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A PRELIMINARY INVESTIGATION OF PBTE AND CMI WITH IMPLICATIONS FOR RESTRUCTURING AN INTRODUCTORY COURSE IN INDUSTRIAL TECHNOLOGY TEACHER EDUCATION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

by

Niall Vincent Corwell, B.S., M.A.

* * * * *

The Ohio State University

1975

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CHAPTER I

THE PROBLEM

Introduction

American education in the mid-1970's is experiencing profound changes that are perhaps unparalleled in the entire history of education. Change has affected virtually all levels of education including the domain of higher education. The selection of the title Ferment and Momentum in Teacher Education for the 1974 Yearbook of the American Association of Colleges for Teacher Education (AACTE) is indicative of the current state of change in teacher education.

The National Association of Industrial and Technical Teacher Educators (NAITTE), in the 1974 publication A National Status of Study of Industrial Arts Teacher Education, stated:

Industrial arts teacher education is in a state of transition as professionals concern themselves with curriculum core structures such as Power, Graphic Communication, Materials and Processes, the implications of career education, the enterprise approach, the concepts inherent in the Industrial Arts Curriculum Project or other innovative programs (pp. 2-3).

In addition to evolving curriculum core structures, industrial arts teacher educators are also interested in exploring a number of concepts and developments that have impacted upon the educational system since the early 1960's. Such developments include the use of behavioral objectives, the systems approach to learning, individualized instruction, computer-based instruction, mastery learning, the personalized
system of instruction, performance-based instruction, modular instruction, and increasing emphasis on concepts, principles, and unifying themes.

In some instances the effective utilization of the new concepts and developments in traditional college courses necessitate that the courses be redesigned. The problem of this study centers on the redesign of an introductory, pre-service course for industrial arts instructors.

Industrial arts has been a part of general education within the American school system for almost a century. Currently, more than five million boys and girls are enrolled in industrial arts programs in the United States. These students are taught by some 45,000 industrial arts teachers who received their formal education at over 200 colleges and universities where degrees are offered in industrial arts education (Olson, 1972).

Industrial Practices and the School (ED:INTEC 120) is an introductory course offered by the Faculty of Industrial Technology Education at The Ohio State University. This course is described in The Ohio State University Bulletin (1974) as:

A study of the history and role of industrial technology and its relation to the school through experiences in planning, organizing, and controlling a managed production system (p. 174).

The course ED:INTEC 120 is offered primarily for students planning on careers as industrial arts teachers in the public schools although other students may, and do, enroll in the course. ED:INTEC 120 is offered during the Autumn, Winter, and Spring terms and carries four hours of undergraduate credit. Classes meet five days per week for two-hour sessions daily.
Approximately 80 students enroll in ED:INTEC 120 each year. Although no accurate profile of these students is currently available, it is known that they vary considerably with regard to course entry knowledge and skills. For example, students have ranged from a veteran with 25 years of experience with the U.S. Army Corps of Engineers to a teen-age girl handling industrial tools for the first time. Many ED:INTEC 120 students have had various military and/or industrial work experience and some students enter the program directly from high school.

According to a Spring, 1975, class handout (Appendix A), the course objectives for ED:INTEC 120 are:

1. To offer an orientation to the technical subject matter in industrial arts through experiences with materials, tools, and processes.

2. To provide an understanding of the history and present status of industrial arts as a career and as a profession.

3. To provide an understanding of industrial arts teaching through observations and participation in public schools.

4. To acquaint beginning students with the nature of their undergraduate program in industrial technology education.

ED:INTEC 120 is essentially a laboratory-type course although course activities include some lectures, class discussions, assigned readings, visiting speakers, and field trips to area schools and industries. The two textbooks used in the course are Metalwork Technology and Practice (Ludwig, et al., 1975) and Constructing and Manufacturing Wood Products (Zook, 1973).
The selected materials processing knowledge and skills taught in the course ED:INTEC 120 are repeatedly used and further developed in subsequent courses. Thus, the course ED:INTEC 120 assumes foundational importance for ED:INTEC majors.

In January, 1973, a group of Industrial Technology Education faculty members and graduate students participated in a seminar for the purpose of exploring the possibilities of restructuring the course ED:INTEC 120 to include increased emphasis on basic manual skills in the areas of wood and metal processing. The major outcome of this seminar (Winter, 1973) was the identification of seven major areas on which to base the course. The seven areas are: Forming; Separating; Combining; Layout; Inspecting; Materials; and Safety.

During the Spring Quarter, 1973, a second seminar was held. Approximately half of the participants elected to continue the initiative of the first seminar. The major outcome of the Spring seminar, with respect to the ED:INTEC 120 course, was the development of individualized learning packages for selected topics in the areas of forming, separating, combining, layout, and inspecting.

The impetus for this study was provided by the writer's participation in the two seminars described above. This study continues the initiative of the seminars, builds upon the achievements, and expands the scope and objectives of the seminar problem.
Statement of the Problem

A major function of the Faculty of Industrial Technology Education is the continual development of an exemplary, innovative, and effective industrial arts teacher education program. The Faculty holds that the industrial technology education curriculum must be dynamic and ever changing as new developments and needs arise. Three recognized needs which had implications for the redesign of the course ED:INTEC 120 were to:

1. ensure that students demonstrate certain basic competencies in materials processing prior to the student-teaching experience,
2. provide for the variability of background, experience, and capability of students entering the program, and
3. explore the general trend toward systems-oriented, individualized, self-paced, and competency-based instruction at the college level which appeared to hold promise for needs 1 and 2.

In short, the problem of this study evolved from the need to restructure the course ED:INTEC 120. More specifically, the problem of this study was to develop a logically adequate rationale, structure, management system, and model components to place the course ED:INTEC 120 on an individualized mode using a systems-oriented, competency-based approach.

A major thrust of the study was the conceptualization and development of a logically adequate rationale and structure for the course.
This is viewed as an essential prerequisite to sound curriculum planning and development.

Some questions the study has attempted to answer are:

1. What needs does the course ED:INTEC 120 serve?
2. What are appropriate objectives for the course?
3. What is appropriate content for the course?
4. What is a logically adequate structure for the course content?
5. What should be the interrelationships between and among the course elements?
6. What is an appropriate management system for the course?
7. What is an economical method of developing course software?
8. What should be the design and content of individual course modules?
9. What are exemplary laboratory activities which will enable students to achieve course objectives?

This study has provided answers to the nine questions listed above. The answers are detailed in subsequent chapters and are summarized in Chapter VIII.

Significance of the Problem

Clark and Guba (Stufflebeam, 1969) proposed four steps for curriculum change:

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<th>Step</th>
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<tr>
<td>Research:</td>
<td>to advance knowledge (i.e., to conceptualize)</td>
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<tr>
<td>Development:</td>
<td>to innovate, plan, construct, and integrate components</td>
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3. Diffusion: to create an awareness

4. Adoption: to familiarize, train, operationalize, and assimilate.

This study is primarily concerned with the conceptualization of subject matter and formulating, planning, constructing, and integrating the content into a new structure. It would appear, therefore, that when placed within the Clark and Guba schema, the study falls within the classification of research and development.

The need for research and development in the area of industrial arts curriculum was recognized by the National Conference on Research in Industrial Arts (1969) in the statement: "The most important task facing industrial arts is continued research related to content selection at all levels" (Suess, 1969, p. 15). This study has contributed to the task of content selection for an introductory course in industrial technology teacher education by providing a rationale, structure, and a management system for the course ED:INTEC 120.

Another important outcome of this study was the development of a model learning module (Appendix D). The model learning module consists of seven learning packages. Each learning package includes behaviorally stated objectives for basic competencies in materials processing which prospective industrial arts teachers should demonstrate.

The rationale, structure, management system, and model components developed as part of this preliminary investigation represent important and essential foundations upon which other curriculum developers may build to complete the development of software for the course ED:INTEC 120.
Assumptions

The assumptions upon which the study is based include:

1. The body of knowledge for the course ED:INTEC 120 can be identified, ordered, structured, and codified for instructional purposes.

2. Knowledge and skills related to industrial processing of standard wood and metal stock are an important part of the industrial technology education curriculum.

3. The multi-media, self-paced, modular approach is an effective means of instructing industrial technology education students.

Delimitations

The course ED:INTEC 120 consists of three major sections:

1. An introduction to the industrial arts teaching profession.

2. A series of field trips to local industries and to local industrial arts laboratories.

3. An introduction to industrial processing of standard material stock.

This study is delimited to section 3 of the course ED:INTEC 120.

The new structure developed for the course ED:INTEC 120 as a result of this study has sufficient flexibility to accommodate virtually all types of standard stock processed by modern industry. However, the
learning objectives and model system components developed were delimited to the areas of wood and metals.

No attempt was made to develop and evaluate all the curriculum materials required for the course. The emphasis was placed on the development of a logically adequate rationale, structure, management system, selected objectives, and model components. The development and formative evaluation of these components serve as a foundation for other researchers who may wish to continue with the development of curriculum materials or to adapt the system to their particular needs.

Limitations

The researcher's opinions relative to the rationale, structure, content, and management of a teaching-learning system in industrial technology teacher education pose a possible limitation to the objectivity of this study. In order to avoid opinions affecting the outcome of the study, a committee of expert reviewers was employed to conduct a formative evaluation of the course rationale, structure, model learning module, and proposed course management system.

Another serious limitation was the lack of time to fully develop and test the total course materials. The scope of that total task would be several times the reasonable time constraints on a dissertation. This study was limited to a preliminary and partial investigation of the complete problem.
Definition of Terms

The first four terms presented below are as defined by Schmieder (1973):

**behavioral objectives:** "statements of educational goals (general or precise) in terms of the observable behavior of the learner as a measure of achievement. Usually, behavioral objectives are expressed in a three-part format: (1) descriptive statement of the goal, (2) the conditions under which the goal is to be reached, and (3) the level mastery expected (p. 62)."

**enabling objectives:** "objectives which describe those knowledges, skills, and attitudes which a learner must attain at some intermediate point if he is to acquire the terminal objective (p. 62)."

**module:** "a package of integrated materials or an identifiable and related set or sequence of learning activities which provides systematic guidance through a particular learning experience or specific program. Modules are of many shapes and styles and may require activities ranging in time from less than an hour to a year or more. Typically, modules include rationale, prerequisites, objectives, strategies, resources, and criteria tests (p. 59)."

**software:** "instructional systems and processes, curriculums, written or printed educational materials, guides, books, tests, work-sheets. They may stand alone as learning packages or units or they may be accompanied by media or other hardware (p. 65)."
industry: "is that subcategory of the economic institution which substantially changes the form of materials in response to man's wants for goods (Towers, Lux, and Ray, 1966, p. 40)."

industrial technology: "is that subcategory of technological knowledge which is derived from the study of industrial practices (Towers, Lux, and Ray, 1966, p. 85)."

industrial arts: "is an organized study of the knowledge of practice within that subcategory of the economic institution of society which is known as industry (Towers, Lux, and Ray, 1966, p. 43)."

formative evaluation: "is the appraisal of instructional sequences and materials during their stages of formulation and development. The major purpose of formative product evaluation is to provide both descriptive and judgemental information regarding the worthiness of an instructional experience. Descriptive information can be used to define or characterize the adequacy or inadequacy of various instructional components; for instance, the degree of specificity of instructional objectives. In contrast, judgmental data can be employed to determine the learning or instructional implications of descriptive data; that is the appropriateness or value of highly delineated learning goals. Both types of information can be used to enhance rationality in making systematic decisions concerning the design and formulation of instructional materials (Lawson, 1974, p. 5)."
Methods and Procedures

There are six different phases to this study. They are:
1. the conceptualization and development of a logical rationale for the course ED:INTEC 120,
2. the conceptualization and development of a logical structure for the course,
3. the development of selected behavioral objectives for the course,
4. the design and development of a model learning module consisting of seven learning packages,
5. the design of a management system for the course, and
6. the formative evaluation by a jury of experts of the course rationale, structure, model learning module, and management system.

The six phases of this study listed above are described in detail in chapters III, IV, V, VI, and VII. The conclusions and recommendations resulting from this study are included in chapter VIII.

The following steps were followed in the development of this study:
1. a comprehensive review of related literature was conducted,
2. a rationale for the course ED:INTEC 120 was conceptualized and written,
3. a structure for the course was conceptualized and documented,
4. a course organizational flowchart diagram was prepared,
5. a procedure for course management was conceptualized and written,
6. selected behavioral objectives for the course were written,
7. one sample learning package was prepared and submitted to the researcher's advisory committee for evaluation,
8. a standardized learning package format was developed,
9. six additional learning packages were developed to complete the model learning module,
10. a formative evaluation of the course rationale, structure, model learning module, and management system was conducted by a jury of experts, and
11. a written report on the formative evaluation and on the conclusions and recommendations of this study was prepared.

The six phases and eleven steps listed above represent the methods and procedures used in this study.

Organization of the Study

This study is organized according to the following outline:

Chapter I provides an introduction, defines the problem, discusses the need for the study, and describes the methods and procedures.

Chapter II contains a review of literature related to the study. The review of literature is presented in five categories: industrial arts curriculum literature, performance-based teacher education literature, systems approach literature, computer-managed instruction literature, and personalized system of instruction literature.

Chapter III contains a rationale for the course ED:INTEC 120. The rationale establishes the need for the course and the purpose of the
course. The rationale also includes a series of considerations upon which the proposed new structure for the course ED:INTEC 120 is based.

Chapter IV contains a proposed new structure for the course ED:INTEC 120. The structure is presented initially as a conceptual structure and finally, with some modifications, as a functional structure for the course ED:INTEC 120.

Chapter V describes the content, format, and time requirements of learning modules for the course ED:INTEC 120. One model learning module, consisting of seven learning packages, was developed as part of this study and is included as Appendix D.

Chapter VI describes how computer managed instruction could be utilized to manage a modularized, individualized course ED:INTEC 120. Two alternative management systems are also briefly described. Chapter VI also contains estimated costs of developing course software.

Chapter VII describes a formative evaluation of the rationale, structure, model module, and proposed management system for the course ED:INTEC 120. The formative evaluation was conducted by a jury of experts.

Chapter VII contains a summary, conclusions, and recommendations to guide the further development of the concepts and curriculum materials which resulted from this study. Several topics discovered in the course of this investigation which appear to need further research are also listed in Chapter VIII.
Chapter Summary

The primary purpose of this chapter was to introduce and describe the problem of the study. The problem evolved from the need to restructure the course ED:INTEC 120 in order to emphasize learner acquisition of specific competencies in materials processing and to provide for individual learner differences. More specifically, the problem of this study was to develop a rationale, structure, selected behavioral objectives, and a model learning module for the course ED:INTEC 120 and to conduct a formative evaluation of these components.

Chapter I also described the significance of the problem. Assumptions, delimitations, and limitations were also presented. Important terms used in the study were defined. The methods and procedures used to conduct this study were listed. This chapter concluded with a description of the organization of the study and a chapter summary.
CHAPTER II

REVIEW OF RELATED LITERATURE

The literature which provided focus and direction to the study is reviewed in this chapter. The chapter is organized in five sections.

The first section contains a review of industrial arts curriculum literature. Curriculum developments from the mid-1800's to the early 1970's are briefly outlined.

The second section of this chapter contains a review of related performance-based teacher education (PBTE) literature. PBTE literature was selected for review because many of the concepts and practices associated with PBTE such as pre-specified competencies, objectives, modules, individualization, evaluation, and particularly the PBTE emphasis on course exit requirements appeared directly related to the problem of the study.

The third, fourth, and fifth sections of this chapter contain a review of related instructional program management literature. Systems approach literature is reviewed in section three, computer-managed instruction (CMI) literature is reviewed in section four, and personalized system of instruction (PSI) literature is reviewed in section five. The literature related to these three areas of instructional program management was selected for investigation in order to identify an appropriate instructional management system for the course ED:INTEC 120.
Industrial Arts Curriculum Development

Early Curriculum Development

Industrial arts, as a school subject, has its origins in the long tradition of practical arts education. Detailed early histories of the field were provided by Bennett (1926; 1937) and Barlow (1967). Historical milestones in the search for practical school subject matter are shown in Figure 1 (Towers, Lux, & Ray, 1966). This overview is primarily concerned with developments after 1868.

The Russian System

Victor Della Vos developed the Russian system of tool work instruction at the Moscow Imperial Technical School in 1868. According to Householder (1973), the Russian system:

...emphasized the primacy of an analysis of the manipulative processes to be taught. An instructional sequence was then designed to foster the acquisition of the requisite manipulative skills. An ordered sequence of exercises was prepared for each area of work, with criterion-referenced requirements for progression through the graded steps in the series (p. 5).

Towers, Lux, and Ray (1966) noted that the Russian analysis of the manipulative processes to be taught:

produced an alphabet of mechanic arts which, once learned, could be put together in any number of combinations to produce the completed job which the tradesman might later be called upon to perform (p. 90).
EARLY CURRICULUM DEVELOPMENT IN INDUSTRIAL ARTS
(Towers, Lux, & Ray, 1966, p. 89)
The Russian system was represented at the 1876 Philadelphia Centennial Exposition by a series of models arranged in sequence of difficulty. Towers, Lux, and Ray (1966) commented on the Russian exhibit as follows:

These models represented the necessary manipulative exercises for progression from little skill to higher levels of skill in the use of tools. Significantly, the models had little if any functional purpose; they were not parts of any machine or any other useful object. These exercises were selected so as to include all the basic elements of the mechanic arts (p. 90).

The Russian system was subsequently utilized in vocational and general education courses in the United States.

The Sloyd System

Educational Sloyd, as developed by Otto Salomon (1849-1907) of Sweden, stressed the development of useful articles. Sloyd instruction was, like the Russian system, graded from simple to complex, easy to difficult, and known to unknown. The Sloyd system of handwork also emphasized the well prepared teacher (Householder, 1973).

The Manual Training Movement

The first manual training school was opened in St. Louis in 1880 by C. A. Woodward (Miller & Smalley, 1963). By 1900, there were over one hundred and sixty manual training programs in operation (Cochran, 1970). Manual training programs were patterned after the Russian and Sloyd systems and included a strong emphasis on tool instruction. Utilitarian projects constructed from wood and metal and involving a wide range of tool practice were characteristic of manual training (Towers, Lux, & Ray, 1966).
**Manual Arts**

Manual training was influenced by the European Arts and Crafts Movement near the turn of the century. Creative design and aesthetics became part of the instructional program. The Arts and Crafts influence also resulted in a new name: "Manual Arts" (Householder, 1973).

**Industrial Arts**

Professor Charles E. Richards was Director of Manual Training at Teachers College, Columbia University and editor of the Manual Training Magazine. In 1904, Richards proposed that the name "industrial arts" replace manual training and manual arts. Richards' contribution was much more than a mere name change; Towers, Lux, & Ray (1966) explained:

\[ \text{Richards' activities were another historical step leading to a modern structuring of subject matter for industrial arts education. In logical argument, he forged a place for the study of industry as a discrete subject at the secondary level (p. 103).} \]

**Industrial Arts Defined**

In 1923, Frederick G. Bonser, Professor of Education at Teachers College, Columbia University, provided a definition of industrial arts which is usually referred to as "the classic definition." Bonser stated:

\[ \ldots \text{industrial arts is a study of the changes made by men in the forms of materials to increase their value, and of the problems of life related to these changes (Bonser & Mossman, 1923, p. 5).} \]

Bonser suggested certain areas of content for industrial arts but did not develop a structure for subject matter (Towers, Lux, & Ray, 1966).
The Contribution of Warner

In the 1930's, Professor William E. Warner of The Ohio State University proposed an industrial arts program for the secondary school which he termed the Laboratory of Industries. Warner's proposal resulted in the wider adoption of the general shop in various forms.

In 1947, Dr. Warner presented A Curriculum to Reflect Technology which included the following subject matter classifications (pp. 41-42):

1. Power
2. Transportation
3. Manufacturing
4. Construction
5. Communication
6. Personal Management

Reaction to Warner's proposal and to the term technology were favorable (Towers, Lux, & Ray, 1966).

Olson's Curriculum Proposal

Delmar W. Olson's 1957 doctoral dissertation Technology and Industrial Arts was described by Towers, Lux, and Ray (1966) as constituting "the vital link between the early work of Richards, Bonser, and Warner and that of contemporary theorists and innovators (p. 110)."

Olson suggested that eight major categories of industry are essential for industrial arts curriculum study:

1. Manufacturing
2. Construction
3. Power
4. Transportation
5. Electronics
6. Research
7. Services
8. Management

Olson attempted to identify subcategories for his manufacturing category but the result was a mix of tools and machines, processes, and materials which, according to Towers, Lux, and Ray (1966), were "operationally inadequate for instructional purposes (p. 113)."

The Schmitt and Pelley Study

A nationwide survey on the status of industrial arts education was conducted during the 1962-63 school year (Schmitt & Pelley, 1966). The study showed that 70 to 75 percent of instructional time in industrial arts programs was devoted to laboratory activities. The study also indicated that the subject-matter content in most industrial arts programs was concentrated in three areas: woodworking, metalworking, and drawing.

In a discussion of the educational contribution of industrial arts education, Schmitt and Pelley stated:

Industrial arts instruction gives meaning to the fundamental hand and machine tools, materials, and industrial processes which make up the technology (p. 3).

Schmitt and Pelley noted that the then current industrial arts curriculum "did not even measure up to the program recommended by the profession 10 to 20 years ago (p. 30)," and called for the profession to develop innovative programs directed to the basic purposes of industrial arts.
The Innovative Decade

The response of the profession during the decade following the Schmitt and Pelley Study was described by Householder (1973) as "the most widespread effort ever devoted to the reorganization of content and activities in the industrial arts curriculum (p. 7)." Cochran (1970) identified thirty-five innovative programs and concluded:

The field of industrial education has been in a constant state of flux and reorientation since its early inception in the secondary schools. The period since 1960, however, has produced more modifications with wider implications than any of the preceding decades during the twentieth century (p. 110).

In his 1968 doctoral dissertation A Comparison of Selected Contemporary Programs in Industrial Education, Cochran selected the following seven innovative programs for investigation:

1. American Industry Project
2. Functions of Industry
3. Galaxy Plan for Career Preparation
4. Industrial Arts Curriculum Project
5. Industriology Project
6. Orchestrated Systems Approach
7. Partnership Vocational Education Project

As a result of his study involving the seven selected programs, Cochran (1970) concluded:

There is general agreement among all of the selected programs, as demonstrated by the identified leaders, on specific items in the curricular framework. In general, these similarities may be stated as follows:

a. A lesser degree of emphasis is placed on manipulative type activities, while the emphasis on the
application of scientific principles through experiences in research and development has been increased.

b. Provision for individual differences is made through multiactivity organization so the student can progress from a general understanding of industry to more specific tasks.

c. There is little classification of instructional content under such areas as "woodworking," and "metalworking," and activities directed toward avocational interests and the crafts are deemphasized.

d. A middle-of-the-road position is evidenced in regards to the emphasis placed on good design and craftsmanship, the use of common hand and machine tools, and consumer knowledge as related to the selection, purchasing, and wise use of industrial products (p. 110).

Cochran (1970) also provided the following observation:

In general, the selected programs represent a reaction to the industrial education programs of preceding decades. This general trend, as represented by the programs under study, is illustrated by the disrepute of terms, such as "metalworking," "instructional sheets," and "industrial arts." Concern is also evidenced in respect to basic manipulative experiences, and heavily craft-oriented activities included in conventional programs (p. 111).

Smith (1975) noted that the single unifying theme in industrial arts curriculum in the mid-1970's appeared to be career education. Smith also reported a considerable movement toward "cluster approaches" in industrial arts particularly at the junior high school level.
Performance-Based Teacher Education

Introduction

This section is not intended to provide the reader with a comprehensive overview or a detailed state of the art report on PBTE. Such documentation has been provided by Elam (1971), Elfenbien (1972), Schmieder (1973), Rosner and Kay (1974), and others.

The following is a review of PBTE literature in terms of its relationship to this study. An attempt has been made to focus on those aspects of PBTE which had a major influence upon the development of the rationale, structure, management system, and model components resulting from this study.

Terminology

There are ample indications that the terminology of the PBTE movement has yet to be standardized. Schmieder (1973) listed eight current labels for the movement and indicated a preference for the term "competency-based education and certification." The problem of definition has been identified by Rosner and Kay (1974) as one of the major issues likely to impede the progress of the PBTE movement.

Much of the controversy appears to center on distinctions made between the terms "performance-based" and "competency-based." Elam (1971) stated that the term "competency-based" is preferred by some authorities who suggest it is a more comprehensive concept. Lindsey (1973) indicated that the term "competency-based" is being adopted by an increasing number of educators. Burns (1972) made the distinction that objectives describing a behavior, but without additional criteria, lead
to performance-based education; while behavioral objectives with performance criteria lead to competency-based education. Rosner and Kay (1974) appear to straddle the issue by employing the term "C/PBTE."

The American Association of Colleges for Teacher Education (AACTE) has adopted the term "performance-based" but has indicated that this term is viewed by the Committee as synonymous with "competency-based" (Weber & Cooper, 1972). The AACTE terminology is used throughout the study.

Antecedents

The roots of the PBTE movement are variously identified by different authors. Klingstedt (1972) identified the philosophical basis for performance-based education as Experimentalism and the psychological basis as the school of Pavlov, Hull, Watson, Thorndike, and Skinner.

Hamilton (1973) viewed PBTE as a response to the public discontent of the 1960's and as a reflection of federal interest in systems management. Elam (1971) noted that federal money became available for experimental programs following the launching of Sputnik and that some of these funds were used by state departments of education to investigate performance-based teacher certification.

The emphasis in education on task analysis and behavioral objectives was cited by Ehman and Okey (1974) as a prominent root of PBTE. Other roots of the movement frequently cited include (1) increasing interest in evaluation and accountability, (2) growing interest in individualized instruction, and (3) developments in educational technology (Elam, 1971; Schmieder, 1973; Hamilton, 1973).
Steffensen (1973) pointed out that PBTE programs depend on two technologies that only recently became available. He explains:

The first of these is a systems design that permits the employment of a sophisticated management schema. Only through such a management plan can the program really be controlled, evaluated, and renewed. The second technology is the modularization of the instructional program. The individualization of the program has been made possible through the development of learning modules whose use permits self-pacing by the students and instructors (p. v).

Broudy (1972) stated that PBTE "had its origins presumably in the dissatisfaction with programs existing in teachers colleges and colleges of education (p. 1)." Broudy is supported by Schmieder (1973) who identified "the continual and conscientious introspection of the educational community (p. 3)" as a prominent root of the movement.

Current Scope

The PBTE movement began in the late 1960's (Ehman & Okey, 1974) and the first group of students to graduate from a PBTE program received their degrees from Southwest Minnesota State College in June, 1971 (Bechtol, 1972).

Schmieder (1973) reported on a survey of 1200 teacher training institutions conducted in an attempt to estimate the involvement of the institutions of PBTE. Of the 783 responding institutions, 125 indicated that they already had PBTE programs, 336 institutions indicated that they were planning PBTE programs, and only 228 teacher training institutions indicated that they were not then involved in PBTE programs.

