COUNCIL ON TECHNOLOGY TEACHER EDUCATION

An affiliate council of the International Technology Education Association

CTTE Monograph 13

# Planning Technology Teacher Education Learning Environments

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Plant and Facilities Committee

**Plant and Facilities Committee, 1989 - 90**

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Appreciation is expressed to Delmar Publishers, Inc. for their generous financial contribution which provided partial support for the publication of this monograph.

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# Chapter 1

## Introduction

The world is presently undergoing major transformations brought about by rapidly advancing technological developments. No segment of our society goes untouched by the influence of technology; significant impacts are felt by all individuals, not only in our society, but in societies worldwide.

Clearly, economic and social systems throughout the world and particularly in the United States are in the midst of fundamental change. This change places great strain on our economic, environmental, and social structures, as well as our entire educational system. Within these arenas, technology is a double-edged sword; while it is the source of many of the problems, it is also the potential solution to our dilemma. It is imperative today, more than ever before, that students be provided with a better understanding of technology, including what it can and cannot do for us as well as its impact on our environment.

Preparation for the future has always been a major goal of education, and technology education is no exception. It is critical that people in a wide range of careers and occupations achieve a greater understanding of the technological world; without this understanding, it becomes less likely that they will be able to function effectively in tomorrow's society. Reports on problems in education in American schools have been produced by a number of educational commissions. One of the best known, *High School: A Report on Secondary Education in America*, funded by the Carnegie Foundation for the Advancement of Teaching (Boyer, 1983), stated:

> We must recommend that all students study technology: the history of man's use of tools, how science and technology have been joined, and the ethical and social issues technology has raised. . . . We are frankly disappointed that none of the schools we visited required a study of technology. More disturbing still is the current inclination to equate technology with computers. . . . The great urgency is not 'computer literacy' but 'technology literacy,' the need for students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history. The challenge is not learning how to use the latest piece of hardware, but asking when and why it should be used. (p. 304)

Technology teacher education is being influenced by many factors while simultaneously being defined within the profession. One of these factors is the scrutiny of the profession by individuals outside it. The problem is compounded by the fact that these individuals frequently look only at facilities. Unfortunately, in an attempt to gain an insight into what technology education is all about, many people look to the facility itself as the only component of the entire program to provide a concrete frame of reference. Yet technology educators realize that the facility, while it represents the end result of extensive curriculum planning and development, only provides a laboratory where students can meet the objectives and goals established for the program.

The preceding discussion applied to the industrial arts programs of the past. It is even more relevant as technology education programs are developed in the future. If the new program continues to utilize the same equipment in the same environment as the traditional industrial arts program of the past while embracing the label of technology education, it becomes very confusing to individuals who observe a change in name only. Technology education must make major changes, not only in the content of laboratory activities, but also in the planning and arrangement of the laboratories themselves. The technology education program must operate in laboratories equipped with the basic tools, machines, equipment, and energy sources found in the modern technological world. These laboratory facilities must provide an environment which is representative of modern technology, while being flexible and readily adaptable to changes reflected in our technological society.

A concerted effort must be made to move away from traditional content organizers which emphasize single-material laboratories such as woods, metals, and plastics, or specific physical phenomena areas such as electricity, energy, and power, to technological systems laboratories which have a much broader scope. The Jackson's Mill curriculum document (Hales & Snyder, 1981), (and most other current literature in the discipline) suggests that the cluster concept is the most appropriate organizer to use when developing curriculum content and laboratory facilities.

Although the four major clusters (communication, construction, manufacturing, and transportation) are the most common, some technology education programs have chosen other approaches. Regardless of the clusters selected, the important fact is that the programs should include conceptual learning rather than skill-specific information on a few limited materials. A potential problem arises when program initiators insist on maintaining and operating traditional laboratories while adding the word technology to the traditional course titles of wood, metals, and drafting. This practice conveys to students and the public that only the name has been changed, not the programmatic content or activities.

The design of today's laboratories and classrooms has too often been based on present and recent past circumstances or needs, with only a superficial look to the future. In an era of extremely rapid technological advancement and curriculum change such as we are presently experiencing in technology education, this procedure often results in facilities which can be obsolete before the building is completed. Since the physical structure is a sizeable investment, the obsolete facility then dictates, to a large extent, what activities are conducted in the laboratory, for years to come. It is imperative that educators, architects, and engineers work together to design facilities which will be functional in fulfilling the needs of students who will be active in the workplace during the 21st century. The design of facilities should be geared to emerging programs and instructional approaches which are now at the forefront of the profession.

The rapid changes occurring in all areas of technology and society will have an overwhelming influence on our educational system. No longer can a program survive and grow by teaching only skill-specific activities with little regard to the promotion of an understanding of the concepts and implications of human activity, the materials and products of the technological society, and the impacts of those activities on each individual. Technology education is that part of the educational program which concerns itself largely with preparing individuals to live in a technological culture. This monograph provides guidelines for the technology teacher education facility planner and includes discussion of a sequential development system for the planning of technology teacher education facilities which will best meet the needs of those individuals who are planning to enter the technology education profession. Appendices are provided to assist the planner with specific information for planning purposes.

# Chapter 2

# Planning Technology Teacher Education Facilities

## Introduction

The objective of this chapter is to describe a procedure that may be used to design a technology teacher education laboratory or to remodel a traditional industrial arts laboratory. The procedure involves five sequential components:

(1) formulation of a philosophy of technology education,
(2) identification of the purpose of technology education,
(3) development of a curriculum rationale,
(4) preparation of a curriculum plan, and
(5) completion of the needs assessment.

## Philosophy

It is important that technology educators formulate or adopt a philosophy of technology education that describes the context, and states the rationale for the development of the curriculum. The most widely accepted document that is used to establish the philosophical base for technology education is the Jackson's Mill curriculum document (Hales & Snyder, 1981). The CTTE Undergraduate Studies Committee (1989) based its monograph mainly on this document in order to arrive at a suggested undergraduate program for the technology teacher education curriculum. In their monograph, the Committee states that technology teacher educators tend to structure the subject in essentially two ways -- technology clusters and general technology. The most common technological clusters are communication, construction, manufacturing, and transportation, with biotechnology now emerging as a fifth cluster. The second method for categorizing subject matter is through the use of general technology, in which emphasis is more on system theory and critical thinking processes used to analyze the nature of the system than on technological systems. As an aid in developing a unified departmental philosophy, a good starting point would be to carefully study the CTTE monograph on undergraduate technology teacher education curriculum as well as the Jackson's Mill curriculum document.

## Purpose

The second component in the procedure is to state the purpose of technology teacher education. DeVore stated that a fundamental purpose of any technology teacher education curriculum is to teach the knowledge and skills necessary for individuals to become technologically literate (1983). Daiber and LaClair (1986) define an individual as technologically literate if that person has the ability: (1) to contribute to the improvement of society by using technology; (2) to assess technology; (3) to control technology; and (4) to adapt to a changing world. These abilities relate to specific skills and knowledge that all individuals should possess and thus form the basis for the development of the technology education curriculum.

## Curriculum Rationale

In order to prepare technologically literate individuals by using a technology education curriculum, educators must develop a curriculum rationale, the third component in the procedure. According to Lauda and McCrory (1986), that rationale presents assumptions about the students, the needs of society, the nature of the subject matter, a statement of the purpose of the curriculum, identification of data sources, and provides an outline of the subject matter to be taught (p. 32).

The first step in developing a curriculum rationale is to acquire data from students who are enrolled in technology education courses. These data will be used to aid in course design and curriculum planning. Relevant student data include: age, special needs, mechanical aptitude, attitude towards technology education, preferences regarding delivery systems, and educational and occupational plans; a list of technology education courses, general education courses, and vocational education courses which students have completed; and the identification of technology education courses students intend to take.

The second step in rationale development is to review the occupational needs of society which are changing as a result of the increasing complexity of our technological world. Consequently, these changes demand that individuals be prepared for employment and participation in life as technologically literate citizens. Dyrenfurth (1987) identified six levels of technological literacy: (1) citizen, (2) craftsman, (3) technician, (4) technologist, (5) engineer, and (6) scientist. Level one includes the knowledge, skills, and abilities required by all individuals, while levels two through six depend on an individual's occupational needs. The knowledge, skills, and abilities that individuals acquire through an interdisciplinary education (including technology education) should fulfill the occupational needs of society. Lauda and McCrory (1986) recommend that educators include cognitive, psychomotor, and affective domain components when technology curricula are being developed to ensure that students obtain a balanced education, and that the quality of the technology education curriculum is enhanced. The content of laboratory instruction within the technology education curriculum is dependent upon the desired educational outcomes which should be determined by the technology education teacher and other individuals responsible for the curriculum. Examples of such outcomes are: (1) Students will be able to apply technological principles using cognitive, affective, and psycho-motor skills; and (2) students will learn the knowledge and skills necessary for employment.

The third step in formulating the rationale is to identify the data sources, such as publications, individuals, and agencies, that will be used to develop the instructional materials. This step is extremely important since, if appropriate data sources are not identified, the content of the curriculum may not fulfill the occupational needs of society, or be relevant to the students. The subject matter taught in the laboratory should be identified by each technology teacher educator using the instructional objectives of the university's technology education curriculum as a reference. The subject matter outline should identify the topics, instructional objectives, sequence of instruction, evaluation methods, and instructional strategies which will be used.

Kemp and Schwaller (1988) identified six approaches to teaching technology education: (1) conceptual learning approach, (2) interdisciplinary approach, (3) social/cultural approach, (4) problem-solving approach, (5) integration of technology systems approach, and (6) interpretation of industry approach. Each approach has unique strengths and when the appropriate approaches are selected and combined in the teaching of the topics of technology education, the students can acquire a broad, in-depth understanding of technology.

In the conceptual learning approach, the focus is on conceptual understanding, with the objective of enhancing the transfer of knowledge across many situations. Specific content is used only to demonstrate the concept that is being studied and how it is applied.

The interdisciplinary approach involves applying the content and methods of appropriate disciplines to the study of technology education. For example, when studying the design, operation, and ramifications of nuclear energy, the objective is to describe and cultivate an understanding of the interrelationships among physics, technology, ethics, and sociology. This approach requires that science, technology education, philosophy, and sociology teachers function as a team to teach the identified content, and ensures that students are exposed to the breadth of subjects in technology education.

The social/cultural approach attempts to explain the relationships between the application of technology and the concomitant social and cultural impacts. These impacts have a direct effect on the decision-making process, and thus provide students with an understanding of what factors were utilized in the decision-making process in the selection of appropriate technology.

The problem-solving approach is currently favored by teachers who prefer to function as facilitators. Students are given problems of varying complexity and are expected to utilize their combined knowledge and skills to arrive at valid solutions to the specified problem. The strength of this approach lies in the requirement to use teamwork that enhances the utilization of knowledge and skills in the cognitive, affective, and psychomotor domains to solve the problems.

The integration of technology systems approach provides students with an understanding of the relationships among the systems of technology: production, manufacturing, transportation, and communication. Knowledge and skills are presented, and practice is within the larger context of systems rather than specific examples. This approach places emphasis on the understanding of the application and relationships between knowledge and skills as they are integrated in the enhancement of the quality of life.

The interpretation of industry approach involves studying how the various systems, manufacturing, transportation, communication, and production relate to actual industries. This approach provides students with a broad understanding of the role that technology plays in industry.

