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THE DEVELOPMENT OF A COMPREHENSIVE ACHIEVEMENT TEST
FOR THE WORLD OF CONSTRUCTION

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

By
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PLEASE NOTE:

Some pages have indistinct print. Filmed as received.

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Lastly, the writer would like to express his appreciation for the understanding and patience of his wife, Virginia.
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CHAPTER I
INTRODUCTION

THE INDUSTRIAL ARTS CURRICULUM PROJECT

The Industrial Arts Curriculum Project was initiated in 1965 when a group of educators from The Ohio State University and the University of Illinois decided to make a detailed study of the status of industrial arts in the United States. The project was funded by the Bureau of Research of the U.S. Office of Education. Results of the initial study showed that there was widespread discontent among industrial arts teachers who felt that an industrial arts program based on woodworking, metalworking and drawing was inadequate in preparing youngsters for a life in a technological society. Most programs were found to incorporate processes, tools and equipment which belong to another age and are no longer relevant to activities in modern industry.

A decision was made by project staff to develop a rationale and structure that would form the basis for the development of an innovative instructional system in industrial arts. The staff sought to identify an organized body of knowledge, a system of concepts, sub-concepts and unifying themes which could be applied to all of industry.
Such an organized body of knowledge would have the potential of providing youth with educational experiences in, and knowledge about the structure, relationships, opportunities and requirements of industry.

The results of this research effort were published in November, 1966 under the title: A RATIONALE AND STRUCTURE FOR INDUSTRIAL ARTS SUBJECT MATTER. This report included schemas which illustrate the complex nature of industry and the interrelationship of its sub-elements to each other and to the whole. First, second, and third order matrices of industrial technology explicate increasing levels of specificity of a managed production system which applies to both manufactured (in a plant) and constructed (on a site) industrial goods. The matrix scheme provides a unique way of conceptualizing and codifying the body of knowledge contained in industrial technology.

The second phase of the project was to develop instructional materials which would incorporate the major concepts of industry into a program that could be taught in junior high school. The matrix of industry indicated that everything that is man-made is either constructed or manufactured, so a decision was made to divide the study of industry into an integrated two-year program called "The World of Construction" and "The World of Manufacturing." Textbooks were
written by experts in the field of construction and manufacture and by educators who also edited the materials for readability and instructional content. A laboratory manual was prepared which provides laboratory activities designed to apply and reinforce concepts contained in the Textbook. A Teacher's Guide outlines behavioral objectives and provides a step-by-step procedure for conducting each day's class.

The third phase of the project was to establish field evaluation centers which would field test the instructional materials and methodology, and provide feedback to the project staff for revision of the materials. Essential to the field evaluation program was the development and administration of achievement tests designed to measure the achievement of the behavioral objectives outlined for the course. A table of specifications was developed to provide an overall plan for identifying and writing test items to reflect specific behavioral objectives. Ten achievement tests were prepared and administered throughout the year at specified intervals.

During the first year of field evaluation, a midterm and a final achievement test were also prepared. The midterm test was designed to cover the first semester's work, and the final was prepared to cover the second
semester's work. In each case, the objectives measured for the mid-term and the final achievement tests were randomly selected from the table of specifications. In the second year of the field evaluation, the mid-term test was dropped, and the tenth achievement test was considered to be the "comprehensive" examination. The objectives covered in this test were randomly selected from all the operational objectives for the school year.

All achievement tests were revised from year to year as feedback from the evaluation centers and item analyses of the tests indicated areas needing improvement. New items were written by staff members to supplant weak and faulty items.

The third year (1969-1970) of field evaluation for THE WORLD OF CONSTRUCTION was also the last year allotted for developing and revising construction materials. The U.S. Office of Education has approved McKnight & McKnight Publishing Company as the exclusive publisher for the IACP THE WORLD OF CONSTRUCTION. This instructional program will be ready for use in the public schools by September, 1970. Due to publication deadlines, it was not possible to consult teacher feedback and perform item analyses on the second semester test materials of THE WORLD OF CONSTRUCTION before preparing the final copy of the achievement tests and the
comprehensive examinations. The IACP staff felt that previous comprehensive tests in construction did not adequately measure the achievement of the major objectives of the course. This writer was assigned the task of revising the comprehensive examination in construction so that it would more adequately reflect the attainment of higher level concepts relating to construction technology. The criteria followed in revising the test were as follows:

1. Test items on the previous year's examinations which showed good statistics regarding discrimination index, reliability, and level of difficulty, were retained if they appeared to measure higher level concepts of construction technology.

2. Items which appear to measure higher level concepts but showed poor statistics were revised, i.e., either the stem, or one or more of the distractors were changed.

3. Items which appeared to be impossible to improve were replaced with items that measured the same concept and were selected from the periodic achievement tests. Replacement
items had to meet the criteria expressed in number one, above.

The Problem

The Industrial Arts Curriculum Project has succeeded in developing a curriculum which provides "... a cohesive, comprehensive, and internally consistent framework from which students can draw meaningful insights into that complex and productive social enterprise -- modern industry." (A Brief, 1965, p. 4) The development of the first course, THE WORLD OF CONSTRUCTION, is now completed and the instructional materials were especially organized and illustrated to provide the student with a conceptual framework for understanding construction technology. A conceptual model appears at the end of each reading in the Textbook to help the student understand the context and relationships of concepts he has read about.

The table of contents are so arranged that the hierarchical order of construction concepts may be determined by observing their location on the page. Brochures and other publications written about the IACP program make a special effort to point out that one of the major objectives of the course is to provide students with a grasp of
the major concepts of industry and the relationship of its subelements to each other and to the whole.

"...it is designed to reinforce student understanding of broad concepts and principles of technology." "It is expected that students will gain from the IACP program understandings that will contribute to enlightened citizenship, occupational awareness, integration with the culture, and success in the industrialized world." (IACP Brochure, 1969, p. 3)

The basic problem to be researched in this study evolves from the need to develop an instrument which will measure student achievement in attaining these major goals of the IACP curriculum. The periodic achievement tests which have been developed to measure the attainment of daily operational objectives have been based on a logically prepared table of specifications and have undergone three major revisions. The comprehensive achievement tests, on the other hand, have not been consistently developed according to a logically conceived framework based upon a hierarchically established set of objectives. The highly structured format of THE WORLD OF CONSTRUCTION should readily lend itself to the development of such a framework from which a comprehensive achievement test could be written.

Gronlund states that comprehensive exams should be constructed in such a way that they include all the major topics that were considered during the course. (Gronlund, 1968, p. 6) Research by Tyler and Wert indicated that
learning which involves problem-solving relationships and the operation of higher mental processes are relatively permanent and that unrelated facts and mere information are relatively temporary. Lindquist comments on this research and states that comprehensive tests should measure the student's grasp of relatively permanent knowledge reflected in the application, analysis, synthesis and evaluation categories of Bloom's taxonomy of educational objectives, as opposed to the knowledge and comprehension