Schmieder (1973) also reported that 17 states had given either legislative or administrative support to PBTE and that 14 other states were considering new certification standards and approaches at that time.
Wilson and Curtis (1973), in a summary report on state mandated PBTE programs, indicated that, as of May, 1973, ten states had mandated PBTE programs and at least seven other states were then contemplating mandated PBTE programs.

Rosner and Kay (1974) commented on the apparent rush to implement PBTE programs and noted that in 1972 the Committee on National Program Priorities in Teacher Education had estimated that PBTE would require a minimum of five years and $114,000,000 for research and development (Rosner, 1972).

Characteristics of PBTE

Since 1970, the American Association of Colleges for Teacher Education (AACTE) has commissioned several papers on PBTE. Vogler (1973) has summarized from these papers five characteristics of PBTE, five implied characteristics, and seven related and desirable characteristics as follows:

**Characteristics**

1. Competencies (knowledge, skills, behaviors) to be demonstrated by the student are derived from explicit conceptions of teacher roles, stated so as to make possible assessment of a student's behavior in relation to specific competencies, and made public in advance.

2. Criteria to be employed in assessing competencies are based upon, and in harmony with, specified competencies; explicit in stating expected levels of mastery under specified conditions, and made public in advance.

3. Assessment of the student's competency uses his performance as the primary source of evidence; takes into account evidence of the student's knowledge relevant to planning for, analyzing,
interpreting, or evaluating situations or behaviors; and strives for objectivity.

4. The student's rate of progress through the program is determined by demonstrated competency rather than by time or course completion.

5. The instructional program is intended to facilitate the development and evaluation of the student's achievement of the competencies specified.

Implied Characteristics

1. Instruction is individualized, personalized, and modularized.

2. The learning experience of the individual is guided by feedback.

3. The program as a whole is systematic.

4. The emphasis is on exit, not on entrance, requirements.

5. The student is held accountable for performance, completing the program when, and only when, he demonstrates the competencies that have been identified as requisites for a particular professional role.

Related and Desirable Characteristics

1. The program is field-centered.

2. There is a broad base for decision making (including such groups as college/university faculty, students, and public school personnel).

3. The protocol and training materials provided to students focus upon concepts, skills, knowledges, (usually in units called modules) which can be learned in a specific instructional setting.

4. Both the teacher and the students are designers of the instructional system.
5. The program is open and regenerative; it has a research component.

6. Preparation for a professional role is viewed as continuing throughout the career of the professional.

7. Instruction moves from mastery of specific techniques to role integration (pp. 5-8).

Vogler has suggested that the seventeen characteristics listed above represent a functional definition of PBTE.

**Behavioral Objectives in PBTE**

Bloom (1956) classified behavior into three domains of cognitive, affective, and psychomotor learning. Bloom also provided a taxonomy for the cognitive domain. Krathwohl, et al. (1964) provided a taxonomy for the affective domain and Simpson (1966) provided a taxonomy of educational objectives for the psychomotor domain. Simpson's taxonomy for the psychomotor domain was described by Herschbach (1975) as being "most applicable to the needs of industrial and technical educators (p. 50)."

Hershbach (1975) commented on the lack of interest among many educators in the psychomotor domain and stated:

> Educational technologists are only now beginning to investigate seriously the psychomotor domain and translate their findings into instrumentation which will allow educators to deal effectively with psychomotor skill development, prediction and evaluation (p. 49).

Behavioral objectives serve several important functions in PBTE programs. According to Burns (1972) objectives

1. are a written, public record of what is to be learned,

2. serve to communicate to the learner what he is to be able to do at the end of the instructional period,
3. serve to help select appropriate instructional activities, and

4. serve to help select valid evaluation activities (p. 23).

Mager (1962) has described an objective as "a statement of what the learner is to be like when he has successfully completed a learning experience (p. 3)." Burns (1972) has stated that objectives are "at the heart of performance-based learning (p. 25)." Popham (1971) has claimed that measurable objectives represent the most significant instructional advance during the past ten years.

Popham and Baker (1970) developed a goal-referenced instructional model which is based on the use of measurable objectives. The model is illustrated in Figure 2. The model features four distinct operations: (1) specification of objectives in terms of learning behavior, (2) pre-assessment of current learner status, (3) instructional activities, and (4) evaluation. It is noted that this type of model is focused on the learner and not on the instructor.

The importance of behavioral objectives in PBTE programs was described by Hayman and Mable (1974) as follows:

There is a national movement toward competency-based instruction and individualization in teacher training courses. The former requires that competencies needed for specific instruction-related tasks be concretely and precisely spelled out, and that preservice education be directed toward producing these competencies in recognizable form. The only feasible way this can be accomplished at present is to have courses defined by sequenced behavioral objectives which are measurable with high degrees of precision (p. 60).

According to Wilson and Toosti (1972), "the primary purpose of an instructional objective is to specify exactly what the student is to
If objectives are not achieved, revise.

If objectives are achieved, augment.

FIGURE 2
A GOAL-REFERENCED INSTRUCTIONAL MODEL
(Popham & Baker, 1970, p. 17)
learn in a way that will permit verification that it has been taught (p. 60)." These authors recommend that behavioral objectives be prepared but not deified. Wilson and Tosti also suggest that when an instructor is satisfied that the objectives he has prepared "are an accurate reflection of what he wants to teach, further effort can be spent to better advantage in developing good test items (p. 23)."

Ralph W. Tyler, a pioneer in the study of behavioral objectives, stated:

I think many current uses of the term behavioral objectives imply procedures that are too specific... many behavioral objectives should be set at a considerably higher or more general level than the extremely specific things I find in many current efforts to write them (Shane & Shane, 1973, p. 42).

The literature on behavioral objectives suggests that objectives written at a general level can be very useful. Popham (1973) described such objectives as possessing "content generality (p. 7)." Popham notes that:

There are unresolved questions regarding what level of generality should be employed so that objectives are both useful in promoting clarity of content and also parsimoniously usable by educators (p. 7).

The literature on behavioral objectives also suggests that time spent agonizing over degrees of specificity of behavioral objectives could be put to better use.

**PBTE Models**

Howsam (1972) presented a model aimed at promoting understanding of the performance-based movement. The model is composed of three concentric circles (Figure 3). The inner circle represents performance-based instruction (PBI) and has four essential elements: (1) precise
FIGURE 3
A PERFORMANCE-BASED TEACHER EDUCATION MODEL
(Howsam, 1972, p. 3)
objectives, (2) performance criteria, (3) instruction pertinent to the criteria, and (4) learner accountability in terms of the criteria.

The second circle of the Howsam model represents ideas and practices termed enhancers. Enhancers include: (1) individualization of instruction, (2) modularized instruction, (3) alternative learning opportunities, and (4) use of technology.

The outer circle of the model represents considerations termed enablers. Enablers include: (1) application of systems, concepts, and principles and (2) management by objectives. Howsam (1972) stressed that the use of enhancers and enablers significantly expand the utility and effectiveness of PBI.

Elam's (1971) conceptual model for PBTE is illustrated in Figure 4. Elam's model is noteworthy in that the American Association of Colleges for Teacher Education (AACTE) has stated that only professional training programs that include all five essential elements of the model fall within the AACTE's definition of PBTE (Elam, 1971).

Learning Spaces

The characteristics of PBTE programs suggest that PBTE learning space requirements differ from those of traditional programs. Gentry and Johnson (1974) recommend the establishment of PBTE learning centers having the following seven essential subsystems:

1. Reference System,
2. Resource Section,
3. Instructional Materials Laboratory,
1. Teaching competencies to be demonstrated are role-derived, specified in behavioral terms, and made public.

2. Assessment criteria are competency-based, specify mastery levels, and made public.

3. Assessment requires performance as prime evidence, takes student knowledge into account.

4. Student's progress rate depends on demonstrated competency.

5. Instructional program facilitates development and evaluation of specific competencies.

FIGURE 4
A CONCEPTUAL MODEL FOR PBTE
(Elam, 1971, p. 8)
4. Learning Programs Laboratory,
5. Microteaching Laboratory,
6. Simulation and Gaming Laboratory, and
7. Testing Laboratory.

Bailey (1972), whose background includes four years of experience in PBTE programs, has concluded that physical facilities are a significant factor in determining the success of PBTE programs. A nine-component module laboratory (Figure 5) proposed by Bailey includes:

1. Competency/Module Index,
2. Creation Center/Module Bank,
3. Videotaping Station,
4. Independent Study Carrels,
5. Videotape Playback Station,
6. Multiple Activity Room,
7. Work Tables
8. Pre-Post Assessment Station, and
9. Planning and Counseling Station.

A listing of spaces and equipment utilized in thirteen functioning PBTE programs was compiled by Elfenbein (1972). The listing suggests that space requirements for PBTE programs can be quite complex.

Teaching-Learning Modules

The generic term "module" applies to units that comprise a larger entity (Postlethwait & Russell, 1974). Gentry and Johnson (1974) have described a module as "a cluster of objectives (p. 25)."
FIGURE 5
A PBTE MODULE LABORATORY
(Bailey, 1972, p.8)
There appears to be a growing trend toward the development of such small units of instruction under such titles as "learning activity package (LAP)," "individualized learning package (ILP)" and "instructional module (IM)," to name a few. Several publications devoted entirely to the construction and use of learning modules are currently available (Kapfer & Orvad, 1971; Kapfer & Kapfer, 1972; Houston, et al., 1972; Postlethwait & Russell, 1974). The AACTE PBTE Committee has described the use of modules as "a practice commonly followed in order to facilitate the adaption of instruction to individual needs and abilities (AACTE, 1974, p. 10)."

Elfenbein (1972) examined seventeen PBTE programs from thirteen institutions of higher learning and found that some form of module or cluster existed in each of the programs. Each of the thirteen institutions used a different name to describe their product. However, six among the thirteen used the word "module" as part of the institutional name (e.g. instructional module). Other institutional names for teaching-learning modules include: "packages," "learning packages," and "competency packages" (Elfenbein, 1972).

It appears that PBTE programs usually base their instructional content on modules. Schmieder (1973) claims "the use of modules allows a much greater variety of experiences than standard "courses" and provides a far better basis for the individualization of instruction (p. 59)."

Kean and Dodl (1973) argue strongly for the use of instructional modules as the basic organizational unit and present the following rationale:

1. Because they are objective oriented, modules are consistent with the systems approach.
2. Because of their objective orientation, modules can be evaluated much more easily than semester-long courses.

3. Modules are much more easily added, changes, or discarded than courses.

4. Because modules usually do not run a full semester (they usually vary from a day to several weeks), a more flexible use can be made of instructional personnel and student time.

5. More options are available to the students in the sequencing and composition of their curriculum.

6. Module credit—a fraction of a semester credit hour—can be assigned to each module and easily converted to the semester credit system for record-keeping purposes (pp. 40-41).

Cooper and Weber (1973) claim that the instructional module is at the very heart of the PBTE program and list the following module characteristics:

1. A rationale that (a) describes the purpose and importance of the objectives of the module in empirical, theoretical, and/or practical terms; and (b) places the module and the objectives of the module within the context of the total program.

2. Objectives that specify the competency or competencies the student is expected to demonstrate.

3. Prerequisites, i.e., any competencies the student should have prior to entering the module.

4. Preassessment procedures—usually diagnostic in nature—that provide the students with an opportunity to demonstrate mastery of the objectives or relevant to the objectives.

5. Learning alternatives, which are the various instructional options available to the student and each of which is designed to contribute to his acquisition of the objectives.

6. Postassessment procedures that permit the student to demonstrate achievement of the objectives.
7. Remedial procedures to be undertaken with students who are unable to demonstrate achievement of the objectives on the post-assessment (p. 17).

Module development demands a wider range of skills and knowledge than do conventional courses. The problem of developing suitable instructional modules has been addressed by Dick and Dodl (1973) who point out that faculty members have not typically been trained to develop instructional materials with specified learning outcomes and a defined set of procedures to evaluate the outcomes. These authors suggest that graduate students working with faculty members could play an important role in the development of such materials. Gentry and Johnson (1974) favor an interdisciplinary team approach to the problem of developing learning modules.

Frantz and West (1974) discussed the need for module evaluation and stated:

Preparers of learning packages must be able to determine if their creations are effective in moving learners from ignorance to enlightenment (p. 137).

Frantz and West also presented an evaluation procedure for use by learning package producers. They described how this evaluation procedure was field tested and recommended further testing of the procedure for the purpose of increasing its reliability and validity.

**Industrial Arts and PBTE**

A nationwide study undertaken to ascertain the involvement of industrial arts personnel in PBTE was described by Brooks and Brueckman (1973). The findings of the study were based on responses received from
one hundred and forty colleges and universities with industrial arts teacher education programs.

The results of the study indicated that 72 institutions had staffs studying PBTE and 34 institutions had staffs engaged in operational PBTE programs. The status of involvement was indicated by the following tabulation presented by Brooks and Brueckman (p. 56):

<table>
<thead>
<tr>
<th>Status</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cautiously Watching</td>
<td>12</td>
</tr>
<tr>
<td>Beginning</td>
<td>48</td>
</tr>
<tr>
<td>Well Along</td>
<td>8</td>
</tr>
<tr>
<td>Done and Waiting</td>
<td>3</td>
</tr>
</tbody>
</table>

Hauenstein (1974) reported on the planning of competency-based industrial arts teacher education programs at Florida International University and indicated that:

Technical competency areas were identified in relation to the body of knowledge developed by the Industrial Arts Curriculum Project ($2.5 million research project), state and national trends in industrial arts, legislation, and state certification requirements (p. 60).

Hauenstein concluded that CBTE "appears to be a viable alternative for industrial arts teacher education and teacher education at large (p. 64)."

Other industrial arts PBTE programs described in the literature include the programs at Millersville State College (Wynn, 1974), the University of Wisconsin-Stout (Wright, 1974), and Wayne State University (Bies, 1974).

Four Dissenting Views

Although the literature is overwhelmingly favorable to the modularization of instruction, reservations expressed by four scholars are
worthy of serious consideration. Broudy (1972) has expressed concern with the fragmentation of the teaching act into separate components. Broudy has described the assumption that the teaching act is the sum of the performances into which it is analyzed as "notoriously inadequate (p. 3)." Elam (1971) has cautioned:

Modular material that is largely self-instructional is likely to attract into teaching only those students who are efficient and well organized and sufficiently self-controlled to pace themselves through large chunks of materials. While some would argue that this is desirable and will give us better teachers, we don't know whether this is the case. Further, modularization provides a self-screening to entrance into teacher education that we have not had heretofore. It may therefore be desirable to continue our nonmodularized conventional programs until we are sure we know the effects of modularized self-instruction (pp. 20-21).

Kingsley Price (1974), professor of philosophy at Johns Hopkins University, warns: "teaching is not a performance, not even the performance of a machine; and to treat it as if it were carries in its train confusion and false expectations (p. 327)."

Day (1974) called for the rejection of what he termed a "behavioral-industrial model (p. 38)." Day found PBTE:

...to have serious short-comings--it rests on a rigid, skill-centered, controlled Skinnerian-industrial base, it denies freedom, its effects are divisive, its dogma is superficial, it is anti-intellectual, and its legality is questionable (p. 42).

Those considering the adoption of a PBTE program should be aware of the concerns of Broudy, Elam, Price, and Day.
Problems and Concerns

The literature is replete with statements regarding problems and concerns related to PBTE programs. The following listing represents a selection of such claims and concerns which appear to have particular relevance for this study. Items one through seven were adapted from a similar listing by Schmieder (1973).

1. There is a severe shortage of experienced resource persons in PBTE (p. 27).

2. There is a severe shortage of PBTE program software (p. 27).

3. What are the most effective processes for determining key competencies to be demonstrated? (p. 28).

4. Who should determine key competencies? (p. 28).

5. One of the goals of PBTE is to facilitate more personalized learning programs. To be both more personal and more specific will require very complicated program logistics (p. 29).

6. Module development is essential for "personalizing" PBTE programs. What are the best type of modules? Who develops them? How "hard" should they be? (p. 29).

7. Does PBTE cost more or less than other program alternatives? (p. 29).

8. A major problem is that of management (Gay & Daniel, 1972, p. 49).

9. Many students have difficulty in disciplining themselves to follow a self-paced schedule (Getz, et al., 1973, p. 301).

10. An instructor may not have time to write his own objectives and by using objectives prepared by
others he may jeopardize the unique aspirations of his class (Palardy & Eiselle, 1972, p. 546).

11. PBTE's greatest problem is the lack of knowledge regarding the relationship of teacher behavior to pupil outcome (Hamilton, 1973, p. vii).

**Advantages Claimed**

Proponents of PBTE have claimed that a variety of advantages are associated with PBTE programs. A selection of such claims which appear to have particular relevance for this study is listed below.

1. The long-range promise, and ultimately the only justification for PBTE, is to improve the quality of instruction in the nation's schools as a consequence of improved teacher education (Rosner & Kay, 1974, pp. 290-291).

2. PBTE represents one of the most significant trends affecting the profession (Danemark & Espinoza, 1974, p. 194).

3. PBTE is a potentially superior strategy for developing the teacher knowledge, skills, and attitudes necessary to facilitate pupil learning (Elam, 1971, p. 22).

4. A behavioral statement of course and program objectives will enhance students' understanding of the program as a whole and the specified expectations held for them (Shepardson, 1972, p. 168).

5. Evaluation takes place when the student indicates he is ready (Yount & Mondfrans, 1972, p. 16).

6. Instruction is individualized, personalized, and modularized (Vogler, 1973, p. 7).

7. PBTE can reduce negative psychological effects and increase learning (Yount & Mondfrans, 1972, p. 17).

The literature reviewed was, on the whole, very favorable to the PBTE concept.
The Systems Approach

Introduction

The term "systems" was defined by Banathy (1968) as:

deliberately designed synthetic organisms, comprised of interrelated and interacting components, which are employed to function in an integrated fashion to attain predetermined purposes (pp. 2-3).

The systems approach may be viewed as "a philosophy of organization and management (De Vault, 1973, p. 32)." There is some evidence to indicate that the potential power of the systems approach is attracting increasing numbers of educators. Such terms as "systems," "systems approach," and "systems analysis" have appeared with increasing frequency in the educational literature in recent years and, according to Hayman (1974), this trend is likely to increase.

Background

Some of the systems concepts have evolved from the activities of Herbart in the early 1800's (Silvern, 1972) although the systems approach proper appears to have emerged during the 1940's as a result of research and development of complex man-machine systems such as combat aircraft (Banathy, 1968). Merwin (1974) has noted that Ralph Tyler was conceptualizing a systems approach to instruction as early as 1940. However, it appears that the application of the systems approach to the training of instructors was not given serious consideration until the 1970's (Merwin, 1974).
Silvern's Systems Approach

Silvern (1972) defined the term "system" as:

simply the structure or organization of an orderly whole, clearly showing the interrelations of the parts to each other and to the whole itself (p. 2).

Silvern suggested that the following criteria apply:

1. There must be a structure or organization.
2. The whole must be orderly.
3. The whole must have parts.
4. Parts can be shown clearly relating to each other.
5. Parts can be shown clearly relating to the whole (p. 3).

The term "systems approach" was described by Silvern (1972) as a process consisting of four major parts in sequential order:

1. Analysis, performed on existing information to identify the problem, identify existing elements, and identify the interrelation.
2. Synthesis, performed to combine unrelated elements and relationships into a new whole.
3. Models, constructed to predict effectiveness without the actual implementation of the system.
4. Simulation, performed to reveal alternative solutions (p. 5).

Silvern's four part sequence is illustrated within a model for producing a course (Figure 6). The circles in Silvern's model represent feedback loops. Figure 6 also illustrates how subsystems function within the overall instructional system.
FIGURE 6

MODEL FOR PRODUCING A SYSTEM
(Silvern, 1972, p. 7)
Le Baron's Systems Analysis Model

Le Baron (1973) presented a six-step systems analysis model which permits the isolation and definition of systems elements according to their function and subsequently, the identification of interrelationships among the functions (Figure 7). Le Baron used the term "reiteration" to describe the implementation of the six-step process. One begins by working through all the steps (except operation) at a general level and then returning to the beginning to develop each step in greater detail based on the overview. As this process is repeated, each step is more clearly developed until the required degree of specificity is attained.

Instructional Systems

Stolurow (1974) discussed basic problems in the development of instructional systems and listed the following basic or common developmental activities required:

1. Analysis of a domain of knowledge.
2. Organization of analytical elements in terms of micro-curricular units.
3. Determine the relationships and possible hierarchies, including learning conditions.
4. Plan presentation or delivery - defining learning environments: learner controlled; teacher controlled.
5. Plan the techniques of assessment of student performance and quality of materials and procedures.
6. Plan system for revision—formative evaluation, and revision cycles.
7. Plan the management, personnel allocations, and resource allocations for (a) development; (b) delivery, and (c) evaluation (p. 105).
FIGURE 7

STEPS IN SYSTEMS ANALYSIS
(Le Baron, 1973, p. 17)
The application of the systems approach to the training of teachers was outlined by Buffer (1971). Buffer's graphic model is illustrated in Figure 8.

The Systems-Oriented Teacher

According to Wong and Wong (1973), the systems-oriented teacher:

1. thoroughly assesses the input to his system;
2. explicates his specific purposes unambiguously based on the input feedback, on constraints on his system, and on the needs of the students and the suprasystem;
3. gathers as much data as possible about his subject matter and alternative processes for achieving his purposes;
4. makes decisions concerning processes and content based on the best means of furthering the purposes;
5. activates the system by putting the plan into action;
6. gathers ongoing feedback data systematically and accurately;
7. modifies the system's content and processes based on the feedback;
8. assesses the effectiveness of the system by comparing the output product to the purposes of the system and to the input product; and
9. modifies the system based on all his sources of feedback before it is again activated (p. 90).

One might conclude from the above listing that the systems-oriented teacher is in a much better position to manage the learning environment than is his non-systems-oriented counterpart.
FIGURE 8

THE APPLICATION OF SYSTEMS ANALYSIS TO THE DEVELOPMENT OF TEACHER EDUCATION INSTRUCTIONAL SYSTEMS

(Exner, 1971, p. 147)
Advantages and Limitations

Le Baron (1973) concluded that the application of systems procedures to the planning, organizing, and controlling of educational processes appears to have the following advantages:

1. A comprehensive, long-range view of large-scale problems within a productive framework for understanding the processes and functions inherent within the system.

2. A basis for developing goal-oriented programs that are sensitive to the environment and changing context of education.

3. A method for the effective organization of parts into meaningful, problem oriented frameworks.

4. An analysis of alternative allocations of resources based on the relation of resources to goal achievement within the process of educational change.

5. A context for understanding the constraints imposed on the institutional structure of education (p. 30).

Razik and Elsie (1973) concluded that the systems approach is a powerful methodology for improving the educational process but listed the following as limitations:

1. Systems procedures cannot show ways to operate below certain necessary minimums.

2. They cannot remove the constraints imposed by institutional force, but they can suggest ways to work around them.

3. Systems analysis cannot compensate for a lack of clear-cut purpose or for a confused operational philosophy.

4. Systems analysis cannot provide simplistic procedures for arriving at incontestable conclusions.

5. There can be no guarantee that procedures developed in one discipline will be automatically transferable to another field.
6. Systems analysis cannot replace judgements or the necessity for decision making (pp. 23-24).

A comparison of the advantages and limitations of the systems approach to instruction, as described in the literature reviewed, indicates that this approach has much to offer the curriculum developer who recognizes the complexities inherent in the teaching process.

Computer Managed Instruction

Introduction

There were about a dozen computers in the United States in 1950. In 1960, there were about 6000. In 1970, there were almost 80,000. Levien (1972) estimated that this number would double by 1975, and double again by 1980.

Levien described the basic components of the computer as a central processing unit (CPU), a memory of storage unit, and an input-output terminal. The CPU carries out the arithmetic and logical operations at speeds measured in nanoseconds (billionths of a second).

The memory or storage unit of the computer contains an electronic record of numbers. The most common types of computer memories are magnetic core, disc and drum, and magnetic tapes. The information contained in the Encyclopedia Britannica can be stored on five full tape reels.

Input-output terminals have various forms. The typewriter as a terminal is inexpensive, familiar, and widely used. A terminal may also include other features such as a cathode-ray tube or a small projector and screen (Levien, 1972).
The basic operation of computers and their applications in education were described by Dyer (1972). The relationships among computer components in an educational application are shown in Figure 9 (Newsom, 1970).

According to Luehrmann (1971), the principal advantage in using the computer in education "lies in the fact that large amounts of the curriculum can be restructured away from the lecture and toward a problem-solving context (p. 3)."

The computer is rapidly becoming an integral part of our educational institutions. Nearly every university and more than one-third of the four year colleges provide computer services for research and instructional purposes. In 1970, more than one third of the nation's secondary schools had access to and used computers for administrative and/or instructional purposes (Watson, 1972).

**Description**

Tennyson (1974) suggested that current computer support of instruction consists of three types of activities: computer-managed instruction (CMI), computer-assisted instruction (CAI), and learning simulations. Tennyson distinguishes between CMI and CAI applications as follows:

While CAI encodes the learning materials within the computer system, CMI depends upon a rich resource of conventional printed and multi-media materials being available. CMI uses the capability of a computer to monitor the progress of a student through a program of instruction, testing at many points, and using CAI techniques for remedial purposes (p. 50).

The CMI approach is favored by Tennyson on the grounds of cost-effectiveness and because he views CMI as having the best potential for
FIGURE 9

AN EQUIPMENT DIAGRAM FOR A COMPUTER-BASED INSTRUCTIONAL SYSTEM
(Newsom, 1970, p. 17)
incorporating CAI and learning simulations. Tennyson's view is supported by Anderson (1974) who suggests that CMI is much more promising than CAI, at least for the near future. Dick and Dodl (1973) offered the following comment on CMI:

The computer is certainly the most powerful device presently available for use in the management of teacher education programs and its effective use will be a challenge for years to come (p. 85).

CMI was described by Richards (1974) as "the use of computer terminals by students for diagnostic, prescriptive, and assessment purposes with no on-line instruction (p. 46)." Off-line instruction is accomplished by means of multimedia devices and materials. Richards also described student activities in a CMI program as follows:

1. Takes diagnostic test on the computer terminal.
2. Receives score and prescribed beginning behavioral objectives.
3. Returns to classroom to study materials related to specified objectives.
4. Completes study and returns to computer terminal for criterion test on objectives.
5. Continues this process for the next objective if pre-determined criteria are attained.
6. Restudies materials and/or consults teacher if pre-determined criteria are not attained.
7. Returns to terminal for alternate criterion test.
8. Repeats step five or steps six and seven (p. 46).

CMI Systems Software

The development of the necessary computer software for implementation of a CMI system requires the services of individuals who are well
versed in both the instructional and computer fields (Baker, 1973). Baker has described a course taught at the University of Wisconsin, Madison, for the purpose of providing students "with experience in the conceptualization, design, implementation, and documentation of software systems to be used in an instructional setting (p. 33)." The course is titled "Hardware/Software Systems for Instructional Use." The course outline is as follows:

I. First Semester
   A. Individualization of Instruction
      1. History of individualization
      2. Basic instructional concepts involved
   B. Existing CMI Systems
      1. Instructional component
      2. Computer component
   C. Principles of Software Systems Design
      1. The systems design process
      2. Systems documentation
   D. Conceptualization of a CMI System
      1. The instructional system
      2. Computer hardware/software
   E. Term Paper

II. Second Semester
   A. Systems Design
      1. Detailed design of computer program
      2. Software system design documentation
   B. System Implementation
      1. Computer programming
      2. Program documentation
   C. Evaluation of the CMI Design and Its Implementation (Baker, p. 33).