### Curriculum Plan

Once technology teacher educators have developed a curriculum rationale, a curriculum plan (the fourth component) can be prepared. According to Lauda and McCrory (1986), the curriculum plan provides the connection between the curriculum rationale and the actual needs of teachers and students in the school. This plan identifies and justifies the "arrangement of people, content, materials, time, space, and activities directed toward attaining desired educational goals and conditions" (Lauda & McCrory, 1986, p. 37). The curriculum plan contains information that is required during the completion of the needs analysis.

The selection or development of instructional materials is very important and very difficult. Teachers should base the instructional materials on the information and activities contained in the curriculum rationale. New materials can be developed or existing materials can be modified to fulfill specifically identified instructional objectives and goals. Representative instructional materials include textbooks, equipment, videotapes, movies, computer programs, handouts, and technical literature such as journals, magazines, and industrial manuals.

As the curriculum plan is completed, we must be concerned with whether or not we have the laboratory facilities to teach technology education. Until recently, technology education has been taught in existing industrial arts laboratories. Because of the differences between industrial arts and technology education, technology educators have realized that traditional industrial arts laboratories are not appropriate for technology education instruction. Traditionally, industrial arts laboratories are designed for the teaching of woodworking, electricity/electronics, plastics, ceramics, power mechanics, automotive, metalworking, graphic arts, and mechanical drawing skills (Seal and Goltz, 1975). Although technology education curricula will continue to include instruction in some of these skills, the instructional focus will be on the acquisition of knowledge and skills used in communication, manufacturing, construction, and transportation (Helsel & Jones, 1986). Therefore, as traditional industrial arts laboratories are remodeled or new technology education laboratories are designed, the properly planned laboratory will assist students in the completion of instructional objectives. This requires that technology teacher educators recognize the complexity of the design or remodeling project.

The design of technology education laboratories or remodeling of traditional industrial arts laboratories is a complex endeavor. The complexity is inherent in the difficulty of identifying equipment, determining facility needs, and identifying other instructional requirements used to support the technology education curriculum. The resulting challenge of developing a functional technology education laboratory requires that technology education administrators identify key design issues.

Braybrooke (1986) identified flexibility, safety, and quality of environment as the three key factors to be considered in technology education laboratory design. The purpose of identifying these issues is to provide philosophical guidelines around which the design or remodeling can occur. Flexibility is defined as the ease with which a classroom environment, laboratory environment, available equipment, and other resources can be adapted or used to teach various subjects. Safety is related to the personal safety of students, faculty, and support staff, the environmental health factors, and structural integrity that affect the completion of laboratory instruction. Quality of environment is related to the lighting, temperature, ventilation, humidity, classroom arrangements, access, and appropriate furniture within the laboratory.

### Needs Assessment

The fifth component in the procedure to design or remodel a laboratory for technology educators is to complete a needs assessment. The steps followed in conducting a needs assessment are: (a) appointing a needs assessment committee, (b) collecting data, (c) evaluating data, and (d) preparing a needs assessment report.

### Committee Appointment

A needs assessment committee should be established. The size and composition of the committee will depend on program size, school resources, and the scope of the proposed technology teacher education curriculum. The committee should consist of individuals who are familiar with the proposed technology teacher education curriculum, who possess appropriate knowledge of technology education, and who are competent in technology education laboratory operations. Needs assessment committee members may be divided into two classifications. The first classification includes personnel such as students, technology teachers, administrative members within the university, or a person responsible for the university budget, who have direct involvement in the program. The second classification includes individuals from the community, such as a safety professional (if the design or remodeling project is extensive) and an engineer or qualified architect. F.M. Johnson (1979) recommended that the school administrator responsible for appointing individuals to the needs assessment committee consider the appointment of three, five, or seven individuals. The rationale for having a committee consisting of an odd number of qualified individuals is to enhance the decision-making process and to prevent tie votes on critical remodeling decisions.

### Data Collection

Data collection is enhanced by using a needs assessment checklist (refer to Appendix A). This is a compilation of information to be collected, and questions to be answered, that have been identified in the literature (Gould, 1986; Huss, 1959; F.M. Johnson, 1979; Lewis, 1951) and while designing, remodeling, constructing, and maintaining research and technology laboratories at the University of Illinois, Urbana-Champaign (D.L. Rokke, 1988). A needs assessment necessitates the sequential enumeration of instructional requirements, the identification of equipment requirements and specifications, the completion of the engineering phase, and selection of laboratory furniture.

### Enumeration of Instructional Requirements

The instructional requirements that were identified during the development of the curriculum rationale and curriculum plan should be reviewed by the needs assessment committee.

### Selection and Acquisition of Equipment

There are two classifications of equipment that must be identified, based on the instructional requirements. Equipment may be classified as either instructional equipment or laboratory equipment. Instructional equipment includes audio-visual, computers used for instructional requirements, and associated classroom resources (Broadwell, 1976). Laboratory equipment includes those things which are used for demonstrations of technology experiments, production processes, manufacturing processes, communication processes, transportation processes, and computers used for equipment support and operation. The selection and acquisition of laboratory equipment hinges on three categorizations.

(1) Instructional equipment. Identification of instructional equipment depends on what delivery systems and approaches to teaching the instructor will use in the laboratory setting. Audio-visual equipment consisting of slide projectors, tape recorders, video records and players, overhead projectors, and audio systems are kinds of equipment that are used to support instruction. The identification of this equipment is completed by carefully examining the curriculum plan.

(2) Laboratory equipment. Selection of laboratory equipment, is dependent on the subject matter and instructional objectives. This process must be completed as a portion of the needs assessment. Equipment that can be used for instruction of more than one subject should be selected and acquired since flexibility is a key design issue . Equipment that is both flexible and functional, and designed for specific needs, reduces equipment costs and enhances the learning process. It may be acquired through purchase, donations, rental, or loan programs. Equipment which is new or in operationally good condition can be obtained from organizations that act as clearinghouses for corporate donations, by paying shipping costs. Also, numerous school/business partnership support programs exist. These often take the form of loans of equipment commonly used in specific businesses, or direct grants for equipment purchase. Local agencies and trade unions may also provide loans of equipment if they understand the value of participation in instruction and training.

(3) Equipment specifications. These include utility criteria, such as electrical power requirements, humidity and temperature control specifications, and structural requirements necessary for equipment operation. It is important that equipment specifications be identified prior to designing the laboratory. During the selection of equipment, it is also important that technology educators consider instructional needs and the possibility of providing utilities needed for equipment operation. If utilities cannot be provided, then other equipment for which utilities can be provided should be selected. If the design is completed without considering the equipment specifications, problems in the adaptation of facilities for installation and use of equipment will occur. After technology educators have selected equipment and identified equipment specifications, the laboratory engineering phase may begin.

### Engineering Phase

This phase concerns the determination of facility requirements such as structural design and utility requirements. The guideline for structural design is *The BOCA Basic Building Code* (Building Officials and Code Administration, 1984). This code is followed throughout the United States, although regional guidelines may supplement it. The three key design issues, flexibility, safety, and quality of environment, apply in the determination of a structural design.

Laboratory equipment has unique characteristics such as space requirements, weight factors, stability requirements, and utility specifications. If a structure is not designed to accommodate equipment, then problems may develop. Doors, elevators, and service ramps should be designed for equipment installation, operation, and maintenance.

Structural design engineers should consider noise control, explosion-resistant design, fume dispersal, and utility access (Price, 1959). Additional concerns include material compatibility, decontamination properties, ease of cleaning, ceiling heights, wall or partition placement, and size of aisles. The development of programs that include special-needs persons requires that all facilities be designed to provide unlimited access (Erekson, 1981). As these structural design requirements are developed, the technology education teacher should prepare classroom and laboratory floorplans which identify the placement, space utilization, and relationships between the equipment and activities to be conducted in the facility. Upon completion of the structural design component, utility design and installation should be addressed.

Utilities and communication support required for the operation of laboratory equipment include electricity; combustible gases; compressed gases; vacuum systems; deionized and distilled water; steam; heating, cooling, and ventilation; exhaust systems; humidity control; potable water; drainage; lighting; and fire suppression. These are required for equipment operation, instruction, and laboratory maintenance. All three key design issues apply. An additional issue is accessibility. Access to all utilities is essential. Modification, maintenance, and safety requirements dictate that all utilities should be identified and accessible. Maintenance operations and laboratory modifications will be costly if utilities are enclosed within walls.

### Selection of Laboratory Furniture

The selection of laboratory and classroom furniture should be completed after identification of the instructional objectives since laboratory instruction may involve chemistry, biology, mechanics, physics, administration, or any manufacturing or construction activities. The selection of the laboratory furniture is dependent upon what will be taught. For example, instruction involving chemistry or biology requires benches that are easily cleaned and chemical-resistant, physics research requires stable and mar-resistant benches, construction and manufacturing require heavy wooden benches, optics instruction dictates the use of stable benches with mounting hardware, and electronics instruction requires non-conductive, smooth surfaces. All surfaces of benches should be non-absorbent, easily cleaned, chemical-resistant, mar-resistant and adaptable (Scientific Apparatus Makers Association, 1951).

The installation of benches with services available will depend on laboratory size, type of instruction, and bench design. The arrangement of drawers and shelves should be designed to meet storage requirements. There is a wide selection of shelving units available, and all shelves should be provided with doors for safety and security.

Bench height should comply with the fundamentals of ergonomics, the study of persons and their work environment (Murrell, 1971). A height of 36" for standing work, and 30" for sitting work is recommended. Chair seat height should be approximately 16" and stools should have back and feet supports.

Sinks, troughs, and piping selected for use in the laboratory should be chemical-resistant, breakage-resistant, and incorporate a tank for the neutralization of acid. They should be suitably located for convenience of use and the prevention of contamination.

It is important to remember that placement of laboratory benches and other furniture will affect air circulation, safety, traffic patterns, and activities.

### Data Evaluation

Designing or remodeling decisions should be made by the needs assessment committee only after collection and evaluation of the relevant needs assessment data, because the reliability and validity of these decisions are dependent on the quality of the needs assessment process. The collected data may be evaluated by using peer interaction, expert panels, content analysis, equipment analysis, or other appropriate methods. The objective of the evaluation is to enable members of the needs assessment committee to prepare the needs assessment report.

### Needs Assessment Report

Upon completion of the needs assessment, members of the committee should be able to identify the course objectives, course content, laboratory equipment, teaching aids, equipment specifications, engineering design criteria, and utilities required to permit the teachers to fulfill the purposes and instructional objectives of the selected technology education curriculum (Gould, 1986). These should be consolidated into a written report and submitted to the appropriate administrator responsible for the design or remodeling projects. The administrator should review the findings and, depending on the scope of the project, forward the needs assessment report to the maintenance staff, a contractor, or a qualified architect. The group or individual is then selected according to the complexity of the project and the ability of the selected group or individual to complete the project. Architects refer to the completed needs assessment as the program statement. This program statement is used to prepare the architectural drawings and engineering plans. As these design and remodeling needs are identified, members of the needs assessment committee must be aware of potential problems.

### Potential Problems

There are two potential problems that deserve special attention. The first concerns the identification of design and remodeling needs which are based on the proposed instructional objectives of the laboratory component that were identified during the needs assessment. These instructional objectives will determine whether available equipment and existing facilities can be utilized, which may result in fewer problems being encountered. However, if the proposed instructional objectives require equipment that is not available, then the needs assessment committee must identify the appropriate design and remodeling needs. If the committee identifies design needs or remodeling needs that are not based on instructional objectives, then instructional, safety, technical, and maintenance problems will likely ensue. Consequently, the designed technology education laboratory or remodeled traditional industrial arts laboratory may be obsolete before instruction begins.

