td>11. Location of piping</td>
<td>Inside the wall or along the wall</td>
</tr>
<tr>
<td>12. Automatic sprinkler system (in each area indicated)</td>
<td>Laboratory proper, tool cribs, storage rooms, and finishing room</td>
</tr>
</tbody>
</table>

M. Power Equipment:

<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Width of main aisle of travel</td>
<td>Minimum of 4 feet designated by painted lines</td>
</tr>
<tr>
<td>2. Space between machinery and equipment</td>
<td>Minimum of 3 feet</td>
</tr>
<tr>
<td>Facility and/or Feature</td>
<td>Standard</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>3. Color coding of equipment</td>
<td>Each piece of equipment color coded to comply with an approved color scheme (the Pittsburgh Color Scheme may be used)</td>
</tr>
<tr>
<td>4. Location of machines</td>
<td>To accommodate largest size of materials commonly handled</td>
</tr>
<tr>
<td>5. Location of machines for roughing stock</td>
<td>Near storage room</td>
</tr>
<tr>
<td>6. Arrangement of machines</td>
<td>Equipment used in sequential order is located in the order of their operation</td>
</tr>
<tr>
<td>7. Location of dangerous machines</td>
<td>Isolated away from the passage of students</td>
</tr>
<tr>
<td>8. Guarding of machines</td>
<td>All belts, pulleys, shaft couplings, and moving parts</td>
</tr>
<tr>
<td>9. Safety zones</td>
<td>Painted around each machine</td>
</tr>
<tr>
<td>10. Floor surface around machines</td>
<td>Nonskid surface on the floor around dangerous machines to prevent slipping (Ferrox, safety mats, sand on shellac or other nonskid paints)</td>
</tr>
</tbody>
</table>

N. Chalkboards, Bulletin Boards, and Display Areas:

1. Space for chalkboard
   a. Woodworking, metalworking, power mechanics, electricity and electronics, graphic arts, and handicrafts laboratories

Minimum: 30 square feet
Facility and/or Feature | Standard
--- | ---
b. Drafting laboratory | Approximately 50 to 70 square feet with a map and display rail above

c. Demonstration and/or instructional area | Approximately 30 to 50 square feet with a map and display rail above

2. Type of chalkboard | Chalkboard rather than slate blackboard

3. Width of chalkboard | Minimum: 3 1/2 feet

4. Space for bulletin board
   a. Woodworking, metalworking, power mechanics, electricity and electronics, graphic arts, and handi-crafts laboratories | Minimum: 20 square feet with additional smaller ones strategically located in laboratory

   b. Drafting laboratory | Approximately 50 to 70 square feet

   c. Demonstration and/or instructional area | Approximately 30 to 50 square feet

5. Display area | 30 cubic feet of lighted display case in each laboratory and 30 cubic feet of lighted display case in the main corridor of the school building

0. Fire Extinguishers:

1. Type of fire extinguishers | One for each exposure, i.e., class A, B, or C type fires, and marked and labeled conspicuously
<table>
<thead>
<tr>
<th>Facility and/or Feature</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Size of fire extinguishers</td>
<td>Sufficient size and in accordance with fire regulations</td>
</tr>
<tr>
<td>3. Location of fire extinguishers</td>
<td>On the wall convenient to fire hazard area</td>
</tr>
<tr>
<td>4. Upkeep of fire extinguishers</td>
<td>Inspected frequently and recharged when necessary</td>
</tr>
</tbody>
</table>
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Letter from W. A. Mayfield, Consultant for Industrial Arts, Texas Education Agency, Austin, Texas, June 20, 1967.