The importance of the systems concept in the development of CMI software is clearly evident in Baker's course outline. Baker reported that the outcomes of the course, then in its third year of operation, were significant.

Dick and Gallagher (1972) described how a systems approach was used to develop CMI software at Florida State University. The model used by Dick and Gallagher to develop software is shown in Figure 10.
FIGURE 10

A SYSTEMS APPROACH MODEL FOR THE DEVELOPMENT OF CAI COURSE MATERIALS

(Dick & Gallagher, 1972, p. 34)
The Naval Air Technical Training Center CMI Program

Mayo (1974) has described the application of CMI to two courses at the Naval Air Technical Training Center at Memphis. The two courses are the Aviation Mechanical Fundamentals Course and the Aviation Familiarization Course. The class size for the two courses considered jointly is between 500 and 600 students.

The regular Fundamentals course was four weeks in length. In the CMI mode, the average time per student to complete the course is only one week.

The regular Familiarization course was two weeks in length. Using CMI, the average time required to complete the course was reduced to one week.

Mayo estimated the resulting savings in manpower (students and instructors) to be $3,500,910 per year. Formative evaluation of the program indicated important gains for CMI over conventional classroom procedures.

The Mayo article also indicated that skills can be taught via CMI in addition to knowledge and procedures. Mayo stated:

...it has been demonstrated clearly that the essential skill in aviation mechanics of lockwiring can be taught effectively by audiovisual modules in the CMI system (pp. 192-193).

Unfortunately, Mayo did not elaborate further on this most interesting aspect of his report.

The Pennsylvania State University CMI Program

Hayman and Mable (1974) described a CMI system which is proving effective in Pennsylvania State University College of Education. This
CMI system is reportedly practical, economical, popular with students and instructors who are directly involved, and its use is being voluntarily requested by other faculty members.

The relationship between PBTE and CMI was described by Hayman and Mable as follows:

Competency-based instruction lends itself well to the CMI approach being used at Penn State. This type of instruction requires a high degree of structure, and this is often accomplished by breaking a course into modules and submodules which have sequenced objectives within them. The same type of structure is required for CMI, so that the transition to CMI of a course which has already been structured to a competency base is relatively straightforward (p. 60).

The CMI applications at Pennsylvania State University include language education, measurement and evaluation, and mathematics education. Although Hayman and Mable were quite optimistic about CMI and its potential in higher education, they identified the following problem areas:

1. Most difficult, perhaps, is the work instructors have to do to structure the course for the system... a high degree of structure is required and most instructors are not accustomed to disciplining themselves in this way. Even when a course is individualized and modularized, a good deal of work is necessary...

2. ...the system demands daily attention. Performance data from individuals must be gathered each day, and the system has to run so that output is produced each day.

3. ...If the computer goes down, the system does not operate.
4. ...there is the problem of overcoming the fear which many instructors have of computers and other types of technology. Compounding the problem is the reluctance of many people to admit this type of fear. The answer is to produce a non-threatening image and to assure that this is a support system which is flexible enough to be modified for their needs and which will actually be helpful (p. 63).

Hayman and Mable suggest that persons considering implementation of a similar CMI system should be aware of these four problem areas.

Hayman and Mable claimed that CMI "represents a highly desirable application of technology in higher education (p. 60)" and also stated that:

Experience at Penn State to date has been positive, and use of the system will undoubtedly continue to expand (p. 63).

The Ohio State University CMI Program

The Ohio State University has between 3000 and 4000 students per quarter involved in computer-based instruction. Applications of CAI or CMI include classics, German, mathematics, biology, psychiatry, music, statistics, education, accounting, computer language, chemistry, home economics, dentistry, agriculture, library training, psychology, veterinary medicine, and philosophy (Christopher, 1974).

Allen, Meleca, and Myers (1972) described a CMI system developed at The Ohio State University in cooperation with the South Dakota State University. This CMI system was first successfully implemented in the Introductory Biology Program at The Ohio State University and serves approximately 12,000 undergraduate students per year (Meleca, 1973).
The CMI model developed by Allen, et al., is of interest because it was designed for adaptability to any content area at any level. This CMI model is described as:

...text-free to allow immediate implementation of the complete management system in any academic discipline. Modifications are relatively simple because of the logical organization of the subprograms and subroutines. To allow short answer responses instead of multiple choice responses, for example, would be a very simple alteration (p. 12).

The model has also been successfully implemented at South Dakota State University. A summarized course flow chart is shown in Figure 11.

The State of the Art

There appears to be an abundance of literature available on the subject of computer-based learning. However, questions dealing with the value of many computer applications in relation to traditional approaches are largely unanswered, as is the question of whether a program yields educational benefits that justify additional costs (Johnson, 1971).

In attempting to establish a "state of the art" in 1972, Levien (1972) examines several hundred articles in the published literature and found them inadequate for the following reasons:

1. They tended to overreport the formal projects in computer assisted instruction whose participants publish as part of their research activities, and to underreport the many instances of classroom computer use developed directly by the instructor, who does not have the same incentives or outlets for reporting.

2. They are often imprecise about the distinction between what is planned and what is done.

3. They generally lag behind the current state of the reported activity by a year or more (p. 125).
FIGURE 11
A SUMMARIZED FLOW CHART FOR A CMI COURSE
(Allen, Meleca, & Myers, 1972, p. 12)
Despite the difficulties involved in assessing the current state of CMI, few would disagree with Watson (1972) who concluded that computers are now making a significant impact on the educational establishment, and will continue to do so, eventually leading to greater use of computers in CMI and CAI modes. Some further insight into the state of the art may be gained from a consideration of the achievements and problems of computer-based instruction. According to Levien (1972), the principal areas of achievement in instructional use of the computer are the following:

- Computer systems adequate for instructional use have been designed and implemented.
- Programming language adequate for the preparation of course material have been designed and implemented.
- Course materials have been prepared for use in various computer modes in a wide variety of subjects.
- Time-sharing systems that facilitate the utilization of the computer for instructional purposes have been installed on a number of campuses.
- Research centers devoted to the development of computer-based instructional systems have been established.
- Basic research is being conducted in a number of relevant areas, including instructional technology and educational technique.
- Experimental development of large-scale computer-based instructional systems is under way (pp. 328-329).

Levien also suggested that the current state of computer-based instruction is perhaps more appropriately characterized in terms of the problems it faces. Levien summarized the major problems as follows:

- Research and development resources have been limited, fragmented, and generally focused on elementary school applications.
Research goals have often been vague; evaluation of the research results have been inadequate.

Implementation resources have been severely limited and subject to unfortunate budgetary constraints on the campus.

Incentives to work on instructional uses of the computer have been virtually non-existent; often there have been strong disincentives.

Dissemination of instructional materials and research results have been inadequate because mechanisms for dissemination are lacking.

The acceptance of computer use in instruction by faculty members has been limited.

The isolation of research and development on computer use in instruction from the remainder of the academic community, especially computer scientists, has hampered development.

The computer industry's commitment to instructional uses of the computer in higher education has not been adequate.

Access to the computer for instructional purposes is still severely limited for college instructors and students (p. 335).

Johnson (1971) concluded that decades will pass before the capabilities of the computer for instruction are fully realized and that evolution rather than revolution will characterize developments in this field.

Personalized System of Instruction

Introduction

Personalized system of instruction (PSI) is a non-computer-managed form of individualized instruction at the college level. The system is
also known as the Keller Plan or proctor-managed instruction (Wilson & Tosti, 1972).

The critical features of PSI were described by Keller (1968) as follows:

1. The go-at-your-own-pace feature, which permits a student to move through the course at a speed commensurate with his ability and other demands upon his time;

2. The unit perfection requirement for advance, which lets the student go ahead to new materials only after demonstrating master of that which preceded;

3. The use of lectures and demonstrations as vehicles of motivation, rather than sources of critical information;

4. The related stress upon the written work in a teacher-student communication; and finally:

5. The use of proctors, which permits repeated testing, immediate scoring, almost unavoidable tutoring, and a marked enhancement of the personal-social aspects of the educational process (p. 83).

In a 1968 journal article, Keller supplies a quotation from a handout given to students in the PSI course "General Psychology" at Arizona State University. This quotation is included as Appendix C. It served as an excellent description of the teaching method to which students are exposed in PSI courses (Keller, 1968).

**PSI Applications**

Green (1974) reported on the successful implementation of PSI in physics teaching at the Massachusetts Institute of Technology. Green
indicated that 90 percent of those who have taken on Keller courses have applied to enroll in another.

Austin and Gilbert (1974) described how the Keller Plan was used in an introductory electricity and magnetism course. A group of 25 students were chosen at random from a larger class and taught in a PSI format. A comparison of performance indicated that Keller-Plan students did 10-20 percent better, both on a common final examination and on a retest administered two months later. Austin and Gilbert commented on the remarkable improvement in the performance of lower ability students who were in the Keller-Plan group.

Micah (1974) reported on the successful implementation of the Keller Plan in a chemistry course at Barrington College. Micah reported that students' reactions were most favorable and concluded that "the Keller Plan appears to be an excellent alternative method for teaching chemistry as well as other disciplines of today (p. 101)."

Problems and Concerns

In a paper titled "Fifteen Reasons Not to Use the Keller Plan," Green (1974a) pointed out that there are circumstances under which it would be neither possible nor desirable to use PSI. However, Green's paper was more complimentary than critical of the Keller Plan. Green's fifteen possible objections or reasons not to utilize PSI are as follows:

1. Mastery is not the objective of your course.
2. There is no adequate text for your course.
3. Your subject changes too fast.
4. You have 500 students, no help, and no time off to prepare materials.
5. Your students can't read, at least not well enough to do without lectures.

6. You are legislatively required to lecture for a large number of hours.

7. You don't have the energy to try something new at this time.

8. Good teaching isn't rewarded at your school.

9. You can't get undergraduate tutors for love, credit, or money.

10. One undergraduate cannot judge proficiency in your subject on the part of another undergraduate.

11. Your administration will not tolerate a large fraction of A's.

12. You object on principle to specifying detailed objectives in your course.

13. You cannot specify objectives in your course.

14. You are too soft-hearted to withhold a privilege from a student who has not earned it.

15. You are satisfied with your present methods (Green, 1974a, pp. 118-119).

Sherman (1974) described some problems inherent in PSI courses. Sherman's concerns centered on problems related to the substantial logistics and administrative load inherent in PSI applications and instances of students falling behind, procrastinating, and earning incompletes.

Chapter Summary

Literature related to the present study has been reviewed in this chapter. The review of related literature was presented in five editions.
Industrial arts curriculum literature was reviewed in the first section. Significant developments during the past century were outlined.

PBTE literature was reviewed in the second section. The antecedents and current scope of PBTE were briefly outlined. Characteristics of PBTE programs were described in some detail and pertinent PBTE models were illustrated. Specific elements of PBTE programs which appeared to have particular relevance for the restructuring of the course ED: INTEC 120 were discussed. Such elements included behavioral objectives, teaching-learning modules, and learning spaces. An attempt was made to include a sampling of concerns related to PBTE as expressed by some leaders in education. Finally, a listing of advantages and problems associated with PBTE programs was included in the first section of this chapter.

The third, fourth, and fifth sections of this chapter contain a review of instructional program management literature. Systems approach literature was reviewed in section three, computer-managed instruction (CMI) literature was reviewed in section four, and personalized system of instruction (PSI) literature was reviewed in section five. In addition to describing the characteristics of the systems approach, CMI and PSI, an attempt was made to identify the advantages and limitations of each. The instructional system designer requires an understanding of the characteristics, limitations, and advantages of these three approaches to instructional program management in order to develop a total system that will incorporate the best mix of these management strategies.
CHAPTER III

A RATIONALE FOR THE COURSE ED:INTEC 120

Introduction

Evans and McCloskey (1973) described a rationale as "a reason for existence (p. 6)" and as "an examination of underlying principles (p. 6)." Wollin (1974) stressed the need for an adequate rationale for PBTE programs and stated:

...the agreement on rationale is probably the most important component in the design of any teacher education program (p. 342).

The following rationale consists of a series of considerations upon which the proposed new structure for the course ED:INTEC 120 is based. The rationale was developed primarily to serve as a guide in conceptualizing a more adequate course structure. It was also found useful in the preparation of course objectives and in the selection of appropriate student learning activities.

Program Mission

The mission of the undergraduate program of the Faculty of Industrial Technology Education is the preparation of competent industrial arts teachers for the "real world." The real world of the industrial arts teacher exists in the industrial arts laboratories in the public
schools where a majority of the nation's youth are provided with experiences in industrial arts for the purpose of providing technological literacy and other essential developments.

The Purpose of the Course ED:INTEC 120

The course ED:INTEC 120 is the first course in the professional sequence for prospective industrial arts teachers. Therefore, the course is designed to provide the student with a broad overview of his chosen profession, specific information concerning his undergraduate program, and basic skills and knowledge in materials processing.

Broadly stated, the goals of the course ED:INTEC 120 are as follows:

1. To offer an orientation to the technical subject matter in industrial arts through experiences with materials, tools, and processes.

2. To provide an understanding of the history and present status of industrial arts teaching as a career and as a profession.

3. To provide an understanding of industrial arts teaching through observations and participation in public schools.

4. To acquaint beginning students with the nature of their undergraduate program in industrial technology education. (Appendix A).

The course ED:INTEC 120 may be viewed initially as consisting essentially of three major activity areas:

1. A series of field trips to observe selected local industries and industrial arts laboratories.

2. An orientation to the undergraduate program and to the profession which consists essentially of selected readings, lecture-type presentations by leaders in the profession, and a question and answer period.
3. A series of hands-on experiences in processing standard wood and metal stock cumulating in the fabrication of one or more products (projects).

Each of the major activity areas outlined above is directly related to the stated broad goals of the course.

The three major activity areas are illustrated in Figure 12. Two of the major divisions of the course, (orientation and field trip activities) having proved very successful over a long period of time, are not a concern of this study. This study is concerned only with the restructuring of content for the materials processing area.

The knowledge and skills taught in the course ED:INTEC 120 are placed in the broader materials processing context in a number of subsequent courses (construction and manufacturing) which make up the 80 quarter hour comprehensive technical major. The effort here is simply to assure that in these subsequent courses all students will have learned minimum competencies in measuring, safety, etc. These minimum competencies may have to be reviewed again by certain individual students, but they will not again be part of the formal instruction. Thus, whenever students are expected to skillfully drive nails, lay out a mitre joint, or prepare a sand mold for metal casting, they will be expected to perform the skill. There are two implications of this. The first is that the course ED:INTEC 120 assumes foundational importance in teaching selected skills which are repeatedly used and further developed in subsequent courses. The recording of the individual achievement of these skills in the course ED:INTEC 120 is an important part of the learner's progress profile. The second implication is that the possible need for review of these basic
INDUSTRIAL TECHNOLOGY EDUCATION
COURSE ED:INTEC 120

FIELD TRIPS TO
INDUSTRIAL ARTS LABORATORIES
AND LOCAL INDUSTRIES

PROCESSING
STANDARD STOCK
MATERIAL

ORIENTATION TO
UNDERGRADUATE PROGRAM
AND PROFESSION

FIGURE 12
ED:INTEC 120 COURSE ACTIVITIES
program elements make it essential to have some review system which is accessible to individual students in order to avoid instructors having to interrupt subsequent presentations to duplicate previous instruction.

Time Allotments for the Course ED:INTEC 120

Classes for the course ED:INTEC 120 are currently scheduled to meet five days per week for a two-hour period each day. This results in an approximate total of one hundred class hours per ten-week academic quarter. It is desired that this established class meeting schedule be continued in order to avoid conflicts with existing university, student, and faculty schedules.

The one hundred hours of formal class attendance required of each student enrolled in the course ED:INTEC 120 is allocated to the three major course activity areas as follows:

- Field Trips: 20 hours
- Orientation: 5 hours
- Processing: 75 hours

This time allocation within the course ED:INTEC 120 is illustrated in Figure 13. The twenty hours allocated for field trips and the five hours allocated for orientation have proved satisfactory over a period of several years. Therefore, there is no apparent need to alter these time allocations.

Due to the fact that twenty-five of the one hundred course hours are allocated for field trips and orientation, the balance of seventy-five hours represents the maximum number of in-class hours a student
FIGURE 13

ED: INTEC 120 TIME ALLOCATIONS
may devote to the processing segment of the course. The new structure for the course must be designed with this time limit in mind.

The Learner

Students who enroll in the course ED:INTEC 120 vary considerably with regard to course entry-level skills in materials processing. Some students have had experiences with industrial arts in the public schools, some have gained various skills in materials processing in industry or in the military forces, and others have had relatively little or no contact at all with materials processing.

It is therefore desirable that some form of diagnostic pre-testing be incorporated in the course ED:INTEC 120 so that students can begin the learning sequence at a level commensurate with their course entry-level skills and knowledge. It is also desirable that the course be structured so as to provide, at least to some extent, for individual student capability and interest.

The Need for Basic Competencies in Wood and Metal Processing

Industrial arts subject matter in the public schools varies considerably from one school district to another. Course offerings may range from elementary woodworking to rather sophisticated programs such as the IACP's "World of Manufacturing." All programs, however, require an instructor capable of demonstrating and teaching basic processing operations using standard wood and metal stock. Therefore,
the acquisition of the necessary basic competencies in materials processing is an essential element in the preparation of industrial arts teachers.

The recent publication, *A National Status Study of Industrial Arts Teacher Education*, by the National Association of Industrial and Technical Teacher Educators (1974), describes a survey of industrial arts teacher education programs in 176 private and public colleges and universities. The findings of the study include the following:

1. The teaching areas offered within the major were ranked in terms of frequency as (1) Drafting, (2) Woodworking and Metals, (3) Electronics, (4) Machine Shop, (5) Crafts, (6) Graphic Arts, (7) Auto Mechanics, (8) Others, and (9) Photography.

2. The new content courses offered within the departmental degree were listed most frequently as Industrial Processes, Industrial Materials, and Plastics.

3. The additional technical areas of the shop requirements offered in the department yielded these ranks: (1) Power, (2) Construction and Manufacturing, (3) Materials, (4) Processes, .... (p. 52).

The areas of woodworking, metals, industrial processes and materials appear to be firmly established in industrial arts teacher education programs.

Wenig (1975) reviewed various viewpoints in the literature related to essential developments provided through industrial arts education and compiled the data shown in Figure 14. It is noted that Objective 9, "Use of Tools and Materials of Industry (Skill)," received a relatively high ranking.
<table>
<thead>
<tr>
<th>OBJECTIVE</th>
<th>LEE &amp; WAY</th>
<th>KRAMER/BAR</th>
<th>MALEY</th>
<th>MITCHELL</th>
<th>J. OLSON</th>
<th>HACKETT</th>
<th>O. OLSON</th>
<th>AVA</th>
<th>DUFORD</th>
<th>NEW SAA</th>
<th>BUFFER</th>
<th>PL 68-316</th>
<th>FEDERAL</th>
<th>SUMMARY</th>
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<tr>
<td>1. Realization of Self</td>
<td>X</td>
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<td>2. Cultural Awareness of Industry</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Technological Literacy</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
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<td>4. Career Awareness, Orientation and Exploration</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Use of Tools and Materials of Industry (Skill)</td>
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<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>10. Develop Desirable Attitude Toward Work</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>11. Vocational-Psychological Training</td>
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<td>X</td>
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<td>X</td>
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<tr>
<td>12. Basic Scientific Principles and Practical Experience</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>13. Health &amp; Safety</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>

**FIGURE 14**

ESSENTIAL DEVELOPMENTS PROVIDED THROUGH INDUSTRIAL ARTS EDUCATION
(Wenig, 1975, p. 165)
The American Council on Industrial Arts Teacher Education (ACIATE), in the 1973 publication *Standards and Guidelines for Undergraduate Program Evaluation in Industrial Arts Teacher Education*, stated:

The industrial arts teacher education goals clearly and explicitly include within their context provisions for preparing the potential teacher to achieve all of the following unique and fundamental purposes of industrial arts in the elementary and secondary schools:

1. To develop in each student an insight and understanding of industry and its place in our culture.

2. To discover and develop talents of students in the technical fields and applied sciences.

3. To develop technical problem-solving skills related to materials and processes.

4. To develop in each student a measure of skill in the use of the common tools and machines.

Items three and four above are directly related to the problem of the study.

The 1968 publication *Minimum Standards for Ohio High Schools* by the Department of Education, State of Ohio, states:

The comprehensive industrial arts curriculum provides experiences in drawing, graphic arts, woods, metals, electricity, power mechanics, and industrial crafts ....(p. 49).

The seven industrial arts areas listed in that publication are also described in some detail. The description of the woods and metals areas are as follows:

**Woods:**

Planning, hand and basic machine woodworking, upholstering, finishing, furniture and cabinetmaking, basic carpentry and pattern making.
Metals:

Planning, cold metal work including sheet metal, art metal, ornamental iron, bench metal, machine tool work, and hot metal including forging, heat treating, foundry and welding (p. 50).

These extracts from Minimum Standards for Ohio Schools suggest that institutions preparing industrial arts teachers for service in Ohio schools must include wood and metal processing in their programs.

Teaching Psychomotor Skills

A major part of the course ED:INTEC 120 is concerned with the acquisition of basic competencies in wood and metal processing and fabricating. This involves the teaching of psychomotor skills.

Davies (1973) discussed the teaching of psychomotor skills and stated:

Teaching the skill content of any job largely involves getting a student to do things, and this means that a teacher must exercise five broad responsibilities:

1. He must demonstrate the skill to the trainees as a complete cycle of operations.

2. He must break down the skill into related, but separate subroutines, and demonstrate these just as a skilled worker would perform them.

3. He must tell, and then show, trainees how a skilled worker actually obtains his results.

4. He must allow trainees to continuously practice each of these subroutines until they learn the skill beyond the criterion, i.e., they overlearn the task.

5. He must then ensure that these subroutines are chained together (retrogressively or progressively), and the complete skill overlearned through constant practice (pp. 198, 200).
Davies also provided a selection of research findings related to the teachings of psychomotor skills (p. 198). These are illustrated in Figure 15.

Industrial educators have traditionally taught psychomotor skills to classes of students by means of demonstrations. Ellis (1973) claims that this method "has failed, is failing, and will continue to fail to teach psychomotor skills well (p. 326)." The solution to the problem, according to Ellis, lies in the utilization of portable video-tape recorders by industrial educators. Ellis described the video-tape recorder as "the simplest, fastest, and cheapest method to present psychomotor information."

Armstrong (1969) conducted an experimental study to determine the feasibility and effectiveness of teaching part of an in-service teacher education course by pre-taped video-taped recordings. Armstrong found no statistically significant difference in the achievement of experimental and control groups in the course Developing Instructional Materials in Trade and Industrial Education. Armstrong noted, however, that:

A class presentation which is video-taped may favorably affect the quality of instruction because of the more obvious need for a careful organization of the subject matter (p. 47).

McClure (1973) described how videotaped demonstrations were successfully utilized in a welding course in a community college. McClure found the videotaped demonstrations relieved instructors of the time-consuming task of repeating demonstrations thus permitting
<table>
<thead>
<tr>
<th>FACTOR</th>
<th>RESEARCH FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement on basic skill motions</td>
<td>Not all basic skill motions (therbligs) improve equally. Stationary acts, like grasp and position, tend to improve more rapidly than movement acts, like reach and move. This difference is probably due to the fact that stationary therbligs involve a greater degree of perception.</td>
</tr>
<tr>
<td>Rate of progress</td>
<td>Progress tends to be rapid initially (because it is associated with the cognitive aspect of the task), but this is then followed by a much longer period of gentle progress (associated with the motor aspect of the task).</td>
</tr>
<tr>
<td>Plateaux</td>
<td>Plateaux, or periods of no improvement, do not generally occur in simple tasks. In more complex tasks, they may occur at different times for different individuals. They tend to result either from subjective factors (like distractions, lack of incentives, working conditions, etc.), or from factors inherent in acquiring the actual skill concerned.</td>
</tr>
<tr>
<td>Skilled performance</td>
<td>Improvement in acquiring a skill continues with practice, but gradually flattens out as mastery is reached, at which point the trend approximates more and more closely to a straight line.</td>
</tr>
</tbody>
</table>

**FIGURE 15**

SOME FACTORS AFFECTING THE RATE AT WHICH PSYCHOMOTOR SKILL IS ACQUIRED

(Davies, 1973, p. 198)
the instructors to spend more time interacting with students on an individualized basis. Students were permitted to observe the videotaped demonstrations as often as they wished while attempting to master the techniques presented. McClure suggested that:

a similar approach should be tried in other fields where the teaching of specific skills lends itself to the modularized and videotaped presentation method (p. 15).

It appears that the use of videotaped demonstrations in a course such as ED:INTEC 120 could facilitate the learning process.

Structuring Course Content

In The Process of Education (1965), Jerome S. Bruner stated "any subject can be taught effectively in some intellectually honest form to any child at any stage of development (p. 33)." Bruner emphasized the importance of structuring the instructional content to facilitate the learning process. He stressed the need for teaching the fundamental structure of a subject and indicated that:

1. Understanding the fundamental concepts and principles makes a subject more comprehensible.

2. If details are not placed in a structured pattern, they are soon forgotten.

3. The understanding of fundamental principles and ideas facilitates the transfer of learning.

4. The emphasis on structure and principles narrows the gap between elementary and advanced knowledge (pp. 23-26).

A major outcome of the Industrial Arts Curriculum Project (IACP), conducted at The Ohio State University from 1965 to 1971, was the
publication *A Rationale and Structure for Industrial Arts Subject Matter* (1966). This document was described by Buffer (1971a) as "the only comprehensive undertaking of this kind in the field of industrial arts education (p. 188)."

The IACP Structure (Towers, Lux, and Ray, 1966, pp. 176-190) indicates that industrial materials are changed in form in three basic ways:

1. Forming,
2. Separating, and
3. Combining.

The IACP publication *The World of Manufacturing* (1971, p. 257) presented the major subprocesses of forming, separating, and combining as shown in Figure 16. This structure for processing industrial materials has implications for the modularization of subject matter content in those industrial arts courses which are offered on various levels under such course titles as "woodworking," "metalworking," "plastics," and "materials processing."

Chapter Summary

The rationale for the course ED:INTEC 120 presented in this Chapter was developed primarily to serve as a guide in conceptualizing a more adequate structure for the course. The rationale includes a statement of the program mission and the purposes of the course ED:INTEC 120.
FIGURE 16

MAIN PRACTICES OF PROCESSING
(IACP, The World of Manufacturing, 1971, p. 306)
The rationale also describes the needs served by the course. The learner's need to acquire a range of basic psychomotor skills in materials processing within the time constraints of the course was emphasized.

Finally, Chapter III includes a description of the basic structure for processing industrial materials provided by the Industrial Arts Curriculum Project (1966) which has implications for the modularization of subject matter content in a great variety of industrial education courses.