The second problem concerns the effect of budgetary restrictions. Ideally, design or remodeling decisions should not be controlled by budgetary restrictions, but if such restrictions are imposed, the intended purposes of the proposed technology education curriculum, the instructional objectives of the proposed technology education curriculum, and the selected instructional strategies will have to be modified. These program modifications must not be allowed to adversely impact the quality of the technology education curriculum, the operational capability of the laboratory, or safety in the laboratory.

### Summary

The design of a technology laboratory or remodeling of an existing industrial arts laboratory for technology teacher education is a complex undertaking. The process includes five sequential components:

(1) formulation of a philosophy of technology education,
(2) identification of the purpose of technology education,
(3) development of a curriculum rationale,
(4) preparation of a curriculum plan, and
(5) completion of the needs assessment.

Each of these components is comprised of various steps that should be followed to complete the design process. It is important to remember that the objective of the project is to provide a technology laboratory that will be useful for short- and long-term curriculum needs. Unfortunately, technology educators are unable to predict future curriculum needs; therefore, all laboratory designs must be completed around the three key design issues: flexibility, safety, and quality of environment. Additional assistance in developing a technology education laboratory can be obtained by consulting the listed references, state agencies, and national agencies.

# Chapter 3

# Identification of Instructional Support Equipment

## Introduction

After selection of the specific courses to be taught in the technology clusters has been made within the parameters of the accepted knowledge-base structure, the process of identifying clusters of support systems can proceed. However, it is essential that the curriculum content, along with the selected activity-based teaching/learning labs, be the primary factors in determining what "things" are necessary to best support the students in their development. Too many times the learning activities are driven, or hindered, by the purchasing of equipment without due regard for the curriculum. As implied by DeVore (1980), a directed technology is for the preparation of future workers and citizens, and the goals of education must accommodate a curriculum that will enhance the ability of all individuals to adapt to the future.

In technology education, as in other disciplines, there are various identifiable support clusters. Probably the easiest cluster to identify is concerned with providing physical comfort to the learners, including the handicapped. Therefore, the furniture should be appropriate for the specific learning environment. All students need a home base which will provide them with an appropriate writing support surface. Most courses have need for problem-solving functions via either individual output or small group processing. There are ideas generated and recorded in all stages of development and complexity. Communication of these ideas through sketching and writing must be aided by the selection of furniture of appropriate size and design.

Depending upon the technology cluster, differing types of general-purpose equipment are required. Just as the industrial arts woodworking courses needed saws, jointers, and surfacers for processing lumber, the production cluster of courses (i.e., construction and manufacturing) requires common material separating, combining, forming, and conditioning equipment. Since the school setting is not a material product producing environment, but rather one in which the learner is nurtured and assisted in his/her development to be better prepared to function in tomorrow's world, the facility need not be equipped with industrial type items. Easy-to-move module units that can be combined or arranged into processing systems are desirable. According to Daiber and LaClair (1986), flexibility, mobility, and adaptability are primary focuses for the selection of equipment and furniture for the technology education cluster labs. However, the durability of equipment must not be sacrificed. Insist on well-built, proven brand name items which are safe and user-friendly.

General-purpose equipment might easily be shared among the cluster labs by locating it in a centralized or common area. Other situations might call for a central storage area from which the equipment could be checked out to the various labs when needed. However, when a method of equipment sharing is chosen, major pieces of equipment will stay in a given lab.

Smaller portable power equipment and hand tools can be handled in a similar manner. The specialized items generally need to be housed near their projected use area. In addition, the frequently used items need to be duplicated for placement in each area of use.

In the last two decades, education has been blessed with an onslaught of audio-visual enhancements that allow educators to bring simulated samples of our technological universe into the classroom environment. We now sit on the threshold of a multitude of user-friendly program systems, many of which are interactive. Practically all of these enhancements to our curriculum are electronically based and interfaced with computers.

Computers which interface with processing material-removal apparatus are still quite expensive. However, math and science concepts involved in the systems can be simulated, demonstrated, and understood through moderately priced labs. The *Principles of Technology* curriculum (CORD, 1985), consisting of 14 structured units, can be taught as two sequenced courses, or individual units can be used as supplementary material within technology clustered courses. Each unit of the *Principles of Technology* curriculum deals with the math and science concepts that pertain to the mechanical, fluid, electrical, and thermal principles on which modern equipment operates.

Many schools today own a satellite dish, which is an excellent state-of-the-art example of a communications system. This system can be studied to help students understand the principles and concepts that are involved in (1) the production of the system, (2) the operation of the system, (3) the sociological impacts brought about by the technology, (4) how governmental and private sector decisions contributed to its development, and (5) what its future applications might be. In addition to these teaching/learning applications, the primary function of the system (i.e., communication or information delivery) is available for direct use or recording for viewing at a later time.

The way in which we communicate with one another to develop and produce devices that will transport goods and services has now reached the state of high technology. Micro-processor electronics, computer-aided manufacturing, laser technology, synthetic material composites, and participatory management systems are examples of today's technology reaching for tomorrow's applications (Rokusek & Israel, 1988, p. 230). As a viable part of education, the technology education curriculum must actively incorporate these state-of-the-art developments. We need not duplicate the industrial segment of our technological world but, through selected teaching/learning activities of simulation, role-playing, audio-visual presentations, problem-solving, and intra-disciplinary concept understanding, we can assist the learner to become a productive citizen.

### Resource Availability

Having established the curriculum from the knowledge base and identified the systems to support the teaching/learning activities of the program, the problem of securing resources must be addressed.

First, we need to identify what is currently housed in the existing facilities. Most curriculum innovators have learned to modify and add to existing equipment holdings. Money has never been available (nor is it ever likely to be) for the disposal of present items and the purchase of all new, state-of-the-art items. Limited monies are usually available for supplementing equipment holdings, provided the local economy is strong.

Other avenues are available for attempting to upgrade equipment to support an enhanced curriculum. One method frequently employed is to write grant proposals specifically for purchasing equipment to implement exemplary programs or to introduce new technology into the school curriculum. Another approach is to establish partnerships with business and industry that are beneficial to both the school and the company. This must be an exchange -- equipment for the school program in return for worker retraining or knowledge/skills enhancement for the company employees. These types of partnerships are usually much more profitable than asking for an outright gift. Gifts tend to be resources outside the realm of state-of-the-art equipment.

Similar, yet different, is a partnership lease or loan agreement. This type of arrangement has the built-in provision for continual upgrading. This might be an important factor, since some types of equipment are advancing at an accelerated technological pace. For example, the computer industry has advanced very rapidly as a direct result of micro-processor development.

Stretching institutional budgets by cooperating with others through sharing policies is another way of gaining access to more equipment. The sharing of items demands great effort in cooperative planning, but quite often there are no major drawbacks. The benefits usually outweigh the disadvantages, particularly if the alternate choice means doing without needed equipment.

Finally, there is always the "design-and-manufacture-it-yourself" approach to getting equipment. This can be very time consuming, but the material consumption price is often quite reasonable. Acceptable, efficiently functioning apparatus can be designed and produced by students in manufacturing classes. To what better technology applications could the students be exposed?

### Analysis of Equipment Specifications

Technology education requires a change in philosophy more than a change in equipment, according to McHaney & Bernhardt (1988). For example, the primary function of the family car has always been to transport people from one location to another, whether it was produced in 1924, 1977, or 1990. Although the vehicles have changed in appearance during this time frame, the concepts of mass, movement, and distance have always been present.

For the last quarter-century, certain equipment requirements have been more or less standard for school environments. The contemporary programs of the '60s strongly recommended multi-purpose, portable equipment which was safe to operate. Recently, reference has been made to setting up module equipment units in simulated, mock, or short-run production enterprise systems.

With so much emphasis now being placed on problem-solving and critical-thinking activities, the students are often called upon to design and produce jigs, fixtures, or other accessory items to assist in product production. This can be an excellent learning activity. As material technology advances, so must the material processing; therefore, applications are continually being altered.

Model equipment kits are available, and should be considered with reference to the students' age level and appropriateness of the activity.

The maintenance of a good technology curriculum depends on the willingness of a teacher to stay in touch with current developments. Journals, conferences, exhibition trade shows, and communication with colleagues are all important in this area.

# Chapter 4

## Learning Environment Design

While the transition from industrial arts teacher education to technology teacher education may cause some teacher educators discomfort (even anxiety), it is certainly not the first time that we have been called on to cope with curriculum change. We have moved from manual training to manual arts, and from manual arts to industrial arts. Each time, groups of teacher educators were convinced that it was the end of the discipline; yet it survived and went on to better serve students and society.

The purpose of this chapter is to suggest guidelines for designing the learning environment for technology teacher education. Suggestions are included for planning classrooms, laboratories, and extended learning environments. Planners should be mindful of the adage, "the learned are prepared for yesterday, the learning for tomorrow." Technology teacher educators must, within reason, plan for tomorrow by rising above budget and facility limitations when designing learning environments. Designs can be implemented in stages as funds and space become available. Technology teacher education is now in its nascent stage; its needs will change as the discipline matures, as technology changes, and as new developments emerge.

### Classrooms

It is too soon to know whether separate classroom and laboratory facilities are preferable to combined classrooms and laboratories for technology teacher education. Based on experience with industrial arts teacher education, there seems to be little consensus for the design of a model learning facility. The separate classroom will be addressed under this heading, while the combined classroom and laboratory will be examined under the heading of "Laboratories."

In terms of broad expectations, the technology teacher education classroom should meet at least the following standards:

(1) Provide a model for technology teacher education graduates when they plan their own classrooms.
(2) Provide a safe and stimulating learning environment.
(3) Make possible the learning experiences needed to meet the objectives of a particular technology cluster.
(4) Be accessible to special-needs students and students of various abilities by the elimination of equipment and learning environment barriers.
(5) Provide secure storage for instructional devices, aids, and resources.
(6) Utilize existing classroom space and facilities.

Lecture areas should be planned for student reaction learning activities such as taking notes, listening to lectures, observing demonstrations, and viewing films, slides, video tapes, and transparencies. Seminar areas must be planned for student interaction learning activities such as small group discussions, displaying materials, and presenting reports.

### Special Considerations

Illumination and Visual Control. For most classroom activities, vision is the primary sensory channel for receiving information. Illumination, then, is a critical part of the design of any classroom; it is defined as a measure of the amount of light falling on, or incident to, a work surface or task from ambient and local light sources. Natural and artificial light must be mutually supporting. Windows must be at least six feet above the floor to avoid outside distractions and to permit use of wall space. North light is preferable. Windows on sides of the building exposed to the sun need to be tinted and/or solar screened to reduce temperature control requirements. Artificial lighting should be such that it permits full nighttime use of the classroom. Fluorescent lighting is preferred, but stroboscopic effects must be avoided. Lighting must be free of both direct and indirect glare, shadowless, diffused, and at a level to conform to the types of activities performed, according to standards developed by the lighting industry. Some typical footcandle (fc) levels for specific activities are presented in the table which follows.

| Activities | fc Levels Required |
|---|---|
| Working space where visual tasks are only occasionally performed | 9-19 |
| Performance of visual tasks of high contrast or large size; reading printed materials, typed originals, handwriting in ink, good xerography; rough bench and machine work; ordinary inspection; rough assembly | 19-46 |
| Performance of visual tasks of medium contrast or small size; reading pencil handwriting, poorly printed or reproduced material; medium bench and machine work; difficult inspection; medium assembly | 46-93 |
| Performance of visual tasks of low contrast and very small size over a prolonged period; fine assembly, highly difficult inspection, fine bench and machine work | 93-186 |
| Performance of very prolonged and exacting visual tasks; the most difficult inspection, extra fine bench and machine work, extra fine assembly | 186-464 |
| Performance of very special visual tasks of extremely low contrast and small size | 464-929 |

Table 1: Typical Footcandle Levels Required for Specific Activities

Lighting levels in the classroom need to be zoned so that footcandle levels can be varied to accomodate student activities such as note taking, desk work, and video tape viewing. Lighting fixtures, switches, and electrical outlets should be explosion-proof if there is any possibility of flammable or explosive fumes originating in the classroom or escaping into the classroom from a laboratory.