The next Chapter describes one method of adapting the IACP structure to the course ED:INTEC 120.
CHAPTER IV

A PROPOSED NEW STRUCTURE FOR THE COURSE ED:INTEC 120

Introduction

The purpose of this chapter is to present a conceptual structure for the materials processing area of the course ED:INTEC 120. More specifically, this chapter shows one way in which the IACP concepts may be adapted and utilized within an ordered, rational structure to provide ED:INTEC 120 students with selected basic skills in processing standard wood and metal stock.

In conceptualizing and designing the new structure, an attempt was made to apply the following criteria:

1. The new structure must be operationally adequate,
2. The new structure should be based on industrial processing concepts rather than on tools, machines, materials, etc.,
3. The new structure should permit the use of behavioral objectives where feasible,
4. The new structure should facilitate modularization of instruction,
5. The new structure should provide for individual learner differences,
6. Responsibility for learning should be placed on the learner,
7. The new structure should be sequenced so that students progress from the simple to the difficult and from the known to the unknown, and

8. Course activities should not exceed a total of one hundred hours for the entire course.

Conceptual Structure

The IACP structure for materials processing can be arranged in a hierarchical order by conceptual level (Figure 17). When arranged in this manner, forming, separating, and combining represent first-level concepts. These three first-level concepts are totally inclusive of the processing concept and are mutually exclusive of each other.

Figure 17 also shows a second conceptual level consisting of ten second-level concepts numbered from 5.0 to 14.0. The ten second-level concepts are also mutually exclusive and totally inclusive of their respective materials processing concepts.

A number of third-level concepts which were derived from the second-level concept, chip removing (5.0), are shown in Figure 17. These are numbered from 5.1 to 5.8. The other second-level concepts (6.0 through 14.0) can also be made to yield groups of subconcepts at the third-level similar to those illustrated for chip removing.

At the third conceptual level the materials processing concepts identified can be equated with distinct basic competencies for learners in the course ED:INTEC 120. For example, sawing (5.1), drilling (5.2), milling (5.3), sanding (5.4), grinding (5.5), reaming (5.6), and shaping
FIGURE 17
A CONCEPTUAL STRUCTURE FOR THE COURSE ED: INTEC 120
(5.7) represent a cluster of related materials processing concepts at the "hands-on" level which can be packaged and presented to learners as a series of related basic skills to be acquired in the course ED:INTEC 120.

Functional Structure

The new conceptual structure for the course ED:INTEC 120, as illustrated in Figure 17, provides a means for the identification of processing concepts at a level appropriate for teaching and learning basic competencies in materials processing. The next steps in the development of the course structure are to consider certain other factors which may substantially affect learner acquisition of processing competencies and to incorporate such factors in the course structure.

It is evident that learner acquisition of basic competencies in materials processing will be enhanced if the learner is provided in advance with knowledge, skills, and attitudes considered prerequisites to the learning tasks. Four broad categories of such prerequisites for materials processing were identified by the ED:INTEC faculty and graduate students as follows:

1. Materials,
2. Inspecting,
3. Laying Out, and
4. Safety.

The content of these four categories could be termed "enabling content" because its purpose is to enable the learner to acquire the terminal competencies listed as third-level concepts in Figure 17. The
four enabling categories (Figure 18) are considered to be the approximate equivalents of second-level processing concepts. Although the four enabling content areas (Figure 18) differ in kind and in purpose from the ten second-level processing concepts (Figure 17), the two figures can be combined to produce a functional course structure for the materials processing area of the course ED:INTEC 120.

The functional course structure (Figure 19) consists essentially of a series of fourteen basic organizational units or modules as follows:

Module 1.0 MATERIALS
Module 2.0 INSPECTING
Module 3.0 LAYING OUT
Module 4.0 SAFETY
Module 5.0 CHIP REMOVING
Module 6.0 SHEARING
Module 7.0 OTHER PROCESSES
Module 8.0 MECHANICAL FASTENING
Module 9.0 BONDING
Module 10.0 MIXING
Module 11.0 COATING
Module 12.0 CASTING OR MOLDING
Module 13.0 COMPRESSING OR STRETCHING
Module 14.0 CONDITIONING
FIGURE 18
FOUR CATEGORIES OF ENABLING CONTENT
Figure 19

A functional course structure for the course ED: INTEC 120
Each of the modules listed above represents a second-level processing concept or an enabling element. The module represents the basic organizational element for the course functional structure.

Based on personal experience, an intensive review of related literature, and on the criteria listed on page 4-1, the following learning units at the third conceptual level were identified and selected for the fourteen modules:

Module 1.0 MATERIALS
  1.1 Introduction
  1.2 Woods
  1.3 Metals

Module 2.0 INSPECTING
  2.1 Introduction
  2.2 Measuring Woods
  2.3 Measuring Metals
  2.4 Precision Measuring
  2.5 Quality Control

Module 3.0 LAYING OUT
  3.1 Introduction
  3.2 Laying Out Wood
  3.3 Laying Out Metal

Module 4.0 SAFETY
  4.1 Introduction
  4.2 Personal Safety
  4.3 Accidents and First Aid

Module 5.0 CHIP REMOVING
  5.1 Introduction
  5.2 Sawing Wood
  5.3 Sawing Metal
  5.4 Drilling Wood
  5.5 Drilling Metal
  5.6 Turning Wood
  5.7 Turning Metal
  5.8 Planing Wood
  5.9 Planing Metal
  5.10 Sanding
  5.11 Grinding
  5.12 Boring
5.13 Filing
5.14 Scraping
5.15 Threading
5.16 Milling
5.17 Jointing
5.18 Shaping
5.19 Reaming
5.20 Broaching

Module 6.0 SHEARING
6.1 Introduction
6.2 Square Shearing
6.3 Rotary Shearing
6.4 Snipping
6.5 Chiseling
6.6 Notching and Punching
6.7 Nibbling

Module 7.0 OTHER PROCESSES
7.1 Introduction
7.2 Thermal Eroding
7.3 Chemical Separating
7.4 Electrochemical Separating
7.5 Induced-Fracture Separating

Module 8.0 MECHANICAL FASTENING
8.1 Introduction
8.2 Nailing
8.3 Doweling
8.4 Riveting
8.5 Hinging
8.6 Stapling
8.7 Threaded Fastening

Module 9.0 BONDING
9.1 Introduction
9.2 Gluing
9.3 Laminating
9.4 Soldering
9.5 Brazing
9.6 Oxyacetylene Welding
9.7 Arc Welding
9.8 Spot Welding

Module 10.0 MIXING
10.1 Introduction
10.2 Achesives
10.3 Finishes
Chapter Summary

A proposed new structure for the course ED:INTEC 120 was presented in this chapter. The structure is based on the ED:INTEC 120 rationale (Chapter III) and the criteria listed on page 4-1.

The proposed new structure was first presented as a conceptual structure (Figure 17). Four categories of enabling content (materials, inspecting, laying out, and safety) were synthesized with the conceptual structure to provide a functional course structure for ED:INTEC 120 (Figure 19).
The next chapter describes the ED:INTEC 120 learning modules in greater detail and describes how the units in each module may be developed as learning packages to individualize instruction in the course ED:INTEC 120.
CHAPTER V

LEARNING MODULES FOR THE COURSE ED:INTEC 120

Introduction

The purpose of Chapter V is to describe in some detail the components of ED:INTEC 120 modules and to present one completed module which may serve as a model for further development of ED:INTEC 120 course materials.

Learning Packages

The units within each of the fourteen materials processing modules can be developed as learning packages. A learning package (LP) is a unit of instruction, usually self-contained, that is designed to be used by students with little or no instructor assistance. LPs are, in short, units that students can work with and learn by themselves.

The number of LPs within each module varies from a maximum of twenty LPs in Module 5.0 (Chip Removing) to a minimum of three LPs in Modules 1.0, 3.0, 4.0, 10.0, 12.0, and 13.0. The total number of LPs in all fourteen modules is seventy-nine. Figures 20, 21, 22, and 23 show the fourteen modules and seventy-nine LPs by enabling, separating, combining, and forming areas respectively.
## ENABLING MODULES

<table>
<thead>
<tr>
<th>MODULES</th>
<th>LEARNING PACKAGES</th>
<th>ESTIMATED HOURS</th>
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Total estimated time requirements for Enabling Modules **11.5** **11.0**

FIGURE 20

ENABLING MODULES AND LEARNING PACKAGES
### SEPARATING MODULES

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<td>6.6 Notching and Punching</td>
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**FIGURE 21**

SEPARATING MODULES AND LEARNING PACKAGES
### COMBINING MODULES

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**FIGURE 22**

COMBINING MODULES AND LEARNING PACKAGES
## FORMING MODULES

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<td>13.2 Bending</td>
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<td>14.4 Tempering</td>
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</table>

Total estimated time requirements for Forming Modules: 8.5 3.8

**FIGURE 23**

FORMING MODULES AND LEARNING PACKAGES
It is the intention that the course ED:INTEC 120 will eventually have available more materials in learning package form than can be covered in the time allotted. This will permit each instructor to select the content best suited for his class as a whole and for each individual student.

Learning packages may be color coded in two categories:

1. LPs containing knowledge and skills that every ED:INTEC 120 student should know/perform.
2. LPs containing knowledge and skills that should be used at the option of the instructor.

It is hoped that out of these modules and learning packages will come agreement on the minimum essential knowledge and skills that each learner should have at the completion of the course ED:INTEC 120.

Estimated Time Requirements

One of the criteria specified in Chapter IV for the new course structure for ED:INTEC 120 was that course activities should not exceed a maximum of one hundred hours. Orientation activities require five hours and field trip activities require a total of twenty hours. This leaves a balance of seventy-five hours for materials processing, fabricating, and proficiency testing activities. An estimated time for completion was arbitrarily assigned to each learning package (Figures 20, 21,
Based on these time estimations, the time allocations for the major activity areas of the course ED:INTEC 120 are:

- Orientation: 5 hours
- Field Trips: 20 hours
- Enabling Modules: 11.5 hours
- Processing Modules: 56 hours
- Fabricating and Proficiency Testing: 7.5 hours

Total: 100.0 hours

The time allocations are illustrated in more detail in Figure 24.

A Model Learning Module

Module 8.0 (Mechanical Fastening) was selected as a model learning module because it contains learning packages for both wood and metal materials and because it may be considered a typical module for the course ED:INTEC 120. The average ED:INTEC 120 module contains 5.5 learning packages and is estimated to require approximately five in-class hours for completion. Module 8.0 contains seven LPs and the estimated time for module completion is approximately five hours. In short, Module 8.0 is considered an average module.

Module 8.0 (Mechanical Fastening) is included as Appendix D. Each of the seven learning packages in Module 8.0 was prepared according to the following outline:

1. Overview
2. Terminal Objectives
3. Specific Objectives
FIGURE 24

ED: INTEC 120 TIME ALLOCATIONS
Materials, Tools, and Equipment

Safety

Suggested Activities

Self-Test

Learning Package 8.1 differs from the other six LPs in Module 8.0 in two respects:

1. LP 8.1 is preceded by a module title page which includes, in addition to the module title, a complete listing of all LPs in Module 8.0 by LP title and identification number.

2. LP 8.1 contains a listing of module prerequisites. It is recommended that the learner complete all prerequisites listed before beginning a module.

Except for the two differences described above, all LPs in Module 8.0 are quite similar and all conform to the seven-step outline. A description of the seven-step outline for writing learning modules for ED:INTEC 120 follows.

In the Overview section of each LP an attempt was made to place the content of the LP within the context of the total materials processing concept presented in ED:INTEC 120. This, hopefully, will provide the learner with a frame of reference from which he may view the course and the competencies he is expected to demonstrate. The Overview section should not duplicate content included in the LP reading assignment.

In the Terminal Objective section of each LP an attempt was made to state simply and clearly what the learner should be able to do after completing the LP. The value of providing the learner with a listing of
objectives prior to instruction had been empirically demonstrated to facilitate learning (Rothkopf and Kaplan, 1971).

In the **Specific Objectives** section of each LP the terminal objective is restated as one or more specific objectives. The conditions under which the performance should occur are described and a statement of acceptable performance is included.

The **Tools, Materials, and Equipment** section of each LP lists all the learning aids for that particular LP. The learner is advised to assemble all the items listed before commencing the activity.

The **Safety** section of each LP contains safety information related to the specific activities required in the LP. The **Safety** section supplements the general laboratory safety content of Module 4.0 (Safety).

The **Suggested Activities** section of each LP contains a listing of activities specifically designed and sequenced to enable the learner to achieve the stated objectives of the LP.

The **Self-Test** section of each LP contains a short paper-and-pencil test which is returned to the instructor as evidence that the learner has completed the LP. The instructor may wish to combine all the self-tests within a given module into a module test which learners could complete at a computer terminal. This procedure could provide the ED:INTEC 120 course instructor with a periodic computer print-out showing individual and class progress.
Estimated Costs Related to Module Development

The following are estimated costs related to module development for the course ED:INTEC 120. The estimates are based on the researcher's experience in writing the seven learning packages for Module 8.0 (Appendix D) and upon current costs of commercially available textbooks and audio-visual teaching aids.

It is realized that many of the videotapes, film loops, and film strips required for the various ED:INTEC 120 course modules are not available commercially. Such learning aids must be developed. Cost will vary significantly depending upon factors such as the availability of video-taping equipment and personnel with the required skills. The following estimates are intended to serve only as guides:

1. Writing Learning Packages
   78 learning packages @ 10 man/hours per LP 780 man/hours

2. Reference Books for Assigned Readings
   10 textbooks @ $10.00 each $100.00

3. Learning Aids
   26 videotapes @ $50.00 each 1300.00
   26 super 8mm (color) film loops @ $20.00 each 520.00
   26 film strips (color) @ $8.00 each 208.00

4. Materials and Supplies (Wood, Metal, Screws, etc.)
   14 kits @ $2.00 each 28.00*
   (note: fourteen kits are required for each learner in the course)

Total: 780 man/hours and $2156.00

*This figure is unlike the others which make up the initial development costs. It should be multiplied by the number of students in a class in order to determine the cost of expendables for that class. The other items (1 through 3) are not expendable or used up in teaching one class.
The above estimated costs for the course ED:INTEC 120 are based upon the costs of equivalent commercially available learning aids in other subject areas. It is anticipated that the costs listed above will vary considerably in actual practice depending upon the resources available to the curriculum developer.

Chapter Summary

This chapter has described the components of ED:INTEC 120 modules as groupings of related learning packages. Appropriate learning packages for each of the fourteen modules were identified. Estimated time for student completion was provided for each of the seventy-nine learning packages which constitute the fourteen learning modules. The total estimated time requirements for the fourteen learning modules was established within the context of the ED:INTEC 120 course.

Module 8.0 (Mechanical Fastening) was presented as a model learning module for the course ED:INTEC 120 (Appendix D). This particular module was selected as a model module because it represents the average size of an ED:INTEC 120 materials processing module.

A seven-step outline for writing ED:INTEC 120 materials processing learning packages was presented and described. This outline was used in writing the seven learning packages for Module 8.0 (Mechanical Fastening). The seven-step outline may be used to develop additional materials processing modules for the course ED:INTEC 120.

Estimated costs related to module development for the course ED:INTEC 120 were also included in this chapter. Estimated costs were
provided for (1) writing learning packages, (2) reference books, 
(3) learning aids, and (4) materials and supplies.

The next chapter describes a management system for a modularized, 
competency-based course such as ED:INTEC 120.
CHAPTER VI

A MANAGEMENT SYSTEM FOR THE COURSE ED: INTEC 120

Introduction

Management involves planning, organizing, and controlling all the activities of the instructional program. Coffing and Hamreus (1973) have succinctly captured the essence of the management function in the following statement:

Unlike the other subsystems, management's primary concern is the well being of the whole system because it is responsible for integrating all the major parts into a goal-achieving combination (p. 74).

Silvern (1972) emphasized the organizational aspects of the management of instruction:

The key to success in training is organization—the logical, meticulous design and implementation of a structure which is orderly (p. 47).

As one moves from a traditional to a modularized, competency-based instructional program, management tasks become increasingly numerous and complex. The complexities of the management function in a modularized, competency-based program stem, to a large degree, from the need to:

1. increase emphasis on learner and program evaluation which requires the collection, sorting, and retrieval of vast amounts of data,

2. employ a full range of innovative materials, equipment, and facilities to foster learner progress,
3. permit students to advance at their own rate to the extent possible,

4. give students module or course credit for knowledge and skills demonstrated through pre-testing, and

5. change the role of the instructor from a dispenser of knowledge to a manager of the learning environment.

In order to accomplish these management tasks and others of similar complexity, modern management technology should be utilized.

Utilizing CMI in the Course ED:INTEC 120

The course ED:INTEC 120 differs from other CMI courses reported in the literature in one significant respect: ED:INTEC 120 course objectives are predominantly in the psychomotor domain whereas other CMI applications reported in the literature are primarily concerned with cognitive learning. Since the core of CMI is diagnostic testing by behavioral objectives, the question arises as to whether the instructional management strategy of CMI is appropriate for the course ED:INTEC 120. Although this question may be eventually decided on a cost/benefit basis when the required data becomes available, there is reason to believe that CMI may be effectively utilized to facilitate the management of ED:INTEC 120. For example, each ED:INTEC 120 module has both cognitive and psychomotor objectives. By arranging for the instructor to evaluate the psychomotor component and for the computer to measure achievement of cognitive objectives, the
instructor may utilize the computer to retrieve, in a matter of seconds, the following information:

1. Learner's name and computer code number,
2. The module identification and sequence,
3. The number of correct responses at each cognitive level (A, B, C) for the module post-test,
4. The performance on the last module post-test taken,
5. The total numeric score on the last module post-test taken,
6. The number of times the test was taken toward mastery,
7. Whether mastery was achieved, and
8. The numbers of the objectives not achieved in the last module.

The above data can be easily retrieved by the instructor for any individual student or for all students in the course. In a course where some fifteen or more students are progressing through fourteen modules involving over seventy self-paced learning packages, some required and some optional, the instant availability of the data listed above can greatly facilitate course management.

The CMI model program described in the publication, *A Model for the Computer Management of Modular, Individualized Instruction* (Allen, Meleca, and Meyers, 1972), may be utilized to facilitate the management of ED:INTEC 120. The model has been successfully implemented at both Ohio State and South Dakota State Universities.

In order to utilize the Allen, et al., CMI model in the course ED:INTEC 120, the following major steps appear necessary:

1. The subject matter for the course should be identified and divided into a number of modules.
2. Each module should be keyed to specific behavioral objectives.

3. Both a statement and a restatement of each behavioral objective is required for the CMI software. The restatement is usually longer and is presented to the learner upon his request for clarification.

4. Test item banks should be developed. At least three test items per objective are required. Test banks are subdivided into three groups: (a) knowledge and comprehension questions, (b) application and analysis questions, and (c) synthesis and evaluation questions (Allen, et al., 1972, p. 3).

5. Appropriate course software should be developed. Software should include: learning modules, student study guide, instructor's manual, and audio-visual aids.

A summarized flow chart for the course ED:INTEC 120 is shown in Figure 25. This diagram is basically similar to the CMI flow chart presented by Allen, et al., (Figure 11).

As illustrated in Figure 25, students will begin the course ED:INTEC 120 by taking an off-line (paper and pencil) diagnostic test. The off-line test is designed to measure the student's entry knowledge. The test will consist of approximately seventy multiple-choice questions based on the learning objectives included in the required course modules and learning packages. Mastery level on the diagnostic test will be established in advance by the instructor and will probably be in the ninety to one hundred percent region. The diagnostic test will be
FIGURE 25

A SUMMARIZED FLOW CHART FOR THE MATERIALS PROCESSING SECTION OF THE COURSE ED: INTEC 120
computer scored and the instructor will be provided with a print-out showing each student's achievement.

Students who achieve mastery level on the off-line test will have the option of taking appropriate skill tests selected by the instructor from the required course modules. Students who achieve mastery on the skill tests will have the option of receiving course credit without additional course work or such students may, with the instructor's permission, elect to complete a series of optional ED:INTEC 120 course modules and learning packages.

Students who do not achieve mastery on the off-line diagnostic test will schedule a planning session with the instructor. During the planning session, the instructor will discuss the student's entry behaviors as indicated by the off-line diagnostic test and assist the student in planning an individualized program commensurate with the minimum course requirements, student grade expectations, and student interests.

Following the planning session, the student will begin his individualized program by working through the series of designated modules. The module sequence may be established in advance by the instructor or the student may be permitted to plan his own sequence on the condition that established module prerequisites are observed. One possible module sequence is shown in Figure 26.

Each time a student completes a learning package activity he will bring the practice piece to the instructor for comment. This procedure will provide the learner with immediate feedback and permit the instructor
A sequence of materials processing modules for the course ED:INTEC 120
to maintain a record of the student's skill progress. The instructor will be provided with a special form for this purpose. A sample form is shown in Figure 27.

When the ED:INTEC 120 student has successfully completed the last activity in a module, he will then take a competency test on that module at the computer terminal. The module competency test may be of the multiple-choice or short-answer variety. Success on the module competency test will give the learner credit for the module and permission to proceed to the next module in the sequence. If the student does not achieve an acceptable score on the module competency test he will be directed by the computer program to restudy all or some of the learning packages in the module. This process will be repeated until the student achieves the mastery level established by the instructor for that particular module.

When the student has completed all the modules in his individual program he will select one or more products or projects to be fabricated from standard wood and metal stock. This activity will provide the learner with an opportunity to synthesize the knowledge and skills he has learned while performing the activities called for in the modules. It will also provide the learner with practice in fabricating a complete product (project) from components.

When the completed product is judged satisfactory by the instructor, the learner has completed the course ED:INTEC 120. Grades may be assigned as follows:

1. Students who complete all required modules and the required number of products (projects) will receive a grade of "C".
| MODULE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | REMARKS |
|--------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|        |
| 1.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 2.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 3.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 4.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 5.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 6.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 7.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 8.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 9.0    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 10.0   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 11.0   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 12.0   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 13.0   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 14.0   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |

FIGURE 27
STUDENT PROGRESS CHART
2. Students who, in addition to the minimum course requirements listed in 1 above, complete at least three optional learning packages will receive a grade of "B".

3. Students who, in addition to the minimum course requirements listed in 1 above, complete at least five optional learning packages will receive a grade of "A".

Obviously, many other grading systems may be used.

Estimated Costs Related to CMI for the Course ED:INTEC 120

The following are estimated costs related to the proposed CMI system for the course ED:INTEC 120. The estimates are based upon recent experiences with CMI in various courses at The Ohio State University.

1. Writing approximately 500 test items for objectives contained in the 14 ED:INTEC course modules . . . . . . . . . . . . 150 man/hours

2. Inputting 500 test items to computer program . . . . . . . . . . . . . . 70 man/hours

3. Writing a student study guide . . . . . . . . . . . . 150 man/hours

4. Writing an instructor's manual . . . . . . . . . . . . 60 man/hours

5. Installation charges for two CRT terminals . .  $70.00

6. Monthly rental charge for two CRT terminals. . $310.00*

Total: 430 man/hours and $430.00

The above estimates are intended to serve only as guides.

*Particularly note that this cost, unlike items 1 through 5, recurs monthly.
Other Components of the Management System

CMI is the major component of the proposed management system for the course ED:INTEC 120. However, certain other relatively minor system components are considered critical for the proper functioning of the management system. These components are briefly described below.

Learning Spaces

The multi-purpose industrial arts laboratory appears well suited to the modular, competency-based approach recommended for the course ED:INTEC 120. It will be necessary, however, to provide additional space to be used as a quiet study area by students. This space should be adjacent to the laboratory and might be termed a resource center. The resource center should include:

1. Approximately sixteen independent study carrels where students can utilize various learning aids as needed. Such aids include slide and movie projectors, and video-tape players. Not all carrels need be fully equipped because all learning devices are not needed simultaneously.
2. A bookshelf housing required and optional reading materials.
3. Two computer terminals.
4. A table and six chairs for counseling and small group sessions.
5. Storage for audio-visual media and equipment.

Learning Aids

The value of videotaped demonstrations for a welding course was the subject of an experimental study conducted by McClure (1973).
McClure used videotaped demonstrations in place of instructor demonstrations in a community college welding course and reported a significant reduction in the time required by students in an experimental group to reach mastery levels when compared to two control groups. McClure also reported significant decreases in failure and dropout rates for the experimental group.

Cushing (1971) conducted an experimental study to compare Super 8 mm Silent Film Loops presentations with live demonstrations to determine if film loops are effective for teaching machine operations. The experiment was conducted with four units: (1) Lathe I, (2) Lathe II, (3) Horizontal Milling Machine, and (4) Vertical Milling Machine. Cushing found:

...no significant difference between experimental and control groups when taught by film presentation or live demonstration for (a) the immediate achievement of knowledge, (b) the retention of knowledge, and (c) the performance of machine operation application (p. 1317-A).

Cushing also found that instructor produced films were more effective than commercial films for teaching machine operations and recommended that industrial education teachers produce their own films to meet local needs.

In order to free the ED:INTEC 120 instructor from repetitious demonstrations, it is recommended that all course demonstrations be videotaped or recorded on super 8 mm color film. This will free the instructor to interact with students on an individual basis. It will also permit the student to view each demonstration when he needs it and as often as he desires. Commercially available learning aids should be
utilized where appropriate. However, it is likely that most video-
tapes or film loops for the course ED:INTEC 120 will have to be made 
in-house.

**Standard Stock Materials and Hardware**

Learners in industrial arts laboratory courses sometimes spend an 
inordinate amount of time procuring appropriate sizes of wood, metal, 
and hardware items needed for their learning activities. In order to 
minimize the amount of student time spent in such activities, it is 
recommended that ED:INTEC 120 students be provided with a materials 
kit for each required module. For example, a materials kit for Module 
8.0 (Mechanical Fastening) might include the following:

- 4 lengths of wood (each 1" x 2" x 10")
- 1 length of wood dowel (1/2" x 10")
- 1 length of mild steel (1/8" x 1" x 10")
- 4 pieces of vinyl fabric (each 8" x 14")
- 4 pieces of 26 gauge sheet metal (each 2" x 2")
- 25 assorted nails
- 20 assorted wood screws
- 20 staples
- 3 soft iron rivets, 1/8"
- 3 blind rivets, 1/8"
- 1 pair of 2" butt hinges
- 4 assorted washers
The cost of materials kits may be reduced by salvaging hardware items from the exercise pieces completed by students. Materials kits may be packaged in plastic bags to facilitate storage and distribution.

Alternative Management Strategies

The modular, competency-based approach suggested for the course ED:INTEC 120 is not dependent upon a CMI application for course management. The PSI or Keller Plan appears to be a practical alternative management system for the course. The Keller Plan was described in Chapter II of this study.

It is also possible that an instructor, possibly with the aid of an assistant, using checklists (similar to that shown in Figure 27) could do a creditable job of course management. Both of these alternative management strategies for the course ED:INTEC 120 are worthy of further investigation.

Chapter Summary

The primary purpose of Chapter VI was to introduce and describe a proposed management system for the course ED:INTEC 120. This chapter described how CMI may be utilized in a modular, competency-based, laboratory course such as ED:INTEC 120. Two alternative course management systems were also identified.

Estimated costs related to a CMI application for the course ED:INTEC 120 were provided. These estimates are useful only as guides.
Recommendations were made concerning three other components of the proposed management system for the course ED:INTEC 120. These components included learning spaces, learning aids, and standard stock materials and hardware.

The next chapter describes a formative evaluation by a jury of experts of the rationale, structure, model module, and proposed management system for the course ED:INTEC 120.
CHAPTER VII

A FORMATIVE EVALUATION OF THE RATIONALE, STRUCTURE, MODEL MODULE, AND PROPOSED MANAGEMENT SYSTEM FOR THE COURSE ED:INTEC 120

Introduction

The rationale, structure, model module, and proposed management system for the course ED:INTEC 120 as contained in Chapters III, IV, VI, and Appendix D of this study were submitted to a jury for the purpose of conducting a formative evaluation of these components. The four-member jury was also provided with Chapters I, II, and V of this study to use, at their option, as reference or background materials.

A formative evaluation instrument and cover letter (Appendix B) were also delivered to the jury. The evaluation instrument is essentially a modification of the formative evaluation instrument presented by Lawson (1974, pp. 65-72). The design of the formative evaluation instrument used was also influenced by the work of Pool (1974) and Houston, et al. (1972).

The following section presents the responses of the jury in five categories: (1) rationale, (2) structure, (3) proposed management system, (4) model module, and (5) other comments. Responses to structured questions are presented as frequency distributions. Responses to open-ended questions are presented in full. Some jurors did not respond to every structured question. Therefore, the total number of responses for some structured questions is less than four.
Responses of Jury

Rationale

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<tbody>
<tr>
<td>1. Is the rationale adequate?</td>
<td>YES: 1, 2, 3, 4, 5, NO</td>
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<tr>
<td>2. Is the rationale logical?</td>
<td>YES: 1, 2, 3, 4, 5, NO</td>
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3. The strongest feature of the rationale is:

"Specific area named seemed well documented, i.e. literature, etc."

"Review of literature in 'Need for Basic Competencies' . . ."

"Documentation of the need for industrial arts teachers to master materials processing skills."

"Formalization of a conceptual framework for developing an introductory professional laboratory course for beginning ITE majors."

4. The weakest feature of the rationale is:

"No mention is made of the students' background and abilities."

"Using Jerome S. Bruner's statement on page 84. My bias!"

"I found it necessary to read Chapters I and II to better appreciate the rationale presented in Chapter III."

"Amount of duplication in wording."

5. Comment on rationale:

"Difficult to correlate the three course activities, i.e. field trips, etc., to the Figure 12. I am sure that some verbal explanation would take care of any concerns I have about this. Am I correct in understanding that psychomotor skill would be taught under 'processing' activities of the course? And that forming, separating, and combining constitute the areas in which psychomotor skills would be developed? I would like to have seen you challenge the rationale (from other courses) to separate the course hours as prescribed (i.e. 5 hours orientation, 20 hours field trips, 75 hours processing). Why not place more hours on psychomotor development? Overall, good rationale for development."

"I found no clear statement of the rationale."
"How does individualized instruction fit with student need?"

"You could improve the rationale in two ways: (1) forget about what was already being done and not allow current program or practice to interfere with your creative developments, and (2) better utilization of information reviewed in Chapters I and II. Page 73 — You jump from an ideal description and goal of IA, that of providing youth with technological literacy, to the teaching of wood and metal processes. Perhaps there is a need to justify the teaching of wood and metal processing as they relate to manufacturing and construction technology. (Your present discussion does not convince me, i.e. IA should include wood and metal processing because most secondary school programs are wood and metal, and also Ohio Standards list manufacturing and construction as two of the seven IA areas.) Your rationale needs to emphasize the unique function of 120 - how it tends to differ from other courses in the Faculty and what does it intend to accomplish? Your discussion tends to emphasize skill development but no mention is made of using the course to screen prospective majors. Why is the course necessary and why should it be included as an integral part of the B.S. program? Value of its activities, e.g., evaluation of present level of competencies and the prescription for subsequent laboratory experiences. Although this information is presented earlier in the m/s, it probably should be presented in Chapter III. Page 75 Time allotments appear satisfactory for whom? What objective and empirical means were used to evaluate? Instructor’s opinion!? How formalized are the 25 hours allotted for field trips and visitation to schools—can this be changed? Eliminated? I recommend that they be eliminated and that this time be devoted to the development of technical (psychomotor) information and skill."

Structure

0 1 2 3 4 5

1. Is the structure adequate? YES 4 , NO
2. Is the structure logical? YES 4 , NO
3. The strongest feature of the structure is:
   "Emphasis on basic concepts integrated with enabling modules."

"The outline of the modules on pages 95-97."

"Creation of an outline of technological processes which may be used as a guide when creating instructional activities for laboratory courses. It appears to be based on a tested conceptual structure for determining subject matter in industrial arts."

"Seems well documented and thought out."
4. The weakest feature of the structure is:

"Minor problem--on the surface it appears that safety has been separated from production practice--you may want to indicate how specific safety instruction will be included within each of the modules."

"Limitations of the study of materials, i.e. wood and metals."

"The model (Figure 19) has an excellent appearance, but I wonder if it serves a real purpose..."

"The structure does not provide an evaluation scheme. You have some criteria but how will you evaluate?"

5. Comment on structure:

"It presents criteria which are logical. The use of the term 'concept' is at variance with its meaning in other educational fields: is it commonly used in this way in Industrial Arts?"

"Are you going to use other 'materials' like liquid polyurethane to protect products? How about the use of plastic wood filler or plastic laminate when manufacturing products? Are these 'materials' or 'non-materials'?"

"In Module 5.0, wood and metal were separated for 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, and 5.9. Why was this differentiation not extended to sanding, forming, filing, scraping, jointing, and shaping?"

"Figures 17 and 18. It would help the reader to have 'levels' labeled; difficulty in following 'second level processing concepts' as being equivalent to the four enabling categories. Even though you undertake the serious business of evaluation under management system, I believe there should be some earlier mention in structure. It need not be detailed."

**Proposed Management System**

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<td>5</td>
</tr>
<tr>
<td>1. Is the proposed management system adequate?</td>
<td>YES</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>NO</td>
</tr>
<tr>
<td>2. Is the proposed management system logical?</td>
<td>YES</td>
<td>4</td>
<td></td>
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<td>NO</td>
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</table>
3. The strongest feature of the proposed management system is:

"Permits student repeatable testing experience with no threat of 'failure'. Student records and feedback, etc., etc."

"It will function with existing technology."

"Explicitness of the procedures (pages 113 ff.)."

"A formalized system which may be tested, revised, and used to improve the efficiency of the undergraduate technological program."

4. The weakest feature of the proposed management system is:

"A person who is not well informed regarding management systems would need some additional information to effectively use the system."

"I am a bit concerned about the S-U situation for practice in the laboratory. This fails to provide a reward for higher standards of craftsmanship and promotes a 'get-by' attitude. How will the record of psychomotor achievement be recorded? In the rationale, mention was made of skill development which goes far beyond merely being able to produce a given product. The factors of time, energy input, and body movement during the performance are not considered. To permit the students to complete a given exercise and receive credit for completion without appropriate consideration for the skill level achieved is not justified in a teacher preparation program. Means of arriving at the objective must be evaluated as well as the end product! I have not figured out the staffing problems which will be generated as a result of this innovation. It appears to require more people to run the system after it is established than is required to operate the existing course. How can this be overcome or justified? What opportunities exist for restructuring other courses or increasing the number of people in each section of this course so that the use of the instructor as a manager can be optimized?"

"Grading suggestions (page 120)."

"The estimated costs on page 121 are not accurate in terms of developmental time (author time). Exceptions are numbers 2, 5, and 6."

5. Comment on proposed management system:

"Fine job. I think it would help if you specifically pointed out how it is possible for the CMI system to flag a problem area for a particular student when he or she misses an objective. The
assumption, of course, is that you are testing for all objectives. Again, a good piece of work."

"It is carefully delineated so that the user knows how to have students use the program. Are there any specific instructions for any modules which should be incorporated?"

"Figure 25—EXEMPT COURSE—What about the other major elements of the course—field trips and orientation to the undergraduate program—do you mean exempt from processing standard stock? Also, what about the synthesis activities? I assume that knowledge and skill beyond the basics is acquired during these activities. How will students demonstrate their competence in these areas?"

"A darn good beginning. Should mastery levels for ED:INTEC 120 be determined by the instructor or should this be a departmental (or committee) decision? Page 120—what criteria are being used to evaluate the attainment of psychomotor skill? Your grading procedures sound like you are merely concerned with project and module completion. Besides, your three options do not take into consideration the student expectations or requirements currently listed, e.g. school visitation and professional studies. Page 122—how were the learning space needs determined? Have all the management activities been identified—planning the course goals, controlling student activities to ensure goal attainment and evaluation? Page 114—you suggest that computerized instruction be used to 'control' the teaching-learning activities. Examples of acceptable copy would be most helpful to prospective course developers. I assume that your reference by Allen (1973) would be the best reference to use. Page 116—your flowchart is based on the assumption that one must be able to demonstrate mastery of technical information before demonstrating skill proficiency. My guess is that there are many skilled craftsmen and artisans who would perform poorly in tests measuring cognitive knowledge. This is a problem worthy of more research."
Model Module

1. Is the format appropriate for the intended population in terms of ease of use?  
   YES 2 1 1 1 1, NO

2. Is the module divided into "units" of appropriate length for the intended population?  
   YES 2 1 1 1 1, NO

3. Does the display layout avoid a crowded appearance?  
   YES 3 1 1 1 1, NO

4. Are the illustrations simple, clear, attractive, and appropriate?  
   YES 3 1 1 1 1, NO

5. Are the display sequences numerically arranged?  
   YES 3 1 1 1 1, NO

6. Do the feedback elements contain the correct answer?  
   YES 2 1 1 1 1, NO

7. Are the display sequences free from grammatical, spelling, and typographical errors?  
   YES 1 3 1 1 1, NO

8. Is the sentence structure clear, simple, and straightforward?  
   YES 4 1 1 1 1, NO

9. Is the use of punctuation and abbreviations correct and uniform?  
   YES 4 1 1 1 1, NO

10. Are the instructions to the learner complete, clear, and easy to follow?  
    YES 3 1 1 1 1, NO

11. Do learners receive frequent and immediate knowledge of the effectiveness of their practice?  
    YES 2 1 1 1 1, NO

12. Have adjustments been made to the instructional program to accommodate learners of different aptitudes?  
    YES 1 1 1 1 2, NO

13. Does the content adequately cover the material specified in the objectives?  
    YES 2 1 1 1 1, NO

14. Is the content complete and up-to-date?  
    YES 3 1 1 1 1, NO
15. Is the content free from factual and technical errors? 

YES 3 . . . . . . . . . NO

16. Does the module avoid over-emphasizing topics which do not merit detailed treatment? 

YES 3 . . . . . . . . . NO

17. Does the module build associations by relating new materials to concepts the learner already knows? 

YES 2 . . . . . . . . . NO

18. Is essential information presented first? 

YES 2 . . . . . . . . . NO

19. Is review cumulative and appropriately spaced? 

YES 2 . 1 . . . . . . NO

20. Are self-checking materials built into the module at appropriate points? 

YES 3 . 1 . . . . . NO

21. Is the product likely to be challenging, but not discouraging to the learner? 

YES 2 . 1 . . . . . NO

22. Is the module personalized; that is, does it use the second person when addressing the learner? 

YES 3 . . . . . . . . NO

23. Are the questions or problems clearly stated and answerable on the basis of information supplied by the module? 

YES 3 . . . . . . . . NO

24. Are examples meaningful and well-chosen? 

YES 2 . . . . . . . . NO

25. Does the response ensure that the learner has understood the critical material in the module? 

YES 2 . . . . . . . . NO

26. Are objectives consistent with good education practice? 

YES 4 . . . . . . . . NO

27. Are objectives appropriate for the target population? 

YES 3 . . . . . . . . NO

28. Are activities consistent with objectives? 

YES 4 . . . . . . . . NO
29. Do activities utilize learning time efficiently?  

YES 4, NO

30. Comment on model module:

"I cannot respond to some of the questions with any great authority hence the (?)." (researcher's comment: the symbol (?) was placed beside questions 11, 12, 14, 15, and 29. Questions 11, 14, and 15 were not responded to by this juror). "Appendix D - LP 8.1 - you are developing psychomotor skills and cognitive understanding yet your terminal is written in such a way as to simply measure cognitive skills. LP 8.2, etc. are OK. You do measure both here. Your learners are probably going to be a bit bored by the format unless a multi-variety of techniques, visuals, etc., can be introduced. I see you are varying the activities."

"Clear and explicit. Measures recall of only factual information plus actual use of skill acquired. My reactions on this section are perhaps not completely valid, since I do not know the competencies of the students who take the course. I tried to answer in terms of what I perceive to be a source of limited breadth: one that presents discrete 'facts' and checks to see if students can apply certain rudimentary skills. Questions 3, 4, 5, 6, 7, 8, and 9, in particular, are by no means basic to evaluating a proposed course."

"Well done! I would like to test the modules with a small group of our majors to get their reactions. Activities appear to be short and could be completed successfully in a limited period of time. I wonder how 'interesting' they will appear to students?"

"Module 8.2--I do not know the content of videotape 8.1 but I assume it places emphasis on body movement--efficient use of body and tool in an effort to drive nails. Also, misses which damage the surface of the wood should be discouraged. If the instructional materials provide the information necessary for the student to analyze his own mistakes and develop a reasonably high level of skill in nail driving, then the evaluation must include observation of the performance as well as evaluation of the product. Without this type of instruction, this is a useless activity because any person, even a small child, could perform the activity. It might take a while and some extra nails may be needed but the frame would be assembled according to plan and likely pass the instructor product evaluation. Also, if the nails are clinched, removal with the tools listed may be a bit difficult. Why shouldn't the self-test include at least cognitive items about the psychomotor elements of the activity? This comment can and should be considered for each package within the module presented in Appendix D."
Other Comments

"There is very little 'originality' exhibited (as far as I can discern) — what others have written forms a large part of the document. How the proposed course of study will actually be different from the present course is unclear to me: the files may contain a different 'model' but will the day-to-day structure actually be different? And of even more importance, will the students be more knowledgeable (not only in facts but also in understandings) and competent (in skills and in knowing how to teach pupils to develop these skills)?"

Comment on Jury Evaluation

Rationale

The juror's responses to questions related to the rationale seem to indicate that the rationale is logical and reasonably adequate but could be improved. Two of the jurors suggested revisions of the ED:INTEC 120 course time allotments (i.e., 5 hours orientation, 20 hours field trips, and 75 hours materials processing). One of these two jurors recommended eliminating the orientation and field trip activities from the course and devoting the entire 100 hours to materials processing. This avenue was not explored in the course of the study as the study was limited to the materials processing area of the course as stated on page 8 of this document.

One juror recommended that the unique function of the course should be emphasized in the rationale. As a result of this recommendation the section titled "The Learner" was included in the rationale.
Structure

There was unanimous agreement among jurors that the structure of the course ED:INTEC 120 is adequate and logical. The jurors' comments on the structure contain some suggestions which could result in improvement in details of the structure.

Proposed Management System

There was unanimous agreement among jurors that the proposed management system for the course ED:INTEC 120 is logical. The jurors' responses also indicated that the proposed management system is reasonably adequate. This section of the formative evaluation elicited the largest number of comments and questions from the jury. As a result of the concerns expressed by jurors, Figures 25 and 26 were modified and revisions were made in the estimated costs related to the proposed CMI system. The concern of one juror that the means of arriving at the objective must be evaluated as well as the final product is regarded as having particular importance. This matter is worthy of further investigation.

Model Module

The jurors' responses to questions related to the model module were generally favorable. Some concern was expressed in relation to question 21, "Is the product likely to be challenging but not discouraging to the learner?" This concern is well founded. However, the learning activities are short, there is little or no duplication of activities, and a variety of learning aids is suggested. These features, together with frequent reinforcement, may help sustain learner interest.
Concern was also expressed in relation to question 12, "Have adjustments been made to the instructional program to accommodate learners of different aptitudes?" The individualized, self-paced, multimedia features of the course should facilitate the instructor's task of accommodating learners of different aptitudes.

Chapter Summary

This chapter has described the formative evaluation of the rationale, structure, model module, and proposed management system for the course ED:INTEC 120. The evaluation was conducted by a four-member jury using a modified Lawson formative evaluation instrument.

The formative evaluation indicated that the rationale, structure, model module, and proposed management system are, on the whole, adequate and logical for the course ED:INTEC 120. The formative evaluation also resulted in the identification of a number of areas in each component where improvements could be made prior to field testing. As a result of the formative evaluation, a number of minor changes were made in the rationale, structure, model module, and proposed management system. The jurors also provided some suggestions related to the problem of the study which merit further investigation.
CHAPTER VIII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

A brief summary of this study is presented in this chapter. Based upon the review of literature and the development and formative evaluation of the rationale, structure, model module, and course management system, conclusions are formulated in answer to the questions posed in the problem statement. Finally, recommendations are made concerning the study's implications for the course ED:INTEC 120 or similar modularized, competency-based, individualized courses in industrial education.

Summary

The Problem

The course ED:INTEC 120 - Industrial Practices and the School - is an introductory course for prospective industrial arts teachers offered by the Faculty of Industrial Technology Education at The Ohio State University. This study represents a preliminary investigation of PBTE and CMI for the purpose of restructuring the course ED:INTEC 120.

The problem of the study was to develop a logically adequate rationale, structure, model module, and management system to place the course ED:INTEC 120 on an individualized mode using a systems-oriented, competency-based approach. The problem of the study also included a formative evaluation of these components.
The problem of the study evolved from the need to:

1. ensure that ED:INTEC 120 students demonstrate basic competencies in materials processing prior to their other professional courses (construction, manufacturing, student-teaching experience, etc.)

2. provide for the variability of background, experience, and capability of students entering the program, and

3. explore the general trend toward systems-oriented, individualized, self-paced, and competency-based instruction at the college level.

Methods and Procedures

The following steps were followed in the development of this study:

1. a comprehensive review of related literature was conducted in the areas of:
   A. Industrial Arts Curriculum
   B. Performance-Based Teacher Education (PBTE)
   C. The Systems Approach in Education
   D. Computer Managed Instruction (CMI), and
   E. Personalized System of Instruction (PSI)

2. a rationale for the course ED:INTEC 120 was conceptualized and written,

3. a structure for the course was conceptualized and documented,

4. a course organizational flowchart diagram was prepared,

5. a procedure for course management was conceptualized and written,
6. selected behavioral objectives for the course were written,

7. one sample learning package was prepared and submitted to the researcher's advisory committee for evaluation,

8. a standardized learning package format was developed,

9. six additional learning packages were developed to complete the model learning module,

10. a formative evaluation of the course rationale, structure, model module, and proposed management system was conducted by a jury of experts, and

11. a written report on the formative evaluation and on the conclusions and recommendations of the study was prepared.

Conclusions

Based upon the review of literature and the development and formative evaluation of the rationale, structure, model module, and course management system, conclusions were formulated in answer to the nine questions posed in the problem statement in Chapter I.

1. What needs does the course ED:INTEC 120 serve?

The course ED:INTEC 120 serves the needs of prospective industrial arts teachers by providing these learners with a conceptual framework, knowledge, and manual skills related to materials processing in the areas of wood and metals. The course ED:INTEC 120 also serves a need of the Faculty of Industrial Technology Education in that is significantly contributes to the preparation of competent industrial arts teachers by providing pre-service teachers with essential skills
and knowledge in materials processing as required by the State of Ohio and as recommended by the American Council on Industrial Arts Teacher Education (ACIATE).

2. What are appropriate objectives for the course?

Specific instructional objectives for the course ED:INTEC 120 can be developed and stated in behavioral terms. A selection of terminal and specific behavioral objectives were written for the seven learning packages that constitute Module 8.0 - Mechanical Fastening (Appendix D). These course objectives were evaluated as appropriate for the course ED:INTEC 120 by a jury of experts.

3. What is appropriate content for the course?

The course content for ED:INTEC 120 can be identified and structured in a logical manner. General content is outlined in the course organizational flowchart diagram (Figure 19) and in the descriptive data on course modules provided in Figures 20, 21, 22, and 23. Specific content for the mechanical fastening section of the course is provided in the seven learning packages that constitute Module 8.0 - Mechanical Fastening (Appendix D). The course content, as identified in the structure and model module, was rated as adequate by a jury of experts.

4. What is a logically adequate structure for the course?

The modular structure for the course ED:INTEC 120 (Figure 19) as described in Chapter IV of this study was evaluated by a jury of experts as being logically adequate.
5. What should be the interrelationships between and among the course elements?

The course ED:INTEC 120 is viewed as consisting of three major areas: (a) an orientation to the undergraduate program and to the industrial arts profession, (b) a series of field trips to industrial arts laboratories and to local industries, and (c) processing standard wood and metal stock (Figure 13). This study was limited to area (c)—processing standard wood and metal stock.

As described in Chapters III and IV, the basic organizational unit for the materials processing section of the course ED:INTEC 120 is the learning module. Modules consist of clusters of related learning packages (LPs). The number of LPs per module varies from a minimum of three LPs (Modules 1.0, 3.0, 4.0, 10.0, 12.0, and 13.0) to a maximum of twenty LPs (Module 5.0). The interrelationships between materials processing modules, enabling modules, and learning packages is further illustrated in Figures 19, 20, 21, 22, and 23.

6. What is an appropriate management system for the course?

The utilization of CMI in the course ED:INTEC 120 should facilitate the management of the course and free the instructor to interact on an individual basis with learners. Alternative management strategies include PSI (Keller Plan) or the use of special student progress charts (Figure 27). However, CMI appears to have the greatest potential for the management of the course ED:INTEC 120. The proposed CMI system for the course was evaluated by a jury of experts as being adequate and logical.
7. What is an economical method of developing course software?

Estimated costs related to the development of course software such as learning modules, learning aids, and test items are included in Chapters V and VI. The relatively high costs associated with the development of such items is perhaps the major disadvantage of the modularized, individualized, self-paced approach recommended for the course ED:INTEC 120. Developmental costs may be minimized if graduate students, working under the close supervision of faculty members, are assigned responsibility for initial LP and module development. Prototype LPs may be developed as part of each graduate student's normal curriculum course requirements. This practice could benefit graduate students by providing them with a "live" rather than a simulated experience in curriculum development.

8. What should be the design and content of individual modules?

The content for individual materials processing modules for the course ED:INTEC 120 is identified by LP title in Figures 20, 21, 22, and 23. Seven examples of the design and content of LPs are provided in Module 8.0 - Mechanical Fastening (Appendix D). Chapter V describes the individual materials processing modules in detail and provides a seven-step outline for writing learning packages for the course ED:INTEC 120. A formative evaluation of the model module indicated that the basic design and content are adequate.

9. What are exemplary laboratory activities which will enable students to achieve course objectives?

Module 8.0 - Mechanical Fastening (Appendix D) describes a selection of laboratory activities which were designed to facilitate student
achievement of selected course objectives. When the appropriate learning aids are developed (videotapes, film loops, etc.), Module 8.0 can be field tested and modified as required to facilitate student achievement of course objectives specified for Module 8.0.

Recommendations

From the experience gained in conducting this investigation, the researcher offers the following recommendations to other researchers considering further study related to the course ED:INTEC 120. These recommendations may also be of interest to individuals concerned with individualized, modularized, competency-based courses in industrial education.

1. The course ED:INTEC 120 appears to serve an essential need for learners and should be maintained.

2. Placing the course ED:INTEC 120 on a modularized, self-paced, individualized, competency-based mode as described in this study is feasible and seems desirable.

3. Suitable learning aids such as videotapes and film loops showing instructor demonstrations of Module 8.0 activities should be developed so that Module 8.0 can be field tested.

4. Module 8.0 should be field tested with learners to determine its effectiveness in achieving desired behavioral change and revised as required.

5. The thirteen additional modules required to complete the materials processing content for the course ED:INTEC 120
6. should be developed based upon the field test results with Module 8.0.

6. Because of the apparent lack of suitable commercially available learning aids and the relatively high costs associated with the few that are commercially available, in-house production of learning aids should be encouraged.

7. A student manual should be developed for the course ED:INTEC 120 to facilitate student progress.

8. An instructor's manual should be developed for the course ED:INTEC 120 to provide an orientation for new instructors and to list faculty requirements for the course, etc.

9. A survey of potential CMI applications in ED:INTEC courses other than the 120 course should be conducted before a final decision is made concerning the proposed CMI system for the course ED:INTEC 120. It is possible that other potential faculty uses of CMI may be identified and this would provide a further justification for installing a CMI system in the faculty.

10. The formative evaluation conducted as part of this study is regarded as a useful and worthwhile activity. It is recommended, therefore, that any additional modules developed for the course ED:INTEC 120 be subjected to formative evaluation prior to field testing.
Recommendations for Further Study

The following recommendations were derived from this study:

1. All learning packages for the course ED:INTEC 120 should be field tested and evaluated.

2. Further study is needed to compare individualized, modularized, competency-based, self-paced instruction with the traditional teacher centered group-paced instructional programs.

3. Student attitudes toward the restructured ED:INTEC 120 course should be investigated.

4. Different types of learning packages and modules should be compared and evaluated.

5. Minimum requirements for the course ED:INTEC 120 in terms of learning packages completed by students should be established.

To conclude, this study has attempted to develop a rationale, structure, model module, and a proposed management system for an introductory course in industrial technology teacher education for the purpose of placing the course on an individualized, self-paced, competency-based, modularized mode. The instructional materials developed as a result of this study may contribute to curriculum development in industrial education.

If teachers tend to teach as they have been taught, it is possible that ED:INTEC 120 students may later utilize individualized,
self-paced instruction in their own programs and base their materials processing courses on a conceptual structure.
APPENDIX A

CLASS HANDOUT USED IN THE COURSE ED:INTEC 120
ED:INTEC 120 - Industrial Practices and the School

TEXTBOOKS


COURSE OBJECTIVES

1. To offer an orientation to the technical subject matter in industrial arts through experiences with materials, tools, and processes of industry.
2. To provide an understanding of the history and present status of industrial arts as a career and as a profession.
3. To provide an understanding of industrial arts teaching through observation and participation in local public schools.
4. To acquaint beginning students with the nature of their undergraduate program in industrial technology education.

COURSE ACTIVITIES

Lectures and Class Discussion
Assigned Readings
Visiting Speakers
School Visitations
Instructor Demonstrations
Laboratory Activities
Quizzes and Examinations

READING ASSIGNMENTS

1. Read all parts of Ludwig and Zook.
2. Pay special attention to the following:
   Ludwig—Parts I, II, III, IV, IX, XI, and XV.
   Zook—Chapters 1, 2, 3, 4, 5, 6, 7, 9, 13, and 14.