*Climate Control*

Discomfort caused by exposure to conditions outside the thermal comfort zone can distract a person from the task at hand and may increase the potential for unsafe work. The thermal comfort zone is determined by the nature of work being performed, air velocity, clothing, and radiant heat. This zone covers a temperature range of 66 to 79 degrees Fahrenheit and relative humidity from 20% to 85%. Provision for year-round use of facilities must be accomplished through heating, air-conditioning, and ventilation systems. Air-conditioning is necessary not only for student and teacher comfort and efficiency, but also for protection of equipment from rust and corrosion due to high humidity.

*Acoustics and Aesthetics*

Acoustical treatment of ceilings and walls is necessary to lessen internal noises as well as those that may come from nearby laboratories. While the overall noise level in technology education environments will not be nearly that of industrial arts environments, there is little excuse for acoustical noise (defined as unwanted sound) interrupting the learning process. The room should be finished in colors that sooth and relax. In Western culture, the order of color preference is blue, red, green, violet, orange, and yellow. While children prefer red-based colors this preference shifts toward the blue end of the spectrum as they grow older. Any paint manufacturer can recommend suitable colors. The paint chosen should be semi-gloss and washable in order to provide a safer, more pleasant, and easier to maintain classroom

*Utilities*

The standard utilities needed in a classroom environment (electricity, water, and sanitary fixtures) should be augmented by others dictated by classroom activities. Serious consideration should be given to the installation of at least one telephone line in the classroom to accommodate demonstration/use of communications devices such as modems and facsimile (FAX) machines.

*Teaching Resources*

In addition to the standard overhead projector and wall-mounted projection screen, a technology teacher education classroom needs several other permanently located teaching resources which are not on loan from a media center or shared with other classrooms. Video cassette recorders/players in both 1/2" and 3/4" formats are now as necessary as overhead projectors for technology education instruction. In the best of all possible classrooms, several TV monitors will be located around the room for easier viewing by students. Typically, these auxiliary monitors are attached to the ceiling on some type of swivel device for ease of viewing. Monitors can also be used in conjunction with a video camera to permit large numbers of students to view teacher demonstrations at close range.

Another visual device that is becoming indispensable to the technology teacher education classroom is an LCD computer screen projection panel which is used in conjunction with an overhead projector so that students can view computer-generated images from the back of the classroom. An alternative to the projection panel might be an LCD projector that projects computer images onto a large screen, much like large-screen projection TV. This system shares most of the resolution and clarity problems of projection TV. For easier viewing of projected visuals, light-blocking shades should be installed on classroom windows.

Another important resource that is needed in the technology teacher education classroom is a variety of professional periodicals. Editors of *Manufacturing Systems, Production Engineering, ID Systems, Materials Handling Engineering, Journal of Industrial Technology, Quality, T.H.E. Journal, TIES, The Technology Teacher,* and *School Shop/Tech Directions* publish articles about state-of-the-art technologies; many provide free subscriptions to qualified persons. Another way to secure free periodicals and journals is to ask local industries for discarded issues. *The Technology Teacher* and *TIES* offer valuable information about technology cluster learning activities.

*Furnishings*

Tables are preferred to arm desks in the technology classrooms. Many classroom study activities require lab manuals and resources which must be shared or opened for group use. At least one table should be fully accessible to students in wheelchairs. Adjustable chairs are preferred to stools. Tables and chairs need to be easily moved so that they can be arranged according to student activities. The cabaret arrangement (see Figure 1), for example, makes easier the formation of buzzgroups for team tasks, games, or individual study. A cabaret setting is especially useful during workshops or modules within a cluster. Each table can be designated for a specified activity. At the same time, sight lines and the closeness of learners encourage exchange of ideas. Large-group discussion is also possible with this configuration. The cabaret arrangement reflects an informal and flexible classroom environment.

A laboratory-type desk with a wet sink, natural gas, and multiple electrical outlets is a valuable aid to many of the exemplary demonstrations presented in technology teacher education.

Because of the ubiquity of computers and video display terminals (VDT) in the technology teacher education classroom, special attention needs to be given to them to ensure that ergonomic principles are observed:

(1) Referring to Figure 2, minimum leg clearance (A) should be 25", slide-out-shelf keyboard home row height (B) 28-31", countertop keyboard home row height (C) 26", mid VDT screen height (D) is the user's normal line-of-sight.

(2) To permit arranging the system, keyboard and monitor should be separate.

(3) A contrast of about 94% for the background versus foreground is recommended.

(4) For black and white VDT displays, dark symbols against a light background are preferable.

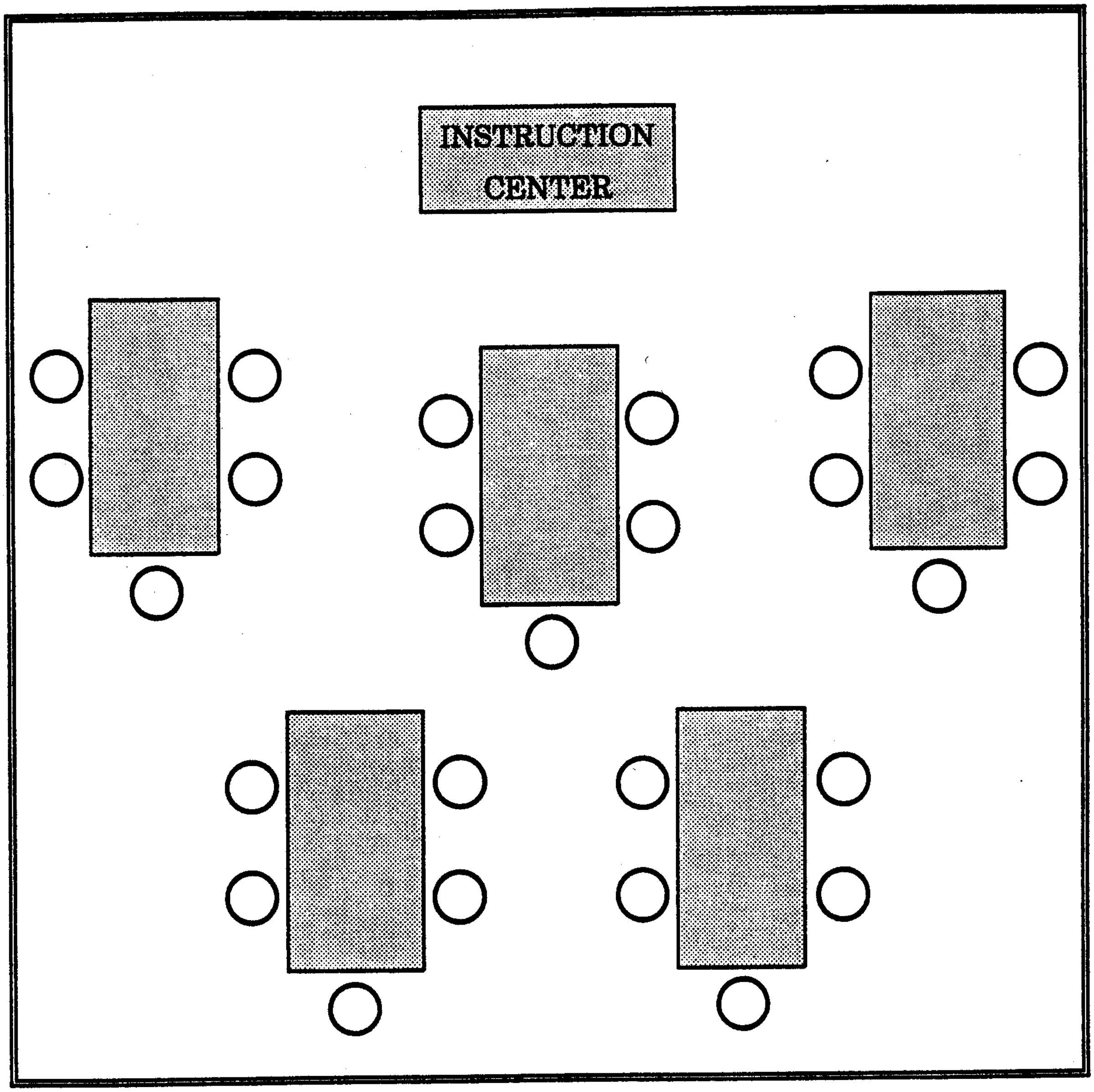
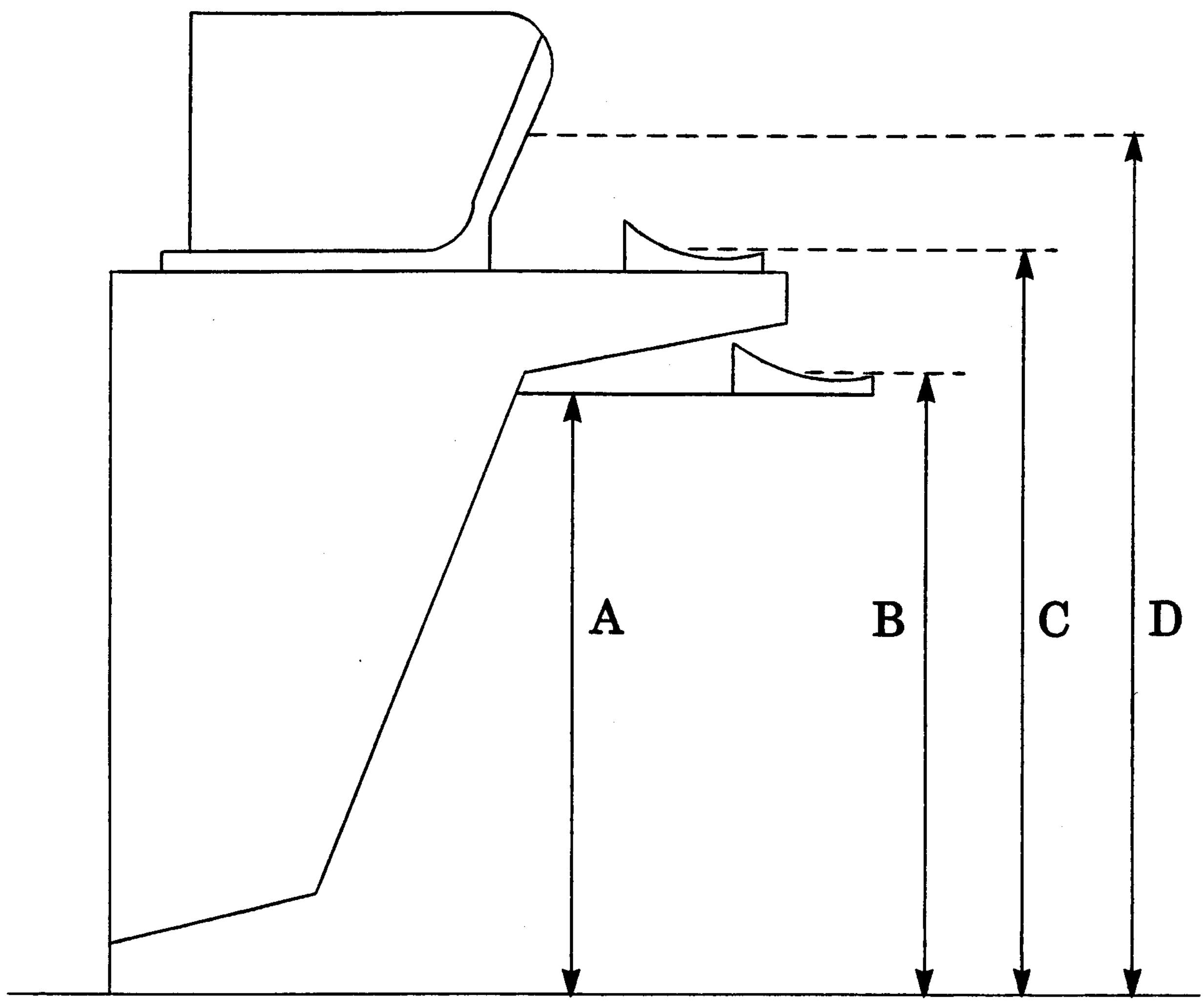



Figure 1. Cabaret Table and Chair Arrangement.