EVALUATION

1. Reports and Examinations
2. Proficiency Profile
3. Projects
4. Work Habits and Attitudes
5. Participation in Class Discussions

OTHER REQUIREMENTS

1. Safety Glasses
2. Shop Coat
APPENDIX B

MODIFIED LAWSON FORMATIVE EVALUATION INSTRUMENT
Dear

The course ED:INTEC 120 - Industrial Practices and the School - is an introductory course offered by the Faculty of Industrial Technology Education at The Ohio State University. The course is described in The Ohio State University Bulletin (1974) as:

A study of the history and role of industrial technology and its relation to the school through experiences in planning, organizing, and controlling a managed production system (p. 174).

The course is offered primarily for students planning on careers as industrial arts teachers in the public schools although other students may, and do, enroll in the course.

One of the objectives of the course ED:INTEC 120 is to offer an orientation to the technical subject matter in industrial arts through experiences with materials, tools, and processes. Consequently, a major portion of the course is devoted to materials processing in the areas of wood and metals.

As a result of my dissertation study, a rationale, structure, model module, and a proposed course management system have been developed for the materials processing section of the course ED:INTEC 120.

Please conduct a formative evaluation of the rationale, structure, model module, and proposed management system using the enclosed formative evaluation instrument. A copy of the dissertation document is enclosed. The materials to be evaluated are contained in Chapters III, IV, VI, and in Appendix D of the dissertation document.

Please complete the formative evaluation by June 6, 1975. Your cooperation in assisting with this study, which will aid in industrial technology education curriculum development, is greatly appreciated.

Sincerely,

Niall V. Corwell
FORMATIVE EVALUATION INSTRUMENT

Reviewer's Name ___________________________ Date ________________

Directions for Reviewers

The ultimate criterion for good instructional products is undoubtedly whether or not they foster or elicit expected behaviors from learners. But in order to assess this criterion, student learning or performance data are needed. In the absence of such data during the developmental phases of the instructional products, it is necessary to assess such materials for their apparent quality and potential to elicit the desired student behavior. This type of assessment is sometimes called formative evaluation. Results obtained from formative evaluation are useful to individuals directly involved in the development of the product, in that they may critically reexamine the proposed instructional materials.

You are to critically review the attached rationale, structure, model learning module, and proposed management system for the course ED: INTEC 120 using this formative evaluation instrument. The information provided by your responses will be useful in the further development of these instructional materials.

A. Rationale

0 1 2 3 4 5

1. Is the rationale adequate? YES _________________ NO

2. Is the rationale logical? NO _________________ YES

3. The strongest feature of the rationale is: ______________________________________

4. The weakest feature of the rationale is: ______________________________________

5. Comment on rationale: ______________________________________

(Additional space for comments is provided on pages 5 and 6)
B. Structure

1. Is the structure adequate? YES __________ NO
2. Is the structure logical? NO __________ YES
3. The strongest feature of the structure is: ____________________

4. The weakest feature of the structure is: ____________________

5. Comment on structure: ____________________

(C) Proposed Management System

1. Is the proposed management system adequate? YES __________ NO
2. Is the proposed management system logical? NO __________ YES
3. The strongest feature of the proposed management system is: ___

4. The weakest feature of the proposed management system is: ___

5. Comment on proposed management system: ____________________

(Additional space for comments is provided on pages 5 and 6)
D. Model Module

1. Is the format appropriate for the intended population in terms of ease of use? YES __________ NO

2. Is the module divided into "units" of appropriate length for the intended population? NO __________ YES

3. Does the display layout avoid a crowded appearance? YES __________ NO

4. Are the illustrations simple, clear, attractive, and appropriate? NO __________ YES

5. Are the display sequences numerically arranged? YES __________ NO

6. Do the feedback elements contain the correct answer? NO __________ YES

7. Are the display sequences free from grammatical, spelling, and typographical errors? YES __________ NO

8. Is the sentence structure clear, simple, and straightforward? NO __________ YES

9. Is the use of punctuation and abbreviations correct and uniform? YES __________ NO

10. Are the instructions to the learner complete, clear, and easy to follow? NO __________ YES

11. Do learners receive frequent and immediate knowledge of the effectiveness of their practice? YES __________ NO

12. Have adjustments been made to the instructional program to accommodate learners of different aptitudes? NO __________ YES

13. Does the content adequately cover the material specified in the objectives? YES __________ NO

14. Is the content complete and up-to-date? NO __________ YES

15. Is the content free from factual and technical errors? YES __________ NO
16. Does the module avoid overemphasizing topics which do not merit detailed treatment?  
YES [_________________]  NO

17. Does the module build associations by relating new material to concepts the learner already knows?  
YES [_________________]  NO

18. Is essential information presented first?  
NO [_________________]  YES

19. Is review cumulative and appropriately spaced?  
YES [_________________]  NO

20. Are self-checking materials built into the module at appropriate points?  
NO [_________________]  YES

21. Is the product likely to be challenging, but not discouraging to the learner?  
YES [_________________]  NO

22. Is the module personalized; that is, does it use the second person when addressing the learner?  
NO [_________________]  YES

23. Are the questions or problems clearly stated and answerable on the basis of information supplied by the module?  
YES [_________________]  NO

24. Are examples meaningful and well-chosen?  
NO [_________________]  YES

25. Does the response ensure that the learner has understood the critical material in the module?  
YES [_________________]  NO

26. Are objectives consistent with good education practice?  
NO [_________________]  YES

27. Are objectives appropriate for the target population?  
YES [_________________]  NO

28. Are activities consistent with objectives?  
NO [_________________]  YES

29. Do activities utilize learning time efficiently?  
YES [_________________]  NO
30. Comment on model module:
COMMENT
APPENDIX C

QUOTATION FROM A CLASS HANDOUT
USED IN A KELLER-PLAN COURSE
The following quotation (Keller, 1968) is from a hand-out given to students enrolled in a Keller-Plan course at Arizona State University. This quotation serves as an excellent description of the teaching method to which students are exposed in PSI or Keller-Plan courses.

"This is a course through which you may move, from start to finish, at your own pace. You will not be held back by other students or forced to go ahead until you are ready. At best, you may meet all the course requirements in less than one semester; at worst, you may not complete the job within that time. How fast you go is up to you.

"The work of this course will be divided in 30 units of content, which correspond roughly to a series of home-work assignments and laboratory exercises. These units will come in a definite numerical order, and you must show your mastery of each unit (by passing a "readiness" test or carrying out an experiment) before moving on to the next.

"A good share of your reading for this course may be done in the classroom, at those times when no lectures, demonstrations, or other activities are taking place. Your classroom, that is, will sometimes be a study hall.

"The lectures and demonstrations in this course will have a different relation to the rest of your work than is usually the rule. They will be provided only when you have demonstrated your readiness to appreciate them; no examination will be based upon them; and you need not attend them if you do not wish. When a certain percentage of the class has reached a certain point in the course, a lecture or demonstration will be available at a stated time, but it will not be compulsory.

"The teaching staff of your course will include proctors, assistants, and an instructor. A proctor is an undergraduate who has been chosen for his mastery of the course content and orientation, for his maturity of judgement, for his understanding of the special problems that confront you as a beginner, and for his willingness to assist. He will provide you with all your study materials except your textbooks. He will pass upon your readiness tests as satisfactory or unsatisfactory. His judgement will ordinarily be law, but if he is ever in serious doubt, he can appeal to the classroom assistant, or even to the instructor, for a ruling. Failure to pass a test on the first try, the second, the third, or
even later will not be held against you. It is better that you get too much testing than not enough, if your final success in the course is to be assured.

"Your work in the laboratory will be carried out under the direct supervision of a graduate laboratory assistant, whose detailed duties cannot be listed here... There will also be a graduate classroom assistant, upon whom your proctor will depend for various course materials (assignments, study questions, special readings, and so on), and who will keep up to date all progress records for the course members. The classroom assistant will confer with the instructor daily, aid the proctors on occasion, and act in a variety of ways to further the smooth operation of the course machinery.

"The instructor will have as his principal responsibilities:
(a) the selection of all study material used in the course;
(b) the organization and the mode of presenting the material;
(c) the construction of tests and examinations; and
(d) the final evaluation of each student's progress. It will be his duty, also, to provide lectures, demonstrations, and discussion opportunities for all students who have earned the privilege; to act as a clearing-house for requests and complaints; and to arbitrate in any case of disagreement between students and proctors or assistants ...

"All students in the course are expected to take a final examination, in which the entire term's work will be represented. With certain exceptions, this examination will come at the same time for all students, at the end of the term....The examination will consist of questions which, in a large part, you have already answered on your readiness tests. Twenty-five percent of your course grade will be based on this examination; the remaining 75% will be based on the number of units of reading and laboratory work that you have successfully completed during the term."
APPENDIX D

MODULE 8.0
MECHANICAL FASTENING
ED: INTEC 120

MODULE 8.0

MECHANICAL FASTENING

CONTENTS:

LP 8.1  INTRODUCTION
LP 8.2  NAILING
LP 8.3  DOWELING
LP 8.4  RIVETING
LP 8.5  HINGING
LP 8.6  STAPLING
LP 8.7  THREADED FASTENING
LEARNING PACKAGE 8.1

INTRODUCTION TO MECHANICAL FASTENING

Overview

Mechanical fastening is one of four major ways of combining materials. The other three ways are mixing, coating, and bonding.

Mechanical fastening devices are used to hold pieces of a project or product together. The type, shape, and size of the mechanical fastening device to be used depends on the nature of the work involved. For example, rivets are used to hold metal parts together permanently. Bolts or screws are used when the pieces may be disassembled occasionally or have to be adjusted. Nails and staples are commonly used for fastening wooden parts. Dowels and hinges are used with both wood and metal materials.

A great variety of mechanical fastening devices are currently available for wood and metal. Time constraints in the course ED: INTEC 120 do not permit an in-depth study of the full range of mechanical fastening devices currently in use. The learning packages in Module 8.0 are designed to help the learner acquire basic competencies in the following six major ways of mechanical fastening: nailing, doweling, riveting, hinging, stapling, and threaded fastening (Figure 8.1).

Prerequisites

Before attempting Module 8.0, it is recommended that the learner first complete:

Module 1.0 (all LPs)
Module 2.0 (all LPs)
Module 3.0 (all LPs)
Module 4.0 (all LPs)
Module 5.0 (LPs: 5.2; 5.3; 5.4; 5.5)
Module 6.0 (LP 6.5)

Terminal Objective for LP 8.1

After completion of this learning package, the learner should be able to list four major ways of combining parts and list at least six major ways of mechanical fastening used with standard wood and metal stock.
FIGURE 8.1

This diagram illustrates the four major ways of combining materials. It also lists six common ways of mechanical fastening used with standard wood and metal stock.
Specific Objectives

After completing this learning package, the learner should be able to perform the following tasks with 100% accuracy and without referring to any resource materials:

1. List four ways of combining materials.
2. List six major ways of mechanical fastening used with standard wood and metal stock.

Materials, Tools, and Equipment

1. IACP. The World of Manufacturing, pp. 389-393.
2. Videotape 8.1

Safety

LP 8.1 does not include any laboratory activities. For this reason no special safety instructions are included in LP 8.1.

Suggested Activities

1. Read the terminal objectives (page 1) and the specific objectives (page 3).
4. Study Figure 8.1 (page 2).
5. Take the self-test (page 4).
Without looking at Figure 8.1, fill in all the empty blocks in the diagram below. You should include at least six entries in the block under mechanical fastening.

When the self-test is completed, return LP 8.1 (complete with self-test) to the instructor and begin LP 8.2. Enter your name and the date above.
LEARNING PACKAGE 8.2

NAILING

Overview

Nailing is a common way of fastening pieces of wood together. Hand nailing is performed using a claw or nail hammer. Air-powered nailing machines are used in the construction industry. LP 8.2 deals only with hand nailing. This learning package is designed to help the learner acquire basic skills in nailing.

Terminal Objective

After completing LP 8.2, the learner should be able to safely fasten pieces of standard wood stock together by nailing. The learner should also be able to remove nails using a claw hammer and ripping chisel.

Specific Objectives

1. Given an illustration showing five different types of nails, the learner will identify, with 100% accuracy, each type of nail by writing the correct name on the illustration.

2. Given four pieces of wood (each 1"x2"x10"), twenty assorted nails (five box nails, five casing nails, five finishing nails, and five common nails), a nails set, and a claw hammer, the learner will demonstrate competency in nailing by:

   A. Fastening the four pieces of wood together to form a square frame as illustrated in Figure 8.2.

   B. Using a different type nail to fasten each corner of the square frame (Figure 8.2).

   C. Setting the heads of the casing and finishing nails.

   D. Clinching all nails.

   E. Removing all nails using a claw hammer and a ripping chisel.

These skills will be evidenced by unaided practice and results satisfactory to the instructor.
FIGURE 8.2

NAILING PRACTICE PIECE
Materials, Tools, and Equipment


2. Videotape 8.2.

3. Four pieces of wood (each 1"x2"x10").

4. Five common nails, size 8d.

5. Five finishing nails, size 8d.

6. Five casing nails, size 8d.

7. Five box nails, size 8d.

8. One claw hammer.

9. One nail set.

10. One ripping chisel.

Safety

1. Make sure the head on the hammer is secure before using it.

2. When nailing, watch the head of the nail and not the head of the hammer.
Suggested Activities

1. Read the terminal and specific objectives on page 5.


3. View videotape 8.2.

4. Study Figure 8.2.

5. Prepare materials, tools, and equipment listed on page 7.

6. Nail the four pieces of wood together as shown in Figure 8.2. Be sure to use five common nails at corner A, five box nails at corner B, five casing nails at corner C, and five finishing nails at corner D.

7. Set the heads of the casing and finishing nails.

8. Clinch all nails.

9. Present frame to instructor for comment.

10. Remove nails using a claw hammer and a ripping chisel.

11. Salvage wood for use later.

12. Dispose of used nails properly.

13. Return tools and materials.

14. Tidy work area.


16. Begin LP 8.3
Without referring to any resource materials, identify the five nails illustrated below by writing the correct names in the spaces provided.

When the self-test is completed, return LP 8.2 (complete with self-test) to the instructor and begin LP 8.3. Enter your name and the date above.
LEARNING PACKAGE 8.3

DOWELING

Overview

Before the general use of nails and screws, round wooden pegs (dowels) were used to hold wood joints together. Today, doweling is often used in furniture and cabinetmaking when high strength joints and good appearance are required.

Learning Package 8.3 is designed to help the learner acquire basic skills in fastening standard wood stock together by doweling.

Terminal Objective

After completing LP 8.3, the learner should be able to fasten pieces of standard wood stock together by doweling.

Specific Objectives

Given four pieces of wood (each 1"x2"x10"), a 10" length of $\frac{1}{4}$" dowel, and the materials, tools, and equipment listed on page 13 of this LP, the learner will demonstrate competency in doweling wood by:

1. Constructing an edge dowel joint as illustrated in Figure 8.3 without using a doweling jig.

2. Constructing a corner dowel joint as illustrated in Figure 8.3a using a doweling jig.

The above skills will be evidenced by unaided practice and results satisfactory to the instructor.

3. Having completed the assigned reading for LP 8.3, the learner will answer all questions on the self-test (page 15) with 100% accuracy.
FIGURE 8.3
AN EDGE DOWEL JOINT
FIGURE 8.3a

A CORNER DOWEL JOINT
Materials, Tools, and Equipment

2. Videotape 8.3.
3. Four pieces of wood (each 1"x2"x10").
4. One piece of ½" dowel, 10" long.
5. Try square
6. Marking gauge
7. Auger bit, ¼".
8. Doweling jig
9. Bit brace
10. Rule
11. Scratch awl
12. Pencil
13. PVA glue
14. Drill depth gauge
15. Wood clamps as required.

Safety

1. Wear safety glasses when drilling holes for dowels.
Suggested Activities

1. Read the terminal and specific objectives on page 10.


3. View videotape 8.3.

4. Study Figures 8.3 and 8.3a.

5. Prepare materials, tools, and equipment listed on page 13.

6. Construct an edge dowel joint (Figure 8.3) using the following procedure:
   
   A. Layout stock and locate holes using clamps, rule, try square, marking gauge, pencil, and scratch awl.
   
   B. Bore holes 1" deep. Use 1/2" auger bit, brace and depth gauge.
   
   C. Cut dowels 1/2" shorter than combined depth of two holes. Bevel dowel ends slightly and provide groove for excess glue to escape.
   
   D. Make a trial assembly without glue. If a hole is out of alignment, plug it and rebore hole.
   
   E. Glue and clamp joint.
   
   F. Test for squareness.

7. Construct a corner dowel joint (Figure 8.3a). The procedures outlined in activity 6 above should be followed with one exception: a doweling jig should be used to aid locating and boring the two holes for the corner dowel joint.

8. Present both dowel joints to the instructor for comment.


10. Tidy work area.


Without referring to any resource materials, answer the following questions in the spaces provided.

When the self-test is completed, return LP 8.3 (complete with self-test) to the instructor and begin LP 8.4. Enter your name and the date above.

1. From what kind of wood is dowel rod usually made? ________________

2. State the rule for selecting the correct dowel diameter: ____________________________

3. Should there be clearance at the bottom of a dowel hole? __________

   Why? _____________________________________________________________

4. Name two kinds of dowel joints used in furniture and cabinet making:

   ____________________________  ____________________________
LEARNING PACKAGE 8.4

RIVETING

Overview

Metal parts can be fastened together in many ways. One of the most common methods is riveting. Riveting is considered a permanent method of mechanical fastening.

Machine riveting is done with a press which forms the rivet head. Hand riveting is done with a hammer and rivet set, or with a blind rivet gun, or with a pneumatic rivet gun.

Learning Package 8.4 is designed to help the learner acquire basic skills in fastening metal stock together by hand riveting.

Terminal Objective

After completing LP 8.4, the learner should be able to fasten sheet metal stock together by riveting.

Specific Objectives

Given four pieces of 26 gauge sheet metal (each 2"x2"), three 1/8" soft iron rivets, three 1/8" blind rivets, a riveting hammer, a rivet set, a blind riveting gun, and the materials, tools, and equipment listed on page 18, the learner will demonstrate competency in riveting by:

1. Riveting two pieces of 26 gauge sheet metal together, as shown in Figure 8.4, using a riveting hammer and a rivet set.

2. Riveting two pieces of 26 gauge sheet metal together, as shown in Figure 8.4, using a blind rivet gun.

The above skills will be evidenced by unaided practice and results satisfactory to the instructor.

3. Having completed the assigned readings for LP 8.4, the learner will answer all questions on the self-test (page 20) with 100% accuracy.
All holes 1/8" diameter.

Distance A is approximately double the diameter of the rivet.

16 gauge sheet metal 2"x2"

FIGURE 8.4

RIVETING
Materials, Tools, and Equipment

2. Film Strip 8.4
3. Four pieces of 26 gauge sheet metal (each 2"x2").
4. Three 1/8" soft iron rivets
5. Three 1/8" blind rivets
6. Riveting hammer
7. Rivet set
8. Blind riveting gun
9. Manufacturer's instruction sheet for blind riveting gun
10. Center punch
11. 1/8" drill
12. Try square
13. Rule
14. Scriber
15. Electric drill
16. Vice grips or clamp

Safety

1. Wear safety glasses when drilling holes.
2. Make sure sheet metal is held securely when drilling holes.
Without referring to any resource materials, answer the following questions in the spaces provided.

When the self-test is completed, return LP 8.4 (complete with self-test) to the instructor and begin LP 8.5. Enter your name and the date above.

1. Sketch three common rivet head shapes in the boxes below and label each.

   [Boxes with labels A, B, C]

2. Name four common materials from which rivets are made.

   [Labels A, B, C, D]

3. How is the size of a rivet indicated? 

   [Blank line for answer]
LEARNING PACKAGE 8.5

HINGING

Overview

Hinging is an important and popular method of mechanical fastening used with wood and metal materials. Hinges are usually made from iron, brass, or bronze and are available in a great variety of styles and sizes.

Learning Package 8.5 is designed to help the learner acquire basic skills in fastening wood stock together by hinging.

Terminal Objective

After completing LP 8.5, the learner should be able to fasten pieces of standard wood stock together by hinging.

Specific Objectives

Given two pieces of wood (each 1"x2"x10"), a pair of 2" butt hinges, twelve wood screws, and the tools, materials, and equipment listed on page 23, the learner will demonstrate competency in hinging by:

1. Fastening the two pieces of wood together to form a hinged joint as illustrated in Figure 8.5.

   This skill will be evidenced by unaided practice and results satisfactory to the instructor.

2. Having completed the assigned reading for LP 8.5, the learner will answer all questions on the self-test (page 25) with 100% accuracy.
Cut width and depth of gains to match the 2" butt hinges used. The butt hinge should fit snugly in the gain. Gains should be cut in one of the two pieces of 1"x2"x10" wood stock.

FIGURE 8.5
HINGING

22
Materials, Tools, and Equipment

2. Film loop 8.5
3. Two pieces of wood (each 1"x2"x10")
4. One pair of 2" butt hinges
5. Twelve flat-head wood screws, 3/4"
6. Wood chisel with 1" blade
7. Wood or fiber mallet
8. Try square
9. Pencil
10. Scratch awl or self-centering screw-hole punch
11. Screwdriver
12. Electric or hand drill
13. Drill bit to match wood screws

Safety

1. Wear safety glasses when drilling holes.
2. Make sure chisel is sharp and use it with care.
Suggested Activities

1. Read the terminal and specific objectives on page 21.


3. View film loop 8.5

4. Study Figure 8.5

5. Prepare materials, tools, and equipment listed on page 23.

6. Fasten the two pieces of wood together to form a hinged joint (Figure 8.5) using the following procedure:
   
   A. Layout stock and mark hinge positions. Locate hinges approximately one inch from each end of wood stock.
   
   B. Using a wood chisel and mallet, cut gains in one piece of wood stock. The width and depth of gains should match the butt hinges used so that the butt hinges fit snugly in the gains.
   
   C. Drill holes for wood screws and assemble.

7. Present hinged joint to instructor for comment.

8. Return tools and materials.

9. Tidy work area.


11. Begin LP 8.6
Without referring to any resource materials, answer the following questions in the spaces provided.

When the self-test is completed, return LP 8.5 (complete with self-test) to the instructor and begin LP 8.5. Enter your name and the date above.

1. What is a gain?

2. Name four kinds of hinges.
   A. ______________   B. ______________
   C. ______________   D. ______________

3. Name the tools used in making a gain.
   A. ______________   B. ______________
LEARNING PACKAGE 8.6

STAPLING

Overview

A staple is a U-shaped fastening device (Figure 8.6) used for wood assembly and for attaching various materials to wood. Staples may be driven into wood with a hammer or with a mechanical stapler (Figure 8.6). Some staplers are powered by air or electricity.

Staples are used for many purposes in building construction including: fastening flooring, roofing insulation, and ceiling tile. Stapling is also used in upholstery to fasten fabric to wood frames. Staples are rapidly replacing nails in production lines in the woodworking industry. Stapling reduces assembly time and costs. Staples have almost the same holding power as nails.

Learning Package 8.6 is designed to help the learner acquire basic skills in stapling.

Terminal Objective

After completing LP 8.6, the learner should be able to fasten vinyl fabric to wood by stapling.

Specific Objectives

Given two sheets of vinyl fabric (each 8"x14"), two pieces of wood (each 1"x2"x10"), twenty wire staples, a tack hammer, a loaded mechanical stapler, and the tools, materials, and equipment listed on page 29, the learner will demonstrate competency in stapling by:

1. Fastening a piece of vinyl fabric to a piece of wood, as illustrated in Figure 8.6a, using staples and a tack hammer.

2. Fastening a piece of vinyl fabric to a piece of wood, as illustrated in Figure 8.6a, using a mechanical stapler.

The above skills will be evidenced by unaided practice and results satisfactory to the instructor.

3. Having completed the assigned reading for LP 8.6, the learner will answer all questions on the self-test (page 31) with 80% accuracy.
FIGURE 8.6
STAPLING DEVICES
FOLD VINYL OVER AT ENDS

FIGURE 8.6a

STAPLING
Materials, Tools, and Equipment

2. Videotape 8.6
3. Two pieces of wood (each 1"x2"x10")
4. Two pieces of vinyl fabric (each 8"x14")
5. Twenty staples (1/4" wide, 1/2" long)
6. Nail hammer
7. Scissors
8. Two sheets of paper (each 6"x12")

Safety

1. Make sure that the head of the hammer is secure before using it.
Suggested Activities

1. Read the terminal and specific objectives on page 26.


3. View videotape 8.6

4. Study Figures 8.6 and 8.6a.

5. Prepare materials, tools, and equipment listed on page 29.

6. Using a nailing hammer and staples, fasten one piece of vinyl fabric to a piece of wood (Figure 8.6a). Use the following procedure:
   
   A. Make paper templates to determine shape of vinyl end folds required (Figure 8.6a).
   
   B. Cut vinyl to size using paper template. Allow for a 3/4" wide edge on bottom to receive staples (Figure 8.6a).
   
   C. Staple edge A first. Pull vinyl taut and secure edge B. Next, make a fold at one end and staple edge C. Finally, make fold and staple edge D (Figure 8.6a).

7. Using a mechanical stapler, fasten a piece of vinyl fabric to a piece of wood (Figure 8.6a). Follow the same procedure listed for activity 6 above.

8. Present both stapling exercises to instructor for comment.


10. Tidy work area.


Without referring to any resource materials, answer the following questions in the spaces provided.

When the self-test is completed, return LP 8.6 (complete with self-test) to the instructor and begin LP 8.7. Enter your name and the date above.

1. A staple is made by bending wire to a _____ shape.

2. Name four industrial applications of stapling
   A. ___________________________  B. ___________________________
   C. ___________________________  D. ___________________________

3. In three sentences, compare stapling with nailing.

   ___________________________________________________________
   ___________________________________________________________
   ___________________________________________________________
LEARNING PACKAGE 8.7

THREADED FASTENING

Overview

In mechanical fastening, non-threaded fasteners such as nails, dowels, hinges, and staples are usually used for permanent joints while threaded fasteners such as screws, bolts, and nuts are generally used for non- or semi-permanent joints.

Threaded fasteners usually take more time to install but have greater holding power. Threaded fastening also permits easy assembly and disassembly without damage to wood or metal components.

Threaded fasteners are available in a great variety of shapes and sizes. Learning Package 8.7 is designed to help the learner acquire basic skills in fastening wood and metal stock using some common threaded fasteners.

Terminal Objective

After completing LP 8.7, the learner should be able to fasten pieces of standard wood and metal stock together by threaded fastening.

Specific Objectives

Given two pieces of wood (each 1"x2"x10"), one piece of mild steel (1/8"x1"x10"), two carriage bolts, five assorted screws, and the materials, tools, and equipment listed on page 35, the learner will demonstrate competency in threaded fastening by:

1. Fastening two pieces of wood and a piece of metal together, as illustrated in Figure 8.7, using two carriage bolts and five types of wood screws.

   The above skills will be evidenced by unaided practice and results satisfactory to the instructor.