A = Minimum leg clearance (25")
B = Slide-out-shelf keyboard home row height (28-31")
C = Countertop keyboard home row height (26")
D = Mid VDT screen height = user's normal line-of-sight

Figure 2. Video Display Terminal Anthropometry.

(5) Glare should be minimized by using either a VDT screen that is deeply recessed, a hood or shield, an etched-glass screen, optical coating on the screen, or the system should be oriented so that ambient lighting comes from a direction to the student's side.

In any case, if classroom computers are shared with a laboratory, the computers need to be located in a "clean" room. Most desktop computers of the kind used in education are not packaged for dirty or dusty environments and will suffer accordingly if placed in them.

## Auxiliary Areas

### *Storage*

Vertical and horizontal storage need to be planned into or built into technology teacher education facilities. This storage can be shared with the laboratory or be for the exclusive use of the classroom. While racks and large storage areas for "raw" materials may be required in limited numbers, most of the storage space will be needed for the many small devices, resources, instruments, projectors, media, and other small-scale items that are common to all technology clusters. This is particularly true of the Principles of Technology resources, which will have to be placed in secure storage. Some instructors prefer large cabinets with doors for the storage of projects and other student materials, while others prefer open shelving. A portion of any storage space should be accessible to physically handicapped students. A central supply storage for heavy, bulky materials is recommended. This area should be accessible to the exterior of the building and the laboratory area.

### *Offices*

The old tenet that the instructor in charge of a particular laboratory should have an office located adjacent to it still has merit. Technology teachers acquire large quantities of books, magazines, and other resource materials for use in their courses. An office or resource room close to where these resources will be used makes the resources accessible and convenient for laboratory use. A central office shared by several instructors also requires less space and encourages discussion and cooperation within the department.

## Summary

The classroom as a learning environment in technology teacher education deserves the same attention to detail as does the laboratory. Those teachers who are fortunate enough to help design classrooms in a new building have an opportunity to customize their classrooms; they should not settle for what comes out of the architect's standards manual. Those of us who must retrofit our classrooms for technology teacher education have less latitude in design, but careful planning and consideration of alternatives can result in a very satisfactory learning environment. In either case, we need to plan for our present needs, as well as for future expansion.

## Laboratories

Any discussion of laboratories for the technology clusters inevitably raises the question, "Yes, but which clusters?" Answers abound, predicated upon such terms as "input," "output," and "process." A common example is the argument that energy/ power is an input, not a technology, and therefore does not qualify as a technology cluster by itself. Energy and power are then spread throughout the other clusters and dealt with as they affect each cluster. Another fruitful area of debate is whether two or more clusters can be collapsed into a single cluster; for example, construction technology and manufacturing technology have been combined to produce production technology. Either one or both of these postures may have some validity at the secondary level, but must be assumed with caution at the technology teacher education level. It is probably better to provide technology teachers with separate, in-depth courses in manufacturing, construction, transportation, communications, and energy/power, as well as a systems course like industrial and technological literacy. This arrangement has the advantage of preparing technology teachers with an in-depth content base for teaching either separate clusters or combined clusters.

### General Design Considerations

All of the recommendations for classrooms are applicable to laboratories. However, one of the more pressing needs in designing any cluster laboratory is removing equipment and learning environment barriers for the handicapped. Many teacher preparation institutions have taken or are taking steps to make their campus and/or specified buildings accessible. Buildings and grounds modifications are typically outside the influence of technology teacher educators, but we can do a great deal to make our laboratories accessible. Observing sound ergonomic principles will make any learning environment more convenient and comfortable not only for the handicapped, but for students across the whole spectrum of nonhandicapping physical attributes; for example, individual differences in reaching distance, height, and strength.

Barriers to the handicapped can be classified as either equipment or learning environment barriers. Equipment includes tools, machines, and other implements used to carry out activities in the laboratory, as well as instructional devices such as tape recorders, slide projectors, and other items used by students to support learning. Learning environment refers to other items, such as instruction manuals, diagrams, visual or auditory signals, storage containers, and equipment carts present in the learning environment that students must use, perceive, or comprehend, as the case may be, to be successful in their studies.

Pieces of equipment and learning environments, like buildings and grounds, place demands on those using them. To complete a learning activity, a technology teacher education student may have to manipulate objects, adjust settings, take readings and recognize their significance, exchange information with other students, and perform a host of other activities that require certain minimal levels of strength, vision, dexterity, hearing, speech, or intellectual ability; most of these are equipment or learning environment demands. A barrier results when demands made by equipment or the learning environment are very difficult to meet by all students.

When designing their laboratories, technology teacher educators have several options for minimizing equipment and learning environment barriers:

(1) Select a standard piece of equipment that does not lead to the problem in the first place. An example of this strategy is selecting a drafting table for communications technology that does not have a cross-member under the drawing surface that might impede the approach of a wheelchair. This option also permits nonhandicapped students to have easy access to the equipment.

(2) Provide the student with an aid that makes it possible to use a piece of equipment or to function in the learning environment. An example of this strategy is a stand magnifier that a visually impaired student can use to read wiring diagrams. However, such aids are sometimes expensive, difficult to obtain, and/or cannot be kept by the student at the end of instruction.

(3) Modify an existing piece of equipment to make it usable by a handicapped student. Using an amplifier to increase the volume of audible signals from a computer so that they can be heard by the hearing impaired student is a common example. In some cases, however, modifications can be complicated, expensive, or only done in a way that makes it more difficult for a nonhandicapped student to learn to use the equipment in its usual fashion.

Sometimes a demand is unavoidable because it is part of the cluster activity. For example, a student must adjust a piece of equipment to a specified value. At other times, demands are more dependent upon the design of particular pieces of equipment than upon the requirements of the activity. Thus, some demands arise because of the activity; others occur not because of activity constraints, but because of the particular piece of equipment or environment used to perform the activity; for example, reading tiny gauges, lifting items from high shelves, and reaching poorly placed controls. Good designs eliminate unnecessary demands as much as possible; poor designs multiply unnecessary demands and can interfere with the performance of even very competent students. Whether or not a particular demand leads to a barrier depends, of course, to a large extent on the innate characteristics and learned capabilities of the individual students. For example, a short person may face a barrier if supplies are on high shelves, while a tall person will not. For these and other reasons, sound ergonomic principles must be observed when designing and/or retrofitting a technology teacher education laboratory.

## The Systems Laboratory

"Systems Laboratory" is an emerging term designating a general laboratory for the study of several technologies and how they interact with one another. Alternative terms are "industrial enterprise laboratory," "technology systems laboratory," and "industrial and technological literacy laboratory."

Like it or not, the systems laboratory has several points in common with the industrial arts general shop. Both deal with multiple areas of study; the systems laboratory with multiple clusters, the general lab with multiple materials-centered areas (e.g., woods, metals, and plastics). Both aim at familiarization in these areas rather than skill building. Both lend themselves to at least two ways to structure content: all students study the same areas at the same time, or different students study different areas at the same time. At the teacher education level, it is recommended that all students study the same clusters at the same time so that both teacher education students and their teachers can give their full attention to each cluster and make the necessary connections between and among parts (clusters) of the system.

### *Designing the Laboratory*

Facility design will begin with a needs assessment which will answer such questions as:

(1) What clusters will be taught in the laboratory?
(2) How much space is required for each student?
(3) How much storage space is required?
(4) What utilities are required?
(5) What are the safety considerations?
(6) Will specialized rooms be required?

At the higher education level, the answers to many of the questions in a needs assessment will be provided by engineers, physical plant personnel, and architects, especially when building and other codes are involved. Again, the technology teacher educator needs to discourage these people from looking for all of the answers in books of standards.

Equipment that can be used for instruction in more than one cluster deserves primary consideration. Equipment specifications must be determined before laboratory design is completed. Designing the laboratory and then writing equipment specifications can result in problems when trying to fit equipment into already designed facilities. Laboratories should be designed around three related concepts: mobility, flexibility, and transformability.

Mobility permits movement of equipment and furniture within the laboratory as dictated by the cluster activity. If learning activities require an open space to build a structure, conduct speed tests of model vehicles, or stage a video presentation, for example, mobility will permit the teacher to bring in what is needed for an activity and to move out what is not needed. The concept of mobility applies especially to furniture and equipment.

Flexibility relates to hardware and to space. Benches and tables are designed to serve a variety of purposes. Flexibility is exemplified by modular hardware that allows a variety of uses of the same components in a range of different applications. Flexible facilities play a supportive role in student problem-solving, support the multiple use of instructional space, permit storage when not in use, and provide for more instructional activities without increasing the size of the available space.

Transformation refers to space plus hardware. Moveable and flexible equipment makes it easier to change things around within the laboratory learning environment. Transforming the laboratory is made easier by a modular overhead support grid in the ceiling, a flexible subsystem of services -- electrical, air, gas, water, and exhaust -- placed within the support grid, and mobile furniture and equipment. The ceiling can be used as part of the instructional facilities. This is done by using a space frame as part of a dropped acoustical ceiling or as an integral part of the structure. The use of this method is well established in industry and offers great promise in education for (1) hoisting away large models, (2) attaching lights for video productions, (3) securing visual barriers, and (4) attaching overhead storage conveyers in production activities.

### *The Floor Plan*

The layout of systems laboratories is similar to that of general shops. An example of a floor plan is illustrated in Figure 3.

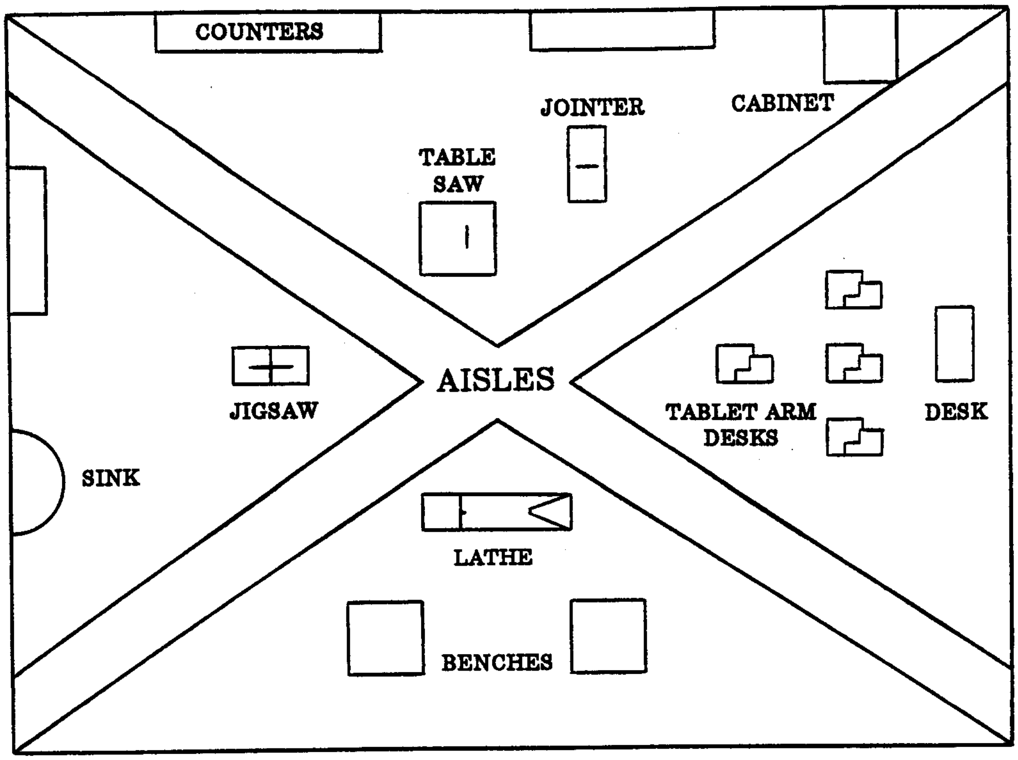



Figure 3. "X" Aisles Arrangement.

The essence of the layout is its "X" shape. Equipment common to all of the clusters can be located near the crux of the "X", while main aisles are formed by the legs of the "X". Equipment that is more specific to each cluster can be located further away from the center, as can equipment and device storage, planning centers, offices, and cleanup areas. Since several of the clusters, notably construction and manufacturing, require a variety of materials like lumber, plastics, and metals, facilities for storing them (and scrap) must be provided. These are best located on the periphery of the laboratory. A space for placement of equipment and furniture when a large open area is needed can be located on the periphery also. If the ceiling height in the laboratory is appropriate (14 feet minimum), a balcony can be an asset, but should not be used for storage.

Few data are currently available concerning the space requirements for technology teacher education laboratories, but some help is available from industrial arts. In the absence of codes or other legal guidelines, reasonable figures for the systems laboratory are:

| | |
|---|---|
| Minimum | 80 square feet per student |
| Adequate | 100 square feet per student |
| Desired | 125 square feet per student |

The shape of the laboratory can vary from square to rectangular, with a width-to-length ratio of 2:3 or no less than 1:2. These ratios lend themselves to more efficient travel lanes, better clustering of bench and machine areas, and more efficient supervision. Any shape that does not permit complete visibility by the instructor from any place in the laboratory should be avoided.

*Furnishings*

Unlike the classroom, the combined classroom/laboratory will not have room to accommodate tables and chairs for students to occupy while doing table work or while involved in reactive learning activities. Foldable tablet-arm chairs allow for easy storage as course enrollment varies. A few maple-topped workbenches will be needed in the laboratory, but are not advisable for use as desks; it is difficult to sit at them for any length of time without discomfort and their height makes them more suitable for standing work than sitting. Essentially, the combined classroom/laboratory will have the same furnishings as the classroom in addition to whatever facilities are needed to familiarize students with the clusters that will be covered in the systems laboratory.

*Clean Room*

Computers loom large in technology teacher education, but do not lend themselves to dusty surroundings. For that reason, a clean room is needed for housing computers and similar equipment. A clean room can control dust by utilizing a ventilation system that draws, filters, and conditions air from the outside to create a high-pressure zone. The high pressure keeps outside dust out and consequently maintains the cleanliness of the equipment and devices in the room.

*Safety*

While all standard safety precautions apply to the systems laboratory, special attention should be given to hazardous materials. While laws dealing with the use of hazardous materials do not apply to educational situations in all states, it is still a good idea to make material safety data sheets (MSDS) available to students and call their attention to them. It is surprising how many of the supplies and materials used in technology education are considered hazardous: finishes, solvents, lubricants, and even steel wool (a respiratory hazard).

*The Manufacturing Laboratory*

The manufacturing laboratory will probably contain the greatest variety of equipment and devices of all the cluster laboratories because of the variety of materials and products that are possible in the manufacturing cluster.

It must be kept in mind that the "grand project" that consumes a whole semester will not be produced in the manufacturing laboratory. Rather, students are likely to produce a series of smaller products that provide learning activities that help them master the concepts of manufacturing. Thus, this laboratory should embody mobility, flexibility, and transformability so that a variety of activities can be conducted.

*Special Furnishings*

It is difficult, and perhaps unwise, to recommend a list of equipment, devices, tools, and other special furnishings for all manufacturing laboratories in technology teacher education. Nevertheless, there are a few special furnishings that are fundamental and can be specified. These include:

CIM cell (CNC milling machine, CNC lathe)
Computer with printer and plotter
Wood storage rack
Metal storage rack
Plastics storage rack
Drafting table(s)
Reference library
Robotic arm
Surface grinder
Hardness tester
Optical comparator
Tensile tester
Impact tester
Circular saw
Jointer
Band saw
Planer
Drill press (bench type)
Sheet metal brake
Sheet metal shears
Heat treating oven
Electric or gas furnace with crucible
Oxyacetylene welder
MIG welder
Vacuum former (plastic)
Strip heater
Injection molder
Kiln
Telephone outlets

*Floor Areas*

Manufacturing laboratories need plenty of room for activities and storage. The following areas should be considered minimum:

| | |
|---|---|
| Laboratory | 2400 sq. ft. |
| Wood storage | 300 sq. ft. |
| Metal storage | 300 sq. ft. |
| Plastics storage | 100 sq. ft. |
| Instructional storage | 300 sq. ft. |
| Project storage | 300 sq. ft. |

Because of the nature and quantity of materials used in the manufacturing laboratory, it should be located on the ground floor and near a delivery area.

*The Communications Laboratory*

The communications laboratory probably contains more "high tech" equipment than any other laboratory. For that reason, security is a concern, not only in preventing theft, but also in insuring that equipment is not abused. Communications students may need to use other laboratory facilities such as the drafting laboratory and the graphic arts laboratory. This is especially true if communications is used to teach the fundamentals of drafting instead of offering a separate beginning drafting course.

There are at least three schemes for subdividing the communications cluster: (1) according to the transmitter and receiver of the communications transaction (human-human, human-machine, or machine-machine); (2) according to the channel or medium (electrical, electronic, or acoustic); or (3) according to the sensing mechanism used to receive the communication transaction (visual, auditory, antenna, or sensors). The choice of one or another of these schemes will have some impact on what is taught in this cluster and, consequently, what standard and special laboratory furnishings will be needed.

*Special Furnishings*

Sharing facilities with other specialized laboratories such as drafting, graphics will reduce the special furnishings needed in the communications laboratory. However, it is best if special furnishings are permanently located (not on loan or shared with other laboratories). The following list of special furnishings should be included in the communications laboratory:

Computers with ink jet printers and plotters
Computer-aided-design (CAD) system(s)
Desktop publishing systems
Darkroom with programmable vertical camera, enlargers, and film processors
Screen printing equipment
Light table
Drafting tables
Rubber stamp machine
Electronic bread boards
Clean telephone line (not through a switchboard)
FAX
Modem
Print copier -- diazo
Electrostatic photocopier
Pilot press
Rotary letter press
Shortwave radio
Offset duplicator
Satellite dish
Platemaker/exposure unit

Since cluster activities in communications do not generate dust and other air-borne particles, a clean room is not essential. However it cannot hurt to keep these special furnishings covered when they are not in use.

*Floor Areas*

Since much of the work done by students in the communications cluster is workspace-oriented, no large open spaces are needed for large products. Therefore, the floor area need not be quite as great as that for the manufacturing laboratory. Two thousand square feet will meet most needs. If a large number of drafting tables will be included in the laboratory, the floor space will have to be increased accordingly.

*The Construction Laboratory*

Like the manufacturing laboratory, the construction laboratory must embody the qualities of mobility, flexibility, and transformability because of the variety of activities and projects involved. A great deal of space is needed for such activities as building wall sections for purposes of illustrating concepts in plumbing, electrical wiring, and framing. Geodesic domes and inflatable structures are also space-consuming. It is likely that cluster activities will include a "real-world" activity such as building a small tool or storage shed for someone in the community. If it is not constructed on-site or modularized, adequate ceiling height and floor space must be available in the laboratory, and doors must be large enough to allow transportation of the project out of the laboratory. When these space-consuming activities are completed, the laboratory will have to be transformed for other activities and uses.

*Special Furnishings*

Furnishings in construction tend to be very specialized. These items should be considered when equipping the construction laboratory:

Computer with printer and plotter
Laser transit
Air compressor
Wheelbarrow
Stadia rod
Conduit bender
Fish tape
Framing squares
Radial arm saw
Panel saw
Saw horses
Drafting tables or CAD systems
Pneumatic staple guns
Pipe vise
Mortar mixing containers
Slump mold

*Floor Areas*

Floor areas for the construction laboratory need to be slightly greater than are required for the manufacturing laboratory because of the increased number of benches and the expanses of open space needed for construction activities:

| | |
|---|---|
| Laboratory space | 2800 sq. ft. |
| Wood storage | 400 sq. ft. |
| Metal storage | 100 sq. ft. |
| Plastics storage | 100 sq. ft. |
| Project storage | 300 sq. ft. |

Drive-in doors are helpful for delivery and exit. Again, because of the air-borne particles, a clean room should be provided for computers and peripheral equipment.

*The Transportation Laboratory*

The diversity of the teaching requirements for presenting the concepts of air, water, land, and space transportation make planning this facility difficult. However, the following specific items need to be considered when planning a transportation facility or area.

*Special Furnishings*

The following items should be considered for inclusion in the transportation laboratory:

Computer with printer and plotter
Band saw
Table saw
Jointer
Dynamometer
Wind tunnel
Drafting table(s) and/or CAD system(s)
Computerized or manual starting/timing device for model cars
Hot wire styrofoam cutter
Blower for wind-powered transportation activities
Electric model train
Large globe
Map cases
Radio-controlled model plane
Small engine stands

Since transportation technology involves vertical activities such as hot air balloons and rockets that extend beyond the height of the average laboratory, it is necessary that the outdoors become an extension of the laboratory. A clear space is needed for rocket launches and similar activities. It is necessary to observe any local regulations governing the launching of rockets, balloons, and any other objects that may go unusually high.

*Floor Areas*

While transportation technology activities require materials, such as wood, metal, and plastic, as well as a variety of kits, storage facilities on the scale of those for manufacturing or construction are not necessary. A storeroom of about 300 square feet with lots of shelves should be adequate for storage of both student projects and teacher resources. The transportation laboratory itself can be approximately 2400 square feet. If small engine repair is included in this cluster, additional space will be needed to store these items until the projects are completed.