2. Having completed the assigned reading for LP 8.7, the learner will answer all questions on the self-test (page 36) with 100% accuracy.
FIGURE 8.7

THREADED FASTENING
Materials, Tools, and Equipment

3. Film loop 8.7
4. Two pieces of wood (each 1"x2"x10")
5. One piece of mild steel (1/8"x1"x10")
6. Two carriage bolts (12x3 1/2")
7. One flat head wood screw (10x2 1/4"), slotted head
8. One flat head wood screw (10x2 1/4"), Phillips head
9. One oval head wood screw (10x2 1/4")
10. One round head wood screw (10x2 1/4")
11. One lag screw (12x2 1/4")
12. One plain screwdriver
13. One Phillips-head screwdriver
14. One 1/8" drill
15. One 3/16" drill
16. One countersink
17. Bit brace or hand drill
18. Two flat washers, 3/16"
19. Two spring washers, 3/16"
20. One scratch awl

Safety

1. Wear safety glasses when drilling holes.
Suggested Activities

1. Read the terminal and specific objectives on page 32.


4. View film loop 8.7

5. Study Figure 8.7

6. Prepare materials, tools, and equipment listed on page 34.

7. Construct the assembly illustrated in Figure 8.7 using the following procedures:
   A. Layout and drill shank holes in top piece of wood
   B. Layout and drill holes for carriage bolts in both pieces of wood.
   C. Layout and drill 3/16" holes in metal strip.
   D. Make trial assembly using carriage bolts only.
   E. Drill remaining holes as shown in Figure 8.7
   F. Use flat and spring washers under nuts on carriage bolts.
   G. Complete assembly.

8. Present assembly to instructor for comment.

9. Return tools and materials

10. Tidy work area

11. Complete self-test on page 36

12. Inform instructor that you have completed Module 8.0
Without referring to any resource materials, answer the following questions in the spaces provided.

When the self-test is completed, return LP 8.7 (complete with self-test) to the instructor and request permission to begin the next module in your individualized program. Enter your name and the date above.

1. Sketch six types of screws in the boxes below and label each.

   A.  
   B.  
   C.  
   D.  
   E.  
   F.  

2. Sketch three types of washers in the boxes below and label each.

   A.  
   B.  
   C.  

36
SUGGESTED READING FOR LP 8.1


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Mechanical fastening is quite different from the other ways to combine parts you have learned about. Before you started to read this book, you probably already knew more about this way to combine parts than you did about the others.

Mechanical fasteners were used long before men began to write down what they were doing and thinking. Tying, lacing, sewing, pinning, and nailing are all very old ways of mechanical fastening. Modern fasteners include threaded bolts and nuts, zippers, snap hooks, swivels, and door hinges. In this reading, you will learn about some of the ways in which they work and some of their uses, Fig. 62-1.

Fastening with Nails and Staples

Nails and staples are very common in assembling (combining) wooden parts. They are used a great deal in cabinet-making and in constructing wood-frame housing, Fig. 62-2.

Nails and staples come in many different styles and sizes. Tacks, brads, and spikes are names of nails that come in special sizes and shapes, Fig. 62-3. Some nails are serrated (grooved). Some are coated so that they won't work loose from the wood.

When a nail is driven into a piece of wood, some of the wood fibers are pushed aside. The wood around the nail is compressed (squeezed together). As long as the wood does not shrink or crack, it will keep on pushing against the nail and holding it in place. Nailed assemblies are held together by the strength of this resistance (pushing back). This kind of resistance is called...
friction. Other assemblies that are combined with mechanical fasteners are also held together by this kind of friction.

Staples are used to fasten papers, cartons, magazines, cloth, and baskets, Fig. 62-4. There is not enough friction to hold straight staples in flexible (easily bent) materials like paper. Therefore the ends of staples driven into paper clinch over (bend over).

Fastening with Threaded Devices

Many products are made of parts that are held together by threaded fasteners. Bolts and screws are the most common of these.

Threaded fasteners have screw threads, Fig. 62-5. External screw threads are ridges wrapped around the central core (body) of the fastener. Internal screw threads are made inside a hole in a part or in a nut.

Bolts have external threads, and nuts have internal threads. Most bolts must have nuts to fasten parts of a product together. Screws that are used in soft stock like wood, or in thin material like sheet metal, cut their own internal threads. They do not need threaded nuts to lock (hold) parts together.

There are other assemblies that are held together by threaded fasteners. For instance, many kinds of pipe and fittings are threaded. A common light bulb is held in its socket by threads.
The resistance of friction is what holds most threaded assemblies together. The holding power of a threaded fastener refers to the number of threads per inch. In general, the greater the number of threads per inch, the greater the holding power will be.

Devices for Lacing, Sewing, and Strapping

Lacing is a very old way to tie things together. Primitive man used leather strips very much like modern shoe laces. The large holes in his leather clothing were not made by machines, of course, but lacing and tying things worked for him just as they do for you.

Sewing is a lot like lacing. After sewing, though, the cloth or leather parts usually have a great many small holes, instead of a few large ones. Instead of a short strip of leather, the lacing is usually a long piece of thread. Thread is much finer and thinner than the primitive man’s lacing.

Modern sewing is different from lacing in one other way. The thread is sewn into the parts by machines, Fig. 62-6, since clothes are now mass-produced (made in very large numbers of the same product or part).

Thread is used to assemble the parts that make our clothes, tents, sails, furniture covers, bedding, and leather goods. Twine (heavy cord) is used when the fastener must have more strength to hold the parts together than thread has. Twine is often used to close the sacks of such products as flour, sugar, grass seed, and lawn fertilizer.

Flat metal strapping is used to fasten together the parts of wooden crates and boxes. Wire and straps are widely used in assembling bed springs and mattresses.

Besides thread, lacings, and straps, there are several other kinds of mechanical fasteners: rope, wire, cable, and chains.

Devices That Allow Movement of Parts

Some parts must be assembled so that one is free to move while the other is not. A door must swing open. Wheels must turn. In a car engine, pistons must move back and forth in cylinders. During the past century,
a great many different devices have been used in assemblies with movable joints. Many have pins that pass through the parts in such a way that only one of the parts can move. A common door hinge works this way. The hinge plate on the door jamb does not move. The hinge plate on the door, though, does move. The hinge pin should “float” freely, but it really sticks to one of the plates in most assemblies. If it stuck to both plates, the door could not swing open.

Fastening with Other Devices

Cotter pins, retainer rings, and clips are used in assemblies that have to be taken apart later on for repairs or changes, Fig. 62-7. Dowel pins, shear pins, keys, and splines are fasteners that hold parts together rigidly (so that none of them can move or turn). Rivets are widely-used fasteners. A rivet is a pin or bolt with a head at one end, and a way of spreading the other end after the rivet has been put into place. Riveted joints must last as long as the parts they hold together.

Fastening by Interference Fits

Two parts can be designed to fit in such a way that friction is the only thing that holds them together. Therefore no separate fasteners are needed. This is called fastening by interference fit. The tightness of the fit is fixed by the design engineer, since he sets up the dimensions (sizes) of the matching surfaces of the parts to be fastened. Such fits can be very loose or very tight, depending on how the assembly is to be used.

Summary

Many different mechanical fasteners are used to assemble parts, Fig. 62-8. Most assemblies that are mechanically fastened are ones that can be taken apart later on for repairs or changes. Only a few of them last as long as the parts they hold together.

Fig. 62-7. A tire weight is being clipped to the rim of the tire.

Fig. 62-8. Many of the parts of this press are assembled with mechanical fasteners. How many examples can you find in the picture?
Mechanical fasteners include nails and staples; threaded fasteners like bolts and screws; thread, wire, and strap; cotter pins, keys and splines, and rivets. Each one is used in a different way to fasten different kinds of parts into assemblies. Many of them allow one part to move while the other stays rigid. The common door hinge is an example.

Mechanical fastening can also take place through interference fit. The parts are designed and made so that they fit together by friction alone.

**Terms to Know**

- mechanical fastening
- mechanical fasteners
- nails
- staples
- assembling
- tacks
- brads
- spikes
- serrated
- compressed
- resistance
- friction
- flexible
- clinch
- threaded fasteners
- external screw
- threads
- core
- internal screw
- threads
- lock
- holding power
- lacing
- sewing
- thread
- mass-produced
- twine
- strapping
- rigidly
- rivets
- interference fit
- dimensions
- identify
- threaded devices

**Think About It!**

1. Look at a toaster, mixer, blender, or some other small appliance. Can you identify (name) the kinds of fasteners that are used in one of the products?
2. Identify three products in your home that have been fastened by:
   a. nails and staples
   b. threaded devices
   c. lacing
SUGGESTED READING FOR LP 8.2


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unit

20

Driving and pulling nails

It takes skill to drive, set, and pull nails correctly. Almost everyone has occasion to drive and pull nails. You should know how to use a hammer and how to select the correct nail. To set a nail, drive the head below the surface with a special tool.

The kinds of nails most often used in woodworking are shown in Fig. 20-1. Box nails are relatively thin, have flat heads, and are sometimes cement-coated to increase their holding power. They were first made for nailing together boxes built of wood which was thin and easily split. Common nails have heavy, flat heads and are slightly larger in diameter than box nails. Finishing nails have small heads. They may be set with a nail set and covered with putty or a wood plastic. The brad is a small finishing nail. It varies in length from 1/4 to 1 1/4 inches, and is used to nail thin stock together. Casing nails have coneshaped heads. As this shape gives good holding power, the casing nail is used mostly for interior trim and cabinet-work. Resin-coated nails in any of the above types are used extensively because of their holding power.

The size of nails is usually indicated by the term penny or its abbreviation, d. It is believed that these terms are derived from the weight of a thousand nails. For example, one thousand 10-penny (or 10d) nails weigh 10 pounds, and a thousand 6-penny nails weigh 6 pounds.

The nail chart, Table 20-1, shows the sizes and lengths of nails. A 2-penny, or 2d, nail is 1 inch long. For each additional penny add 1/4 inch in length up to 3 inches. For example, a 10-penny is 3 inches long. See the chart for the lengths of nails over 3 inches.

Important rules to remember when you nail:

1. Have the length of the nail three times the thickness of the first board the nail goes through.
2. See that the size of the nail is not too large or it may split the wood.

3. Drill a very small pilot hole through the first board when you drive nails through hardwoods such as oak, maple, birch, and others.

4. Do not put nails in your mouth.

TOOLS

The tools used for driving and pulling, or drawing, nails are the nail hammer, half hatchet, nail set, and sometimes the ripping bar.

Nail Hammer. The size of a nail hammer (Fig. 20-2) is determined by the weight of the head. The most popular sizes are the 14- or 16-ounce ones. The one pictured is all steel, having a perforated neoprene-rubber grip handle. This offers a non-slip grip. Other nail hammers have steel heads with white hickory wood handles. The claw may be either curved or straight.

Half Hatchet. The tool illustrated in Fig. 20-3 is all steel with a non-slip neoprene-sleeve handle. It makes a \( \frac{3}{12} \)-inch cut. Carpenters sometimes prefer the half hatchet for nailing and hammering because it has a cutting end and also a nail-pulling slot.

Nail Set. The nail set (Fig. 20-4) is used to set the head of a finishing or casing nail or brad. The tip of this tool has a slightly concave surface. This keeps it from sliding.

Fig 20-2. Sixteen-ounce nail hammer, showing curved and straight claws.

Fig 20-3. Half hatchet.

Fig 20-4. Nail set.

Fig 20-5. Self-centering nail set, showing sequence of steps for its use: (A) drive nail into wood until head protrudes \( \frac{1}{8} \) inch, (B) place sleeve of nail set over nail head, and (C) strike plunger with hammer to set nail below the surface of wood. The plunger retracts automatically.

Fig 20-6. Ripping bars: (A) goose neck and (B) straight.
Fig 20-7 Ripping chisels

off the nail head too easily. Nail sets are obtainable in tip sizes from 1/4 to 5/8 inch, and are approximately 4 inches long.

Self-centering Nail Set. Figure 20-5 shows a nail set which is self-centering. Its use is illustrated by the sequence steps shown in this figure. A similar tool is available for setting brads.

Ripping Bars. Figure 20-6 shows a gooseneck and a straight ripping bar having a claw with a nail slot. These and other types of ripping bars are sometimes used in construction for pulling or drawing spikes, and for wedging apart nailed boards and planks. They vary in length from 12 to 36 inches.

Ripping Chisels. Either of the ripping chisels shown in Fig. 20-7 is often used by home builders to pry and wedge floor strips while nailing. The cutting edge varies from 1 1/4 to 2 inches, and they are approximately 18 inches long.

DRIVING NAILS

1. Select the proper type and size of nail for the job.
2. Hold the nail firmly in place with one hand. Hold the hammer handle firmly near the end, and strike a light first blow (Fig. 20-8).
3. Remove your hand from the nail. Continue to strike the nail directly on the head until it is driven flush, or even, with the wood (Fig. 20-9). Avoid bending the nail. Also, do not dent the wood with the hammer face.
Fig 20-10  Setting a nail

Fig 20-11  Covering a nailhead

Fig 20-12  Toenailing

Fig 20-13. Driving nails at an angle to increase holding power.

Fig 20-14. Steps in clinching nails for holding two boards.
Keep your eye on the nail. Use a wrist, arm, and shoulder movement as you drive the nail.

4. Where necessary, set the head of the nail about \(\frac{1}{2}\) inch below the surface of the wood (Fig. 20-10). This applies especially to the finishing and the casing nails. Use a nail set slightly smaller than the head of the nail.

5. Fill the hole with putty, wood plastic, or wood dough if the nail has been set (Fig. 20-11).

6. Figure 20-12 shows how to drive nails for toenailing.

7. You can hold two boards together more securely if you drive nails in at an angle (Fig. 20-13). Nails have greater holding power when driven this way.

8. Figure 20-14 shows the three steps in clinching nails to hold two or more boards securely. The nails may be clinched with the grain for a neater appearance. When driving
nails through hardwood, drill a smaller hole first to serve as a pilot hole. Figure 20-15 shows the use of an industrial type pneumatic nailer driving 6d common nails.

**PULLING NAILS**

1. Slip the claw of the hammer under the head of the nail. Pull the handle until it is at an angle of nearly 90 degrees with the board (Fig. 20-16).
2. Sometimes a nail is too long to come out as suggested in step 1. To pull it, slip a block of wood under the head of the hammer (Fig. 20-17). This increases the leverage and lessens the strain on the hammer handle.

**Discussion Topics**

1. List the five common types of nails and brads. Explain their uses.
2. What is the purpose of the nail set?
3. What must you know about nails before purchasing them?
4. Give three important nailing rules.
5. What are the two types of heads for the nail hammer?
6. Where might a person use a hatchet in building construction?
7. What would be the advantage in using a self-centering nail set?
8. Name two types of ripping bars. Explain how each might be used.
9. What are ripping chisels used for?

---

**unit 21**

**Joining**

A piece of furniture or cabinetwork almost always includes one or more types of joints. There are many kinds of joints. Some of them are variations of the few basic types. All have a definite use which requires layout, cutting, fitting, and assembling. Study the several types and then make the application or adaptation which suits your need.

The joints described here are the butt, dado, groove, tongue, tongue and groove, and miter. These and variations are shown in Figs. 21-1, 21-14, and 21-35. Instructions and illustrations shown in this unit are for making these joints with hand tools. Most of the joints can also be made on the table saw (Unit 36).

**TOOLS**

You will use a few special tools which have not been discussed in previous units. These are the commercial miter box with stiff-backed saw, a homemade miter box, a doweling jig, and the dowel pointer.

*Miter Box.* The commercial miter box with stiff-backed saw (Fig. 21-2) is valuable for making joints because of its accuracy. Most miter-box saws have automatic locks at 8, 9, 22½, 30, and 45 degrees, right or left. The 0-degree marking is actually 90 degrees, or at right angle to the back fence.
SUGGESTED READING FOR LP 8.3


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A dowel joint on a leg and rail is sometimes used instead of a mortise-and-tenon joint. Dowels are also used to strengthen an edge, butt, or miter joint. Figure 25-1.

**Dowel Tools and Materials**

Dowel rod is usually made of birch in diameters from \(\frac{3}{8}\) to 1 inch in 3-foot lengths. Small dowel pins are made with a spiral groove and pointed ends. A dowel sharpener points the ends of the dowels. Dowel centers are small metal pins used for spotting the location of holes on two parts of a joint. Figure 25-2.

**Making an Edge Dowel Joint**

To make this joint, clamp the two pieces to be joined with the edges flush and face surfaces out. With a try square, mark across the edges of both pieces at the several points where the dowels will be. Next, set a marking gauge to half the thickness of the stock and mark the center locations of the dowel joints. Figure 25-3. Make sure that you mark these from the face side.

Decide on the size dowel you want to use and the depth to which the dowel will go. The diameter of the dowel should never be more than half the thickness of the stock. Usually the dowel should be no longer than 3 inches; therefore, the holes will be drilled about 1\(\frac{3}{4}\) inch deep. This provides about \(\frac{1}{4}\) inch clearance at the bottom on each side.

After the points have been located, make a small dent with a scratch awl. Select an auger bit the same size as the dowel rod. Carefully bore the hole to the proper depth, making sure that you are working square with the
25-2. A. Dowel joints are simple to construct. B. Dowel pins usually have a spiral groove which helps the glue to flow. C. Dowel sharpener. This is used to cut a slight bevel at the end of dowel rod. D. Dowel centers are useful in locating adjoining holes. The locations for the dowels are marked on the first piece and drilled. Then the dowel centers are put in place. When the two pieces are held together the dowel centers show the hole locations on the second piece.

edge of the stock. Use a depth gauge as a guide. A doweling jig should be used if one is available. Figures 25-4a and 25-4b. With this tool you will always be able to bore the holes square and in the right place. Figure 25-5.

25-3. Marking the position for an edge dowel joint. The pieces are fastened in a vise with the face surfaces outward. Then a marking gauge is set to half the thickness of the stock and the center location is marked. The location for the three dowels has already been marked with a try square and pencil.

25-4A. A doweling jig that will help locate the position of holes and guide the auger bit for boring. This jig comes with several metal guides in sizes of $\frac{1}{32}$, $\frac{1}{16}$, $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{1}{2}$ inch.
25-4B. A self-centering dowel drill guide. This holds the material like a vise. When the workpiece is clamped in the tool, the guide holes for the drill are automatically centered over the work. The jaws will clamp on work up to 2 inches in thickness. The guide accommodates five sizes of bits.

25-5. Using a dowelling jig. This jig has been clamped to the stock and the proper size guide fastened in it. An auger bit of the correct size is being used and a depth gauge is attached to control the depth of the hole.

25-6. Gluing an edge dowel joint. The dowels have already been dipped in the glue and driven halfway into one edge. Glue is being applied to the two edges and to the other half of the dowels.

25-7. Edge dowel joint with the dowels installed.
Section VII. Unit 25. Dowel Joint

thickness of the stock. Hold it against the surface of each piece and mark the exact location. Mark these points with a scratch awl and bore the holes as described above. Figure 25-10.

MAKING A DOWEL JOINT ON A LEG AND RAIL

For its ease and speed a dowel joint is often made on a leg and rail instead.
Square up the leg and rail as for any joint, making sure that the end of the rail is square. Next clamp the leg and rail in a vise with the butting end and the butting edge sticking out and the face surface of each turned out. Hold a try square against the face surface of the rail and mark the location of the dowels on the end of the rail and the edge of the leg. Next set a marking gauge to half the thickness of the rail. From the face surface of the rail, mark the crossline that will show the location of the dowel joints. Then decide how far you want the rail to set back from the face surface of the leg. Add this amount to the setting you already have on the marking gauge. From the face surface of the leg, mark the crossline that will show the exact location of the dowel. Bore the holes, cut the dowels, glue, and assemble as before.

**Can you answer these questions on a dowel joint?**

1. From what kinds of wood is dowel rod usually made?
2. Dowel joints are sometimes used as a substitute for another kind of joint. What is this joint and why is the dowel joint substituted?
3. Why are dowels used in making an edge joint?
4. State the rule for choosing the correct dowel diameter.
5. Should there be clearance at the bottom of a dowel hole? Why?
6. What is a doweling jig? Explain how it is used.
7. List the steps in making a dowel joint on a frame.
8. Why is it necessary to lay out a dowel joint very accurately?
9. What would happen if the dowel holes of two joint pieces were not aligned perfectly?
10. How do you think a dowel joint on a leg or rail will compare with a mortise-and-tenon joint?
SUGGESTED READING FOR LP 8.4

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Many other adhesives are used in industry. A special heat-cured adhesive is used to fasten hood and deck lids to reinforcement members on automobiles. This method is faster and easier than welding, and parts fastened this way will not rattle. Figs. 25-6 and 25-7.

Epoxy glues can be used in the school shop because they do not need to be cured by heat and pressure. These glues are made from chemicals that are very similar to a kind of plastic. They are especially good for overlaying metal.

**QUESTIONS**

1. List three types of sheet-metal seams. Make a sketch of each.
2. How can seams be made watertight?
3. Describe one way that adhesives are used in the automobile industry.

**Riveting** is the process of inserting a metal pin into a hole and clinching it so there is a head at each end. These metal pins, or rivets, are used for permanently fastening two or more sheets, plates, or pieces of metal together.

A head is formed on one end when the rivet is manufactured. The shank (body) of the rivet is inserted through a hole, then the tip is pounded to form the second head.

In some industries, such as automobile manufacturing, riveting has
been largely replaced by welding. In the air-conditioning and heating industry, much fastening is now done by means of sheet-metal screws or spot welding. However, rivets are still commonly used in many industries, such as building construction. Heavy metal beams that make up the skeletons of office buildings, bridges, and similar structures are riveted because it is the cheapest and quickest method of assembling. Aircraft and space industries use rivets in assembly because such materials as aluminum and magnesium are difficult to weld. In a jet airliner, for example, thousands of rivets hold the parts together. Fig. 26-1.

Rivets

Rivets vary as to the kind of metal, kind of head, diameter, and length. In ordering them it is necessary to give this information completely. For example: \( \frac{3}{16} \)" roundhead, blackiron rivets, \( \frac{1}{2} \)" long.

26-1. The metalworking industries use many different kinds of rivets in assembling metal parts. Here you see how hundreds of rivets are used in one section of an airplane.


Rivets are commonly made of aluminum, copper, brass, mild steel (blackiron), or magnesium. The three common head shapes are round, flat, and countersunk. Fig. 26-2. Common types used in the shop have round or countersunk heads, are made of blackiron, copper, brass, or aluminum, and have diameters of \( \frac{1}{8} \)" or \( \frac{3}{16} \)".

To avoid having a large number of rivets on hand, purchase long ones that will take care of several thicknesses of metal. The shank of the rivet can be cut off with a pliers, hacksaw, or bolt niper.

Tinners rivets are made for use on galvanized sheets, tin plate, and thin blackiron sheets. They are mild steel rivets with a flat head and are coated with black oxide, tin, copper, or zinc. The size of the rivet is indicated by its weight per thousand—a thousand of the smallest size weighs 6 ounces. Common sizes are 10 ounce, 1 pound, 2 pound, and 21/2 pound. For No. 26-gauge metal, for example, use a 1-pound rivet.

Equipment needed includes a ball-peen or riveting hammer, a rivet set, and a punch or drill. For all types of riveting except for tinner's rivets, select a ball-peen hammer of a size heavy enough to form a shank. (The rivet set, which has
26. To protect the rivet head, place it in the rivet set, and peen gently.

26-3. To protect the rivet head, place it in the rivet set, and peen gently.

a clearance hole on one side and a concave depression next to it, is used to squeeze two pieces of metal together before riveting, and to form the rivet head.

The hand punch is used on lighter gauges of metal. It should have a shank with the same diameter as the shank of the rivet. Use a drill on heavier gauges of metal to make neater holes for riveting. Select a rivet set with a hole large enough so the rivet shank will slip into it easily.

Riveting Heavy Metals

1. Lay out the location of the rivet holes. The rivets should be located at least two shank diameters from the edge of the joint and at least three diameters from other rivets. Select a drill of the same diameter as the rivet shank and drill the holes at the proper locations. It is good practice to drill all the rivet holes in one piece first, then drill one hole in the second piece. After one rivet has been installed, the other holes can be drilled accurately, using the top piece as a guide.

2. If countersunk rivets are used, countersink both pieces. Even when roundhead or flathead rivets are used, the second piece is often countersunk so that the rivet can be flattened and filed off to form a flush surface. It is a good idea to countersink all holes slightly to remove the burr formed by drilling.

3. Insert the rivets in the holes. The Shank should extend beyond the metal about 1 1/4 diameters. This can usually be judged by sight. If the back surface is to be countersunk and the shank flattened, about 3/4 of a diameter is needed.

4. When using roundhead rivets, protect the head by placing it over a rivet block or set. Fig. 26-3. To form a head, strike the shank squarely with the ball-peen end of the hammer. This will round off the shank, but be careful not to bend it.

Riveting Sheet Metal

1. Lay out the location for the rivets and then punch or drill the

26-4. Punching holes in metal with a hand punch. The metal is placed over the end grain of a piece of hardwood.
26–5. Using the rivet set to draw and head a tinner's rivet.

holes. When using the hand punch, place the metal over a block of wood. Fig. 26-4.

2. Insert the rivets in the holes, and place the workpiece over a solid metal surface.

3. With a rivet set, draw the seams together.

4. Strike the rivet with the hammer to set the rivet enough to hold the pieces together. Fig. 26-5.

5. Place the concave portion of the rivet set over the rivet and head it. One or two blows will usually be enough.

6. When riveting a seam or a round object, punch or drill several holes. Then install rivets at both ends. Complete the seam by riveting from the center to both ends.

Blind or Pop Rivets

These rivets are made so they can be inserted and set from one side with a special hand tool. They are available with oval or round heads, in diameters from $\frac{3}{16}$" to $\frac{1}{2}$", in aluminum, steel, or copper. Fig. 26-6a and b.

QUESTIONS

1. How do you protect the round heads of rivets when riveting?
2. Make a sketch of the three common rivet head shapes.
3. How is the hand punch used?
SUGGESTED READING FOR LP 8.5


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Figs. 25-7 through 25-11. When you clamp boards, as shown in Figs. 25-6 and 25-7, place bar clamps from 12 to 15 inches apart. You may wish to use scrap blocks to protect the edges of the wood. Note how to operate the handscrew clamp, as shown in Fig. 25-12.

In all clamping operations, it is highly desirable that you have someone to help you. If the boards tend to buckle, keep them in alignment with handscrew and C clamps (see left and right ends of Fig. 25-7). Use a piece of paper between the clamps and the boards. This keeps the clamps from sticking to the glued joints. Use plenty of handscrew clamps in gluing boards to get additional thickness (Fig. 25-10). Fig. 25-13 shows an industrial version of steel bar clamps used for mass production.

8. Remove the surplus glue before it hardens. Use a scraper blade, wood chisel, old plane iron, piece of wood, or damp rag.

9. Wipe the joint thoroughly with a damp or wet rag. You can often clean all traces of glue in this way and avoid the unnecessary work of scraping it off later. All glue must be removed from exposed surfaces before finish is put on.

Discussion Topics

1. Name and give the uses for six types of glue
2. Name and describe the five kinds of clamps which are helpful in gluing
3. Why is it desirable to have all clamps set before gluing?
4. Give at least two uses for handscrew clamps.
5. Why should you remove all surplus glue from the joint before it hardens?
6. Explain the purpose of using scrap blocks between the wood and the cabinet or bar clamps, as shown in Fig. 25-7
7. How long should stock be clamped before it is removed?

unit

26

Fastening hinges and other cabinet hardware

Hardware is a part of the final trim in many pieces of furniture. Its use is also a part of cabinetwork. You must be very accurate in fastening hinges and cabinet hardware. Always look for instructions on the packet or container.