*The Energy and Power Laboratory*

The activities in this laboratory are almost limitless. Much of the content for energy and power relates to electricity, electronics, and transportation, so many of the devices and apparatuses are the same or similar. A general laboratory setting is recommended with the following specific apparatuses.

*Special Furnishings*

Many of the devices and apparatuses used in this cluster will result from student learning activities:

Computer with printer and plotter
Power system/plant simulator
Transmission line simulator
Principles of Technology station(s)
Dynamometer
10-speed bicycle
Digital watt-hour meter
Small engine stands (if needed)
Ammeters
Voltmeters
Pneumatic power table
Hydraulic power table
Tachometer
Solar energy collector
Hot plate
Oxygen bomb calorimeter
Refrigeration
Digital scale
Digital thermometer
Photovoltaic cell array
Automobile alternator
Bicycle generator
Laser
Heat pump
Pyrometer
Electrical/electronic experiment stations

***Floor Areas***

Most energy/power learning activities will take place on table tops and bench tops. Therefore, much of the floor area in the laboratory will be taken up by tables and benches. As a starting point, consider the following:

| | |
|---|---|
| Laboratory | 2500 sq. ft. |
| Equipment and student storage | 400 sq. ft. |
| Materials storage | 200 sq. ft. |

## Extended Learning Environments

The most fruitful extended learning environments for technology teacher education are business, industry, and public works. Industry is always a good source of technical and technique information in manufacturing technology. In most cases, our technology teacher education clusters will use table top simulations of industrial techniques (e.g., materials handling), equipment (e.g., robots), and systems (e.g., CIM cells). Although these are excellent means to introduce students to these technology resources, they are no substitute for the real thing, which can be seen during visitations to industries that actually have them installed. Institutional policy and talents permitting, industrial personnel can teach units in on-campus courses.

The weakness in advocating too much reliance on industry visitations is that some technology teacher education institutions are located in areas that are not industrialized and/or in primarily rural areas. The next best thing may be media prepared by industry to demonstrate their processes and methods. Granted, these are primarily public relations media, but in most cases "selling" is kept to a minimum or blends nicely into the message. Sources of these media are Modern Talking Picture Service, Modern Video Center, and, to a lesser extent, West Glen Films. In most cases, these media cost nothing more than the postage to return them.

Industrial visits should be enhanced by visits to museums, environmental sites (sewage treatment plants, landfills, etc.), government agencies, and electricity generating plants. It is sometimes possible to arrange summer tours of national or international significance.

Another fruitful extension of the learning environment is collaboration with public/private schools with grades kindergarten through 12. It is often easy to lose sight of the realities of conditions in the field when working in the teacher education classroom.

Another phenomenon of the K-12 extended learning environment is that classroom teachers assume they need the same kind and complexity of equipment that they were provided in college. The classic case is the dedicated CAD system that college students learn on and then assume that is what they must have at the secondary level for the purpose of introducing students to computer-aided drafting. It is understandable that they will be familiar with the equipment and resources that provided their learning experience, and will not require a great deal of additional orientation to a new system.

# Chapter 5

# Options

## Assessment of Existing Facilities

Critically assessing a facility which has been "lived in" for several years may be a much greater challenge for the occupants than it would be for a new, eager instructor who has never seen the laboratory before. It is often much easier to be critical of something that is unfamiliar than of something one has been intimately involved with for many years. One may vividly remember building a tool panel eight years ago during spring break when everyone else was worshipping the sun on a white sandy beach. Such recollections may interfere with the assessment of how frequently students actually use all of the tools in the current program or whether the panel should be redesigned to meet current needs.

An objective perspective on assessing a laboratory can be acquired in several ways. Getting out to visit other programs and other facilities can be a most valuable experience for those who just "don't seem to get around much any more." A look at the innovations and attempts of others facing the dilemma of renovating an industrial arts facility for technology education instruction can be a tremendous boost for morale and a source of new ideas.

Keep in mind that many of our colleagues teaching in the secondary schools also have excellent ideas which they are implementing. It may be more practical and a lot easier to visit nearby exemplary junior or senior high school facilities than to travel out-of-state to another college or university. Keep in mind, however, that the program mission and the facility will need to be different.

Attending conferences and regional association meetings as well as supervising student teachers can all be excellent opportunities to acquire ideas and methods for improving the facility. Although there have been few presentations at conferences and conventions specifically addressing design or renovation of entire facilities, more can be expected in the near future as teachers remodel and then share their efforts with peers. Keep in mind that a compilation of several ideas and area design changes can quickly affect the overall laboratory design. Adopt or adapt these ideas to meet the needs of the program.

Many regional associations conduct their monthly meetings in the schools of the various members, thereby giving those attending a look at how the host is addressing the problem of facility transformation. This first-hand exposure to the facility and the opportunity to talk one-on-one with the facilitator is often invaluable.

Most laboratory instructors find it difficult to visit other programs due to their teaching obligations. Daytime visitations would require canceling classes or using vacation days coordinated with days when the exemplary school is still in session. Many instructors are reluctant to cancel their classes because of the impact of reduced instructional time. Others need their vacation time to recoup from the stresses and strains of long days and the multitude of obligations associated with trying to do a quality teaching job.

Supervising student teachers can provide faculty members with the opportunity to get out into the field to visit exemplary secondary school programs and facilities. Most colleges have specific faculty who are responsible for supervisory activities, which leaves little opportunity for laboratory instructors to get away. Rotating the supervisory obligation is possible if the college has a versatile faculty. Teaching some laboratory courses and supervising a few student teachers during a semester or quarter can achieve the objective, but places a heavy burden on the designated faculty member.

Although suggestions and ideas for retrofitting a laboratory may come from a multitude of sources, the very first place to look for direction must be the curriculum. This review could be done by the individual instructor who will be responsible for teaching the course, or it could be conducted by a group, team, or committee assembled for this task. Among the concerns to be addressed are: What courses are to be taught? What is the course content? How will the class be taught? Which room in the building will best meet the needs of the course content and instructional methodology? What needs to be done with this room to best facilitate instruction?

From these initial questions, an inventory or assessment of both the human and physical relationships to the course and facility should be addressed. Human concerns encompass such factors as the projected number of classes, number of students per class, range of students' ages, provision for students with handicapping conditions, and the technical capability of the instructor. Physical concerns would include the required working space per student (in square feet/student), number of work stations, lighting, heating/cooling, ventilation, and electrical, natural gas, and plumbing needs. Tool and equipment inventories must be compared with the projected needs of the technology program. Those items to be retained should be inspected for current condition and estimated remaining years of serviceability.

The laboratory checklist found in Appendix B may be of assistance in assessing a facility. It is intended to be used only as a guide since each laboratory, its related design, capacities, tools, and equipment must individually be dictated by the specific content of the curriculum taught within its confines.

### Modification or Expansion

As in home building, it most often is much more expedient to construct new facilities than to tackle the nightmares associated with remodeling an older structure where everything needs attention and nothing is square, plumb, or located in the designed configuration to meet needs or desires. Those who are able to start at the beginning are fortunate indeed.

After the faculty has reviewed the curriculum, assessed the human and physical relationships, acquired information from all practical sources, visited other facilities considered to be exemplary, and have comprehensively evaluated the facility, the decision must be made: where to begin?

Renovations which were evident at several teacher preparation institutions during their initial efforts in conversion to technology education fell into three general categories. These were based on the clusters of technology, the general systems of technology, and technology integration.

Where the cluster concept for the curriculum was adopted, laboratories addressing communications, construction, manufacturing, and transportation were under development. Some combined the construction and manufacturing facilities into one unit, designating it a production facility. Occasionally the cluster programs also offer instruction in biological technology, but few have considered establishing a separate facility. Instead, they have opted to include an area within one of the other facilities, most often the manufacturing or production laboratory.

Since the structure of general technology relies less on learning about the characteristics and functions of existing technological systems and more on systems theory and critical thinking processes used to analyze the nature of a system, a general laboratory organization somewhat reminiscent of the industrial arts general shop (but substantially modernized and updated) has been considered. The advantage of this general facility is that the diversity of machines, tools, and materials permits a multitude of different activities to be conducted simultaneously.

Some programs have chosen to integrate the newest technologies into modernized unit laboratories. The philosophy of these programs reflects the perceived need for technology education teachers to be both knowledgeable and skilled in materials and process areas to a depth greater than that of the students they will be teaching in the future.

Exemplary approaches to facility design for an integrated program are: computer-assisted design and drafting added to the technical drawing facility; graphic arts is now a part of communications; transportation and robotics are clustered with automotive systems; computer-aided machining is added to metals, woods, and plastics; lasers and digital electronics are combined with electronics; manufacturing is implemented in the material laboratories; and construction is delivered in the wood area. Energy studies can be included in transportation, manufacturing, or become a stand-alone laboratory depending on the perceived importance of in-depth study necessary. Most have found that a general facility is best for offering energy topics due to the broad requirements for materials, tools, and machines in an activity- and experiment-based program.

Most faculties will find it necessary to modify or expand existing facilities since few new laboratory buildings for technology education will be constructed in the near future. Only occasionally are additions made to existing buildings. Expansion in a time of declining enrollments and limited funding is generally not acceptable to administrators.

Expansion can also be considered within a building. If a curriculum is based on technology clusters, there will no longer be a need for separate wood, metals, plastics, ceramics, or other material-oriented laboratories. Expansion from one room to another is a definite possibility.

With the exception of those providing structural support, walls can frequently be removed or relocated to accommodate the new program. Exterior windows often must remain in their original positions, although some modification, relocation, or addition can facilitate study, as in the inclusion of solar panels.

Several former storage rooms and finishing rooms in existing facilities have already been renovated to serve as "clean rooms" for computers, mediated self-study rooms, television studios, communications centers, and laboratory libraries. Before eliminating all storage rooms, however, one should be aware that the diversity of study which will be taking place in the new facility may perhaps require even more storage capability than was formerly necessary. For instance, teaching photographic, graphic, audio, television, computer, laser, satellite, and interactive systems in a communications laboratory will probably mandate expanded, secure storage capacity rather than permit reduction.

No matter what the decision concerning the configuration of a facility, it is important to remember to design for flexibility. Technology is changing rapidly, and today's best efforts will be obsolete all too soon. Change is a constant if one is to provide a valuable educational program for students. One should be prepared for it. Expect it. Even welcome it. And remember that remodeling and renovation are constants in technology education.

### Final Decision

Even with professional, political, and peer pressures, the final decisions concerning what should be done and what will actually be accomplished to retrofit the laboratory resides with the faculty. Some instructors have been slow in accepting the move from industrial arts to technology education. The transition has been long and arduous, with many people nationwide contributing to the endeavor. A return to the past or a refusal to move forward is absolutely out of the question. Believing in technology education and the contribution that it can make to students' lives and society as a whole is of primary importance.

Time and money are also significant factors in making decisions as to what will happen in the facility. There are few people busier than the technology educator. In addition to all the usual committee meetings and associated obligations, faculty meetings, association meetings, and curriculum development, they are also expected to learn about, and develop expertise in the newest technology, remodel the facilities for which they are responsible, and teach students. Some faculty members are obligated to a single facility, but many instructors are professionally responsible for both instruction and facilities related to more than one cluster or system laboratory. (Involvement in family, religion, recreational interests, and additional employment will not even be discussed.) Long work days resulting in long work weeks, abbreviated weekends, and shorter vacations are all a part of teaching a quality program in technology. Yet many instructors would not desire it any other way.

Having adequate financial support to assist in preparing a laboratory for teaching technology education is essential. By liberating student materials and dedicating even more time, many instructors can build their own computer tables, construct a cabinet to house testing, measuring and analyzing instruments, and remodel area tool panels; but the computers, instruments, equipment, and associated tools must be acquired somehow. Technology is expensive.

Most instructors who are attempting to improve acilities are finding that contending with the lack of adequate funding is the largest concern. Facilities for CAD, CAM, lasers, robots, and other technical areas which they are expected to teach will be slow in development without appropriate support.

External funding is available in some areas and through various sources, especially if the state has organized its technology education program under vocational education. For those that place technology educaiton in the general education arena, vocational funding is simply not applicable.

When seeking external support, one should not overlook the possibility of acquiring materials, tools, instrumentation, and equipment in lieu of direct financial funding. Loans or demonstrations of equipment for extended time periods are often possible, especially from vendors who desire to have their products exposed to students who will be near-future purchasers.

Disposing of obsolete government-owned equipment can be next to impossible at many state-supported institutions. It may even be illegal for the faculty nmember or the deparment to handle such a transaction on its own. Private sales, public sales, or auctions can be a great way of getting rid of the old items no longer needed and acquiring cash to purchase new technology needs. Public notice in local newspapers is often required.

There is usually a great deal of red tape associated with private transactions, and accusations of conflicting interest can result if you should sell that old surface planer to a friend or purchase it yourself. Employing the services of an objective, qualified, used equipment appraiser who provides written estimates of value for each item is highly recommended and may be required by the administration. Trade-ins might be possible with some vendors, but many do not want your old shaper in exchange for a new CNC machine. To avoid legal problems, be sure to closely follow the established procedures and policies of the administration.

Administrative support varies from institution to institution. Financial as well as moral support is an absolute necessity in making a successful transition from industrial arts to technology education. Unfortunately, some administrators are unable or unwilling to provide either or both at levels which are necessary for a spirited conversion. Accepting a new curriculum and then providing financial support to implement it is commendable, but often difficult, in periods of economic deficiency. As professional adults, we must accept that sincere recognition and appreciation for commendable service is too seldom received from administrative levels.

Cooperation in the form of assistance through technical service personnel is also an important consideration. Old, heavy equipment often must be disconnected from its direct-wired electrical source and the unit removed from the laboratory. Instructors and students are often burdened with these tasks in expediting facility renovation. Legal and safety issues should be kept in mind as electrical work is performed by faculty or when students are asked to provide maintenance services. New equipment items which require on-site assembly, utility connection, setup, and performance testing should have these requirements included in the request for bids announcement. The instructor should not be responsible for these obligations.

Facility renovation is not an overnight occurrence. It takes planning, thought, creativity, much effort, and sometimes a bit of blood, sweat and tears. The adage, "Rome was not built in a day," still applies. Besides, next year or the year after, you probably will want to remodel it again anyway.

Isn't technology exciting?

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## Appendix A

## Needs Assessment Checklist

This checklist is designed to assist technology educators in completing the needs assessment component of the procedure to develop a technology education laboratory. The checklist is comprised of five sections. The first section concerns administrative information; the second section concerns identification of instructional requirements; the third section guides the selection and acquisition of equipment and the determination of equipment specifications; the fourth section aids in the determination of structural requirements and identification of utility requirements; and the fifth section guides the identification and selection of laboratory and classroom furniture. A separate report should be prepared for each question, with the question listed at the top of the page. There may be more than one answer to each question. Technology education teachers should attempt to answer all questions.

### Administrative Information

1. What is the allocated budget?
2. Who is responsible for project completion?
3. Who is responsible for laboratory safety?
4. Who can authorize changes in design or engineering aspects?
5. Describe any specific requirements that may affect design or construction.
6. What safety requirements must be adhered to?
7. What are the security requirements?

Additional questions . . .

### Instructional Requirements

1. What courses will be taught in the laboratory?
2. What are the audio-visual requirements?
3. How many students will be enrolled in each course?
4. How many sections of the same course will be taught simultaneously?
5. How many teachers will be involved in the program?
6. Which delivery systems will be used?
7. Which approaches to teaching technology education will be used?
8. What types of instructional materials are required for laboratory instruction?
9. How much time is allocated for each class session?
10. What will be the duration of each completed course?
11. What extramural activities related to coursework will students be involved in?
12. What percentage of each course is taught in the classroom?
13. What percentage of each course is taught in the laboratory?
14. What are the specific goals of each course?
15. What are the specific purposes of each course?
16. What are the safety hazards associated with instruction?
17. What are the anticipated curriculum needs:
    In two years?
    In five years?
    In ten years?

Additional Questions . . .

### Identification of Equipment Needs and Equipment Specifications

1. What laboratory equipment is required for teaching each of the courses identified in section one?
2. What instructional equipment is required for teaching each of the courses identified in section one?
3. Which pieces of equipment can be used to teach more than one course?
4. How many pieces of each type of equipment are required to teach each course?
5. How many students will be able to use each piece of equipment during each class period?
6. What are the laboratory equipment specifications?
7. What are the instructional equipment specifications?
8. How will equipment be acquired?
9. What are the specific safety hazards associated with each piece of equipment?

Additional Questions . . .

### Identification of Structural Requirements and Utility Requirements.

1. How many laboratories will be required?
2. What types of laboratories are required?
3. What are the access requirements?
4. Which utilities are required for each of the pieces of equipment identified in section two?
5. What are the heating loads?
6. What are the cooling loads?
7. What are the electrical requirements?
8. What ventilation requirements are needed?
9. The walls should be composed of what materials?
10. The floors should be composed of what materials?
11. From what materials should the ceilings be made?
12. From what materials should the utility lines be made?
13. What specialized rooms are required?
14. What are the coordination requirements among rooms, activities, and classes?
15. What are the specific requirements affecting placement of utilities?
16. What utilities already exist in the facility if this is a remodeling project?
17. What aesthetic requirements must be considered?
18. What are the storage requirements?
19. What are the administrative requirements?
20. What are the maintenance requirements?
21. What are the structural support requirements for utilization of specific equipment?
22. What are the potential noise problems that must be considered?
23. How much space is required for each classroom?
24. How much space is required for each piece of equipment?
25. How much space is required for each laboratory?
26. What is the desired classroom floor plan arrangement?
27. What is the desired laboratory floor plan arrangement?

Additional Questions . . .

### Identification and Selection of Laboratory and Classroom Furniture

1. What laboratory furniture is required?
2. What classroom furniture is required?
3. From what materials should the above identified furniture be constructed?
4. What are the placement specifications?

Additional Questions . . .

## Appendix B

## Facilities Checklist

The criteria in this checklist are generic rather than specific. Most will apply to every facility regardless of the curricular area being addressed. No attempt has been made to analyze the appropriateness of the interface between the curriculum and the facility. No consideration has been made for compliance with state and local laws or building codes. This list is intended to be a guide for an evaluator who is knowledgeable about educational facilities; therefore, it is not inclusive of all factors affecting all laboratories. The interface between human and physical factors is considered. Flexibility and adaptability should be consistently considered.

**A. General Location**
1. Location in relation to the main building
2. Location in relation to other laboratories
3. Delivery access
   a. location
   b. size
   c. driveway

**B. Laboratory Space**
1. Rectangular shape, 1:2 ratio
2. Total floor area
3. Area per student square feet
4. Ceiling height
5. Aisles

**C. Surface Treatment**
1. Floors
   a. appropriate material for area
   b. condition
   c. color
2. Walls and partitions
   a. appropriate material for area
   b. condition
   c. color
   d. acoustical material
3. Ceiling
   a. appropriate material for area
   b. condition
   c. color
   d. acoustical material

**D. Doors**
1. Student access/egress
   a. location
   b. size
2. Service access
   a. location
   b. size

**E. Windows**
1. Location
2. Size
3. Area
4. Height above floor
5. Control of natural light

**F. Heating and Cooling**
1. Size
2. Operation noise level
3. Control
4. Relative humidity

**G. Ventilation**
1. Adequate
2. Control

**H. Dust Control/Vacuum System**
1. Air purification system
2. Specific machines and equipment

**I. Illumination**
1. General lighting
   a. artificial
      (1) adequate
      (2) control
   b. natural
      (1) adequate
      (2) control
2. Task lighting
   a. artificial
      (1) adequate
      (2) control
   b. natural
      (1) adequate
      (2) control

**J. Electrical Service**
1. General availability
   a. voltages
   b. amperage
   c. phases
2. Convenience outlets
   a. adequate number
   b. location
   c. flexibility -- raceway, ceiling drops

   d. surge protection
3. Machine connections
   a. ease to connect/disconnect
   b. ease of relocation
   c. flexibility
4. Master control with multiple shut-off locations
5. Overload protection

**K. Other Utilities**

1. Natural gas
   a. experiment benches
   b. demonstration bench
   c. specific equipment
2. Compressed air
3. Water
   a. personal washing
   b. drinking fountain
   c. utility sink
   d. specified machines
   e. specified areas -- darkroom, etc.
4. Telephone
   a. jacks
   b. modem

**L. Major Area Considerations**

1. Instruction
   a. location
   b. size
   c. seating
   d. chalkboard
   e. overhead projector and screen
   f. television and VCR capability
   g. other mediated instruction capability
   h. tackboard
2. Instructor's area (office)
   a. size
   b. location
   c. privacy
3. Storage
   a. teaching materials
   b. student books, personal items, etc.
   c. student work (experiments, projects, activities)
   d. evening student work
   e. laboratory materials/supplies
      (1) active storage (small quantities)
      (2) inactive storage (large quantities)
   f. portable tools and equipment
4. Finishing area/room
   a. size
   b. lighting
   c. ventilation
5. Display areas
   a. central area of school
   b. corridor
   c. laboratory
6. Project/production assembly area
7. Laboratory library/resource area
   a. references, journals, textbooks, specification books
   b. television with VCR
   c. mediated instruction materials
   d. computer accessibility
   e. individualized instruction capacity
8. Computer area
   a. location
   b. clean environment

**M. Visual Supervision**

1. Ability to see all areas from any position in the lab

**N. Equipment/Machines**

1. Adequate to facilitate instruction
2. Appropriate for anticipated use
3. Meets physical needs of all students
4. Condition of maintenance
5. Logical placement
6. Safe operator area
7. Flexibility

**O. Tools -- Hand and Electrical**

1. Appropriate
2. Quantity
3. Quality
4. Storage facility -- panels, cabinets, etc.
5. Relationship of storage location to use area
6. Security
7. Flexibility

**P. Work Stations**

1. Sufficient number
2. Appropriate types for lab activities
3. Placement
4. Condition

**Q. Traffic Analysis** (consider physical needs of all students)

1. Aisle widths
2. Projections into aisles
3. Spacing between machines
4. Equipment placement for proper sequential use

5. Area-to-area
   a. corridor to instruction area
   b. instruction area to lab work stations
   c. work stations to finishing area
6. Laboratory-to-laboratory

**R. Safety**

1. Machine guards
2. Safety color coded equipment parts
3. Safety zones identified
4. Fire detectors
5. Fire extinguishers
6. Fire alarm system
7. Fireproof storage
8. Automatic sprinkler system
9. Safety glasses
10. First aid kit
11. Waste storage
    a. flammable
    b. toxic
12. Considerations for students with special needs

**S. Evidence of Proper Maintenance**

**T. Restroom Facilities**

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