Some of the more common pieces of hardware for the woodworker are hinges, drawer pulls, cabinet catches and hasps, locks, and furniture glides. Figure 26-5 pictures and identifies a few of the better-known types of hinges.

TOOLS

Adjustable End Wrench. An adjustable end wrench, as shown in Fig. 26-1, is a convenient tool for assembling certain types of hardware to cabinets and furniture. The one pictured is 8 inches long, and has a maximum opening capacity of 1 inch.
**Fig. 26-1.** Adjustable end wrench.

**Fig. 26-2.** Slip-joint pliers.

**Fig. 26-3.** Pump-type pliers.

**Fig. 26-4.** Self-centering screw-hole punch

(A) position the hinge and fit the tapered head of the punch in the countersunk hole; (B) strike the plunger with a hammer to make the screw-starting hole quickly and accurately; the plunger retracts automatically.

**Fig. 26-5.** Butt hinge.

**Fig. 26-6.** Concealed hinge.

**Fig. 26-7.** Ornamental surface hinge.

**Pliers.** Figure 26-2 shows an indispensable tool for fastening. This is called a pair of slip-joint pliers because of its construction.

**Pump-type Pliers.** This type of pliers (Fig. 26-3) has become very popular because of its easily adjusted opening.

**Self-centering Screw-hole Punch.** Figure 26-4 pictures a very convenient tool used to locate and start screw-hole centers for hinges. Use of this tool is illustrated in the sequence of steps under the figure.

**Hinges**

The **butt hinge** (Fig. 26-5) is popular. It requires detailed fitting and gaining or chiseling out, of the cabinet or frame. Some butt hinges are swaged, while others are not (Fig. 26-5). This will determine the depth of the gains (see Fig. 26-6). You can obtain butt hinges with loose or with stationary pins. If the pin is loose, install the hinge with the head of the pin up. Then the pin will not fall out. A variation of this hinge is the concealed wraparound type, shown in Fig. 26-6.

The **surface hinge** (Fig. 26-5) is one of the easiest to install. It is fastened to the surface and is entirely visible. Its patterns vary from ornate shapes to the crude metal strap used on barn doors. Figure 26-7 shows the installation of one type of ornamental surface hinge.

Not shown is the **half-surface hinge**, used in cabinet work. It is installed so that half of it is visible. The other half is gained to the cabinet or into the frame in which it is fitted. The gained portion is fitted like the butt hinge.

The **chest hinge** (Fig. 26-5) supports chest lids. The **combination hinge** may also be used. This hinge pulls the lid away from the wall as it is opened. It serves as both hinge and lid support.

**Cabinet hinges** are made for use on flush doors and on overlapping doors (Fig. 26-5).
Fig. 26-5 A few commonly used hinges: (A) butt, (B) surface, (C) chest, (D) cabinet flush, (E) cabinet overlapping, (F) invisible, (G) concealed pivot pin, and (H) chest-and-lid support.

Fig. 26-6 A concealed wrap-around hinge fastened on a cabinet door.

Fig. 26-7 Installing one type of ornamental surface hinge.
Figure 26-8 shows how to install a hinge on an overlapping, or lip, door.

Invisible hinges are used in fine furniture, such as writing desks (see Fig. 26-5). Manufacturers supply drawings and directions for the installation of this type of hinge.

The *pivot pin hinge* is a very popular hinge used on cabinet and furniture doors (see Figs. 26-5 and 26-9).

**DRAWER PULLS AND KNOBS**

Drawer pulls and knobs come in a great variety of materials, patterns, and sizes. They are made from wood, plastic, composition materials, and metals. You are limited only by your personal preference. Figure 26-10 shows seven typical commercial drawer pulls and knobs.

They are supplied complete with screws for fastening. The single-post, or screw, knobs are easy to install. Mark the location and drill a hole of the proper size. More elaborate pulls and knobs have two posts or screws. These holes must be properly centered for correct fit.

Fig. 26-9. Concealed pivot pin hinges are very popular for cabinet doors.

Fig. 26-10. Seven common types of drawer pulls and knobs.
Fig 26-11. Types of cabinet catches: (A) touch latch, (B) magnetic, (C) rubber roller spring, (D) friction, and (E) double rubber roller spring.

Fig 26-12. Cabinet and chest locks.

Fig 26-13. Marking the gain for a hinge.

Fig 26-14. Chiseling the gain for a hinge.

OTHER HARDWARE

Husps, door and cabinet catches, Fig. 26-11, and furniture glides are some other types of hardware that are relatively easy to install. For successful installation of the cabinet and chest locks pictured in Fig. 26-12, study the manufacturer’s directions carefully. The variety in size and construction of such hardware makes it impractical to outline a uniform procedure for all types.

INSTALLING A BUTT HINGE

1. Select the proper size and kind of butt hinge. The size of the hinge is determined by its length.
2. Place the door in the frame of cabinet. Place wedges below and above to regulate the opening.
3. Locate the hinges according to the working drawing. Mark the location on both the door and the frame or cabinet.
4. Mark the width and depth of the gain (a notch or a mortise). Use a marking gage (Fig. 26-13).
5. Place a chisel in a vertical position on the marked line which locates the ends of the hinge. Drive the chisel lightly with a mallet (Fig. 26-14).

6. Repeat the chisel cut on the line which goes in the direction of the grain. Be careful not to split the wood (Fig. 26-14).

7. Make a series of chisel cuts as shown in Fig. 26-14.

8. Pare the bottom of the gain with a wide wood chisel, as shown in Fig. 26-15.

9. Make a trial fitting of the hinge in the gain. Pare to make a snug fit (Fig. 26-16).

10. Place the hinge in its proper setting. Mark the holes for the screws with a pencil.

11. Drill pilot holes into the wood or drive the hole with a self-centering screw-hole punch (see Fig. 26-4). See Unit 19.

12. Drive the screws with a screwdriver to fasten the hinge securely. Soap the screw threads when driving screws into hardwood. This helps prevent the screw from twisting off.

13. Cut the remaining gains for the hinges in the door or frame and cabinet.

14. Fasten the door in its proper position with screws. It is advisable to fasten only one screw in each hinge leaf first. In this way you can determine if further fitting is needed.

Discussion Topics

1. Name and describe six common types of hinges. Tell where each is used.

2. Name four of the materials from which drawer pulls and knobs may be made.

3. List ten places where you have seen different types of hinges used.

4. What is a gain?

5. What tools are used in making a gain?

6. Why do you soap screw threads?

7. Make a list of ten pieces of cabinet hardware other than hinges. Explain their uses.
SUGGESTED READING FOR LP 8.6


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Exploring Woodworking

B. Hollow wall screw anchor for attaching to a hollow wall. A hole large enough to receive the outside jacket of the anchor is drilled into a hollow wall. The screw is removed from the anchor, then the jacket is inserted into the hole. The screw is replaced in the anchor and tightened. This causes the sides of the jacket to flare, holding the anchor firmly.

C. Wing toggle bolt for anchoring to a hollow wall. A hole is drilled in the wall, then the wings are folded and inserted through the hole. The wings spring outward, inside the wall. As the bolt is tightened, the wings are held firmly inside the wall.

D. Lead screw anchor for lag screws. A hole is drilled with a masonry bit and the anchor is inserted in the hole. A lag screw is placed in the lead anchor and is turned, forcing the anchor firmly against the hole wall.

E. Machine screw anchor. A hole is drilled with a masonry bit. The machine screw is removed and the anchor is inserted in the hole. A special tool is used to drive the anchor to the bottom of the hole. This forces the bottom wedge upward which tightens the anchor against the hole wall. The machine screw can then be turned into the anchor.

F. Lead screw anchor for common wood screws. This is set in the same way as the lag screw anchor.

G. Plastic anchor for fastening to drywall, ceramic tile, etc. A hole is drilled and the anchor is inserted into it. A common screw is turned into the anchor, forcing it against the hole wall.

H. Plastic plug. This is used as a plastic anchor but has a longer screw.

I. Sureset pin. A device is used to hold the pin as it is driven directly into masonry with a hammer.

J. Ram set nail. A special gun (ram set) powered with cartridges is used to hold and shoot nails into masonry.

K. Concrete nail. This is driven directly into concrete or a mortar joint.

Staples

A staple is made by bending wire into a "U" shape. Staples are available in a wide variety of types, sizes, and finishes and come in strips or bars for easy loading. See Fig. 12-9 (K).

Staples ordinarily provide more holding power than tacks or small nails because they have two legs holding instead of one. The staple legs follow the cut of the point on each leg. Different types of points are used so that the staple legs will toe-in or flare out (diverge) to make them stronger. Some staples are clinched on the back side of materials. Fig. 12-11 illustrates how a special, long staple with divergent points clings to the wood.

Staples are used for many purposes including: fastening roofing, insulation, ceiling tile, and upholstery materials. Industry uses staples to fasten wood and numerous other materials.

Staplers

Staplers are developed for many different uses. Some staplers are spring-driven and work well for light or medium work. Other staplers, developed for heavy work, are driven with air pressure.

Stapling

A strip of staples is loaded in a stapling gun or hammer with the sharpened points
Using Metal Fasteners, Gluing, Clamping

Fig. 12-12. Stapling with a pneumatic stapler. Left. Light wood assembly. Right. Attaching a trim strip with staples.

Facing downward. The stapler is held firmly against the work and is activated with a trigger. Fig. 12-12 shows skilled workmen using pneumatic staplers.

Nailers and Nailing

Nailers operate similar to staplers. They are used to drive a variety of nails quickly and efficiently. The nails are attached together in strips. A strip of nails is mounted in a nailer with the points facing downward. The nailer is held firmly against the work and is activated with its trigger. Fig. 12-13 illustrates an air-powered nailer being used for heavy construction.

Glue Blocks

Glue blocks are small pieces of wood attached with glue or metal fasteners to strengthen joints.

Wood Dowels

Dowels are round, usually made of birch and are available in diameters of 1/8 to 1 in, and in lengths of 3 ft. Dowels are frequently used to reinforce pieces of wood fastened together with glue. Short dowel pegs with spiral grooves are specially made for wood joints. The grooves allow air and excess glue to escape to the bottom of the holes during the clamping process.

Fig. 12-13. Using a pneumatic nailer.
SUGGESTED READING FOR LP 8.7


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Screws take more time to assemble but they make a stronger bond. Also, the project can be taken apart if screws are installed correctly. A few will do the work of several nails yet will hold much better.

**THE SCREW DRIVER**

There are three common types of screw drivers. The *plain screw driver* is used to install slotted-head screws. The size depends on the length and diameter of the blades. Figure 34-1.

34-1. Plain screw driver. Screw drivers are available with blades in lengths from 1/2 inches to 12 inches and in diameters from 1/4 to 3/8 inch.

34-2. Selecting the proper size of screw driver. Note the following: A. The screw driver is too narrow with the result that it causes a burr on the head. B. The screw driver is the correct width. C. The screw driver is too wide. It would mar the wood surface. Courtesy the Jam Handy Organization.

34-3. Phillips head screw driver. This is available in sizes from 1 to 4. Size number 1 is used for screws number 4 or smaller, number 2 for screws from 5 to 9 inclusive, number 3 for screws from 10 to 16 inclusive, and number 4 for screws number 18 or larger.

Make sure that the tip of the screw driver is about the same width as the diameter of the screw head. If it is wider, it may mar the surface of the wood as it is set in place. Figure 34-2.

The *Phillips-head screw driver* is made for driving screws with recessed heads. Figure 34-3. The *spiral type screw driver* is usually sold in a set with three sizes of screw-driver bits and a No. 2 Phillips screw-driver bit. Figure 34-4.

Notice in Figure 51-15 the proper
Section VIII. Unit 34. Assembling with Screws

34-4. The spiral ratchet screwdriver is excellent for quick installation of screws.

Method of grinding a screwdriver. This is very important. If a screwdriver is ground to a sharp edge, it tends to slip out of the slot. This would mar the surface of the wood or injure the head of the screw. A screw that has been set with a poor screwdriver usually has a ragged slot.

There are several things you should know about the size and kind of screw to use. These are: the kind of head, the diameter or gauge size, the length, the kind of metal, and the finish. As you see in Figure 34-5, screws are roundhead, flathead, ovalhead, and drive screw. Of course they come with either a slotted head or a Phillips head, and are almost any length from 1/4 inch to 6 inches. Figure 34-6a. Most screws are made of mild steel, although it is possible to buy them in brass or aluminum. These last two are used primarily for boat construction or wherever moisture would rust the other kind. Most flathead screws have a bright finish. Roundhead screws are usually finished in a dull blue. Sheet-metal screws are ideal for fastening thin metal to wood such as attaching metal legs to a plywood top. The sheet-metal screw has excellent holding power because, unlike wood screws, the threaded shank is the same diameter through its length. Figure 34-6b.

34-5. The four kinds of screws. The portion of each style screw included in the length measurement is shown in the diagram. A. Flathead. B. Roundhead. C. Ovalhead. D. Drive screw.

34-6a. The difference between slotted head and recessed Phillips-head screws.

34-7. Table showing the proper size bit or drill needed for the shank hole and the pilot hole for assembling stock with screws.

Wood screw sizes are indicated by the American Screw Wire Gauge with numbers from 0 to 24. The smallest number is 0, which has a diameter of .060. The diameter of each succeeding number is .013 larger. For example, a number 5 screw is .125 (.060 + .013 × 5), or 1/8 inch in diameter. A number 11 screw would be .203, or 3/16 inch in diameter. You will notice that the shank clearance hole is always about this diameter. See Figure 34-7. Two screws can be the same length but have a different gauge size (Figure 34-8). This means that they have different diameters. In most cases, the size of the screw is shown on the drawing. For example, No. 8 R NI. 112 means that the screw is No. 8 gauge size, roundhead, and 11/2 inches long. If the size isn't shown, you should choose a screw.
34-8. Different gauge sizes of 1\(^{1/4}\) inch screws. Wood screws range in length from 1\(\frac{1}{4}\) to 6 inches and in gauge sizes from 0 to 24. Of course, each length is not made in all gauges, as shown by the 1\(^{1/4}\) inch screw.

that will go at least two-thirds of its length into the second piece. If the second piece is end grain, the screw should be even longer, since end grain does not hold well. Other screw devices are shown in Figure 34-9.

Select the kind and size of screw needed. Note in Figure 34-7 the two drill sizes required. The first one is for the shank clearance hole, drilled in the first piece. The second one is for the pilot hole, drilled in the second piece, Figure 34-10. The shank clearance hole should be the same size or slightly smaller than the shank of the screw. In this way the screw can be inserted in the first piece without forcing.

Drill the shank clearance hole in the first piece of stock. Then hold this piece over the second and mark the location for the pilot hole with a scratch awl. If you are assembling softwood pieces, drill the pilot hole only about half the depth to which the screw will go. If you are drilling hardwood, make sure that it is drilled to the total depth of the screw.

34-9. Cup hooks (usually of brass) come in sizes from 1\(\frac{1}{4}\) to 1\(\frac{3}{4}\) inches. Screw hooks are made in lengths from 1\(\frac{1}{4}\) to 2\(\frac{1}{2}\) inches. "L" (square bent) screw hooks come in lengths from 1 to 2\(\frac{1}{2}\) inches. Screw eyes are made with either small or medium eyes in many sizes.

34-10. Here the shank hole and pilot hole are properly drilled and the screw is installed. Courtesy the Jam Handy Organization.
COUNTERSINKING FOR FLATHEAD SCREWS

Countersinking is a way of enlarging the top portion of a hole to a cone shape so that the head of a flathead screw will be flush with the surface of the wood. If flathead screws are being installed, countersink the upper surface of the first piece to allow the head of the screw to be flush with the surface. Figure 34-11. Check the depth of the countersink hole by turning the screw upside down and fitting it in the hole. Figure 34-12. A screw-mate drill and countersink can be used with flathead screws. Figure 34-13. A countersink tool will do all the operations performed by the screw mate, plus drilling plug holes for wooden plugs. Figure 34-14.

Steps in installing a flathead screw.
A. Drill the shank hole. B. Drill the pilot or anchor hole. C. Countersink. D. Check the amount of countersink with the screw head. E. Install the flathead screw.

34-13. This tool will do four things: (1) drill to the correct depth. (2) do the countersinking. (3) make the correct shank clearance. and (4) drill the correct pilot hole.

34-14. A screw-mate counterbore does five things at once. A wood plug can be used to cover the screw head.
Section VIII. Unit 34


34-16. Using a plug cutter. The plug should be cut from the same kind of wood that is used in the project.

34-17. Three methods of covering the heads of screws: (a) with plastic wood, (b) with a plain wood plug, and (c) with fancy wood plugs.

PLUGGING SCREW HOLES

In most furniture construction screws are not supposed to show. Choose a drill or auger bit the same size as the head of the screw. Counterbore a hole in the first surface about 3/8 inch deep. The screw will then be below the surface of the wood. After the parts are assembled, this hole can be filled with plastic wood. Or you can make a little screw plug with the tool shown in Figures 34-15 and 34-16. Furniture supply companies can supply fancy, decorated plugs. Figure 34-17.

DRIVING THE SCREW

To install a screw, hold the body between your thumb and forefinger. Figure 34-18. Grasp the handle of the screw driver in the palm of your hand. Let your thumb and forefinger point toward the shank. Start the screw and then move your left hand up just back of the point of the screw driver. This will guide the tool and keep it from slipping off the head as the screw is set in place. Continue to turn the screw until it is firmly set, but don't strip the threads or shear off the screw from the wood. Be especially careful if the screws are
small or made of brass. A screw-driver bit can be used in a brace for setting screws. Figure 34-19.

1. A screw has several advantages over a nail. Name them.
2. How do you know what size screw driver to choose?
3. Describe the proper way of grinding a screw driver.
4. What information must you have in order to secure the proper kind and size of screw for your work?
5. As the gauge number increases, how is the diameter of the screw affected?
6. What is the general rule for selecting screw lengths?
7. Name two types of screws.
8. What is the shank clearance hole and what purpose does it serve?
9. Why must a pilot hole be drilled?
10. Is the pilot hole drilled in softwood in the same way it is drilled in hardwood?
11. When is it necessary to countersink the hole?
12. How can you check the depth of the countersink hole?
13. What is the purpose of screw plugs?
14. Describe the proper method of holding a screw driver when starting a screw.
15. Why is it important to set the screw with the correct size screw driver?

For a really fine surface on open-grain wood such as oak, mahogany, and walnut, the wood can be scraped after the planing is done by using a hand or cabinet scraper. Figure 35-1. Scraping removes the small bumps left by the plane iron. Some woods, such as curly maple and cedar that can't be
UNIT 26

Fasteners
Bolts, Screws, Nuts, Washers,
Shims, Pins, Keys, and Rivets

26-1. Metal Fasteners

Metal parts can be held together with any of several kinds of metal fasteners, such as rivets, bolts, screws, pins, and numerous special fastening devices. The worker must use good judgment in deciding upon the best kind of fastener.

26-2. Bolts and Screws

Bolts and screws are made in many shapes and sizes. The sizes of bolts and screws are measured by the diameter and length of the body; the head is not included in the length except on flat-head bolts and screws, Fig. 26-1. The kinds most used are shown in Fig. 26-2.

Rough and semifinished bolts and screws are rolled, pressed, hammered, or punched out of cold or hot metal. Finished bolts and screws are cut out of a bar of steel by a screw machine, which is a special automatic lathe.

26-3. Use of Bolts and Screws

Bolts and screws are usually used to fasten together parts which have to be separated later. A bolt is used where one can get at both sides of the work with wrenches. A screw is used where only one side can be reached with a wrench or screwdriver.

26-4. Carriage Bolts

A carriage bolt has a round head, Fig. 26-2. The part of the body under the head is square. It has a black rough finish and has the Unified National Coarse thread.

A carriage bolt is usually used to fasten a wooden part to metal. The square part under the head sinks into the wood, and thus the bolt cannot turn while the nut is being screwed on.

26-5. Machine Bolts

A machine bolt (see Fig. 26-2) has either a square or hexagonal head. It is made with a black rough finish or finished all over. A machine bolt has a Unified National Coarse thread (UNC) or a Unified National Fine thread (UNF).

26-6. Tap Bolts

A tap bolt is like a machine bolt except that the whole body is threaded. It may be used with or without a nut, Fig. 26-2.
26-7. Stove Bolts

A stove bolt has either a round or flat head which is slotted so that it can be turned with a screwdriver, Fig. 26-2. It is made with the UNC thread.
26-8. Stud Bolts

A stud bolt has no head and is threaded on both ends, Fig. 26-2. One end of the stud bolt has more threads than the other. Its use is shown in Fig. 26-3. The cylinder head of an automobile engine is fastened to the cylinder block by screwing the nuts on the stud bolts.

26-9. Cap Screws

Cap screws are made with heads of several different shapes, Fig. 26-2. They are usually finished all over and are made with UNC or UNF threads. Cap screws are used when it is not convenient to get at both sides of the work with wrenches. The head of the cap screw presses against the top piece and holds the parts together, as shown in Fig. 26-4.

26-10. Machine Screws

Machine screws are made with heads of several different shapes (see Fig. 26-2) and are made with either the UNC or UNF thread. They are made of steel, aluminum, or brass. The smaller diameters are measured by gage numbers. The sizes range from number 0 (.060") to ¾" in diameter. Note in Table 29, page 423, that the gage numbers are the same for both machine screws and wood screws.

26-11. Setscrews

Setscrews are made with square heads or are headless, Fig. 26-2. Both kinds are made with different points. Setscrews are case-hardened and are used to fasten pulleys and collars on shafts, as shown in Fig. 26-5. Headless setscrews are described in the next section.

26-12. Headless Setscrews

The headless setscrew is made for safety, Fig. 26-5. Screws with heads are dangerous on moving parts because the worker may be caught and injured. There are two kinds of headless setscrews. One kind has a slot for a screw-
driver. The other kind, known as a socket-head setscrew, has a hexagonal hole. A special wrench is needed, Fig. 26-6.

26-13. Wood Screws

Wood screws are often used to fasten metal parts to wood. They are made with flat, round, or oval heads, Fig. 26-2. The heads are slotted or recessed so they can be turned with screwdrivers. The angle of the flat head is 52°. Wood screws are made of steel, brass, and aluminum. Steel wood screws come in either bright or blued finish, or they are plated with cadmium, nickel, or chromium.

The diameter of a wood screw is measured on the body under the head by the American Standard Screw Gage. Figure 26-7 shows how a wood screw is measured by placing it in the opening of the screw gage until it touches on both sides; the number where it touches is the gage number.

26-14. Lag Screws

A lag screw has a square head like a bolt and is threaded like a wood screw, Fig. 26-2. It is used for heavy work such as fastening a machine to a wooden floor.

26-15. Thumbscrews

A thumbscrew is a screw with one or two wings or with a knurled head. It is used where a screw must be turned by the thumb and finger, Fig. 26-2.

26-16. Nuts

There are many different shapes and sizes of nuts; samples of these are shown in Fig. 26-8. The size of a nut is measured by the diameter of the bolt it fits. In other words, a 1/2" nut fits a 1/2" bolt.

Rough and semifinished nuts are pressed, hammered, or punched out of cold or hot metal. Finished nuts are cut out of a bar of steel by machine.

26-17. Machine Screw Nuts

A machine screw nut (see Fig. 26-8) is six-sided, or hexagonal. The thread may be either UNC or UNF. Stove, carriage, and machine bolts are generally supplied with square nuts.
26-18. Jam Nuts and Lock Nuts

A jam nut (see Fig. 26-8) is sometimes called a lock nut or check nut. It is thinner than an ordinary nut and is used as a lock to keep another nut from loosening by vibration, Fig. 26-9. Although the jam nut is usually put on last, the thick nut may be put on last to make use of the greater strength. Another type of lock nut, a preassembled washer and nut, is also available.

26-19. Castle Nuts

A castle nut (see Fig. 26-8) has slots across the top. The parts which extend upward make it look like a castle, hence the name. A cotter pin is slipped in a slot and through a hole in the bolt to lock the nut to the bolt and thus keep the nut from jarring off. Castle nuts are usually used to hold wheel bearings and wheels in place.

26-20. Wing Nuts

A wing nut (see Fig. 26-8) has two thin, flat wings and is used where a nut has to be turned with the thumb and finger.

26-21. Washers

Washers serve several purposes in fastener assemblies. They are used primarily as a bearing surface for bolts, nuts, and screws. They also serve to distribute the load over a greater area, protect the surface, and prevent movement of parts. They are sometimes used with rivets when fastening leather, fiber, canvas, and similar soft materials.

The common flat washer is a thin, round, metal disk with a hole in the middle, Fig. 26-10. It is used as a bearing surface under a nut or under the head of a bolt or screw.

The size of a washer is measured by the diameter of the bolt that it fits; thus, a ½" washer is for a ½" bolt. Flat washers are sold by the pound.

26-22. Lock Washers

Lock washers serve as a spring takeup between bolts or screws and the workpiece. They also serve to lock the nut or screw in place, thus preventing movement or loosening due to vibration. The helical spring-type lock washer, Fig. 26-10, looks like a coil from a spring. Lock washers of this type are available in light, medium (regular), heavy, and extra-heavy types for screws and bolts from size No. 2 (086") to 3" diameter. They are hardened and tempered and are used under a screw or nut to lock it in place so it will not jar loose. Fig. 26-11.
Tooth-type lock washers. Fig. 26-12, of hardened steel will wedge into the bearing surfaces to prevent bolts, nuts, or screws from turning or loosening due to vibration. Several standard types are shown in Fig. 26-12.

Preassembled screw and washer assemblies, called sems (Fig. 26-13) have a lock washer fitting loosely below the screw head. The expanded rolled thread diameter prevents the washer from falling off. They are used for more rapid assembly on modern assembly lines. Preassembled lock washer and nut units are also available. These also speed up assembly work.

26-23. Shims

A shim is a thin sheet of metal, wood, or paper placed between two surfaces to keep them a certain distance apart so that the shim is a support. The two halves of a bearing around a shaft may be separated a little by placing shims between them as shown in Fig. 26-14. This lessens the tightness on the shaft. As the bearing wears down and
APPENDIX E

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JURY OF EXPERTS

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Dr. James J. Buffer
Professor
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Dr. C. Benjamin Meleca
Associate Professor
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Dr. Marilyn N. Suydam
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Academic Faculty of Science-Mathematics Education
The Ohio State University
Dear Sir:

I am a doctoral student in the Faculty of Industrial Technology Education at The Ohio State University. My doctoral dissertation includes the development of learning packages for pre-service industrial arts teachers.

As examples of suitable assigned readings for the learning packages being developed, I wish to include in the appendix of my dissertation photo-copies of pages 144-148 and 186-192 from Industrial Arts Woodworking and photo-copies of pages 116-119 from Metalwork.

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I look forward to an early and favorable response to this request.

Sincerely,

Niall V. Corwell

Niall V. Corwell
June 27, 1975

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Columbus, Ohio 43201

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Niall V. Corwell

Niall V. Corwell
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Columbus, Ohio 43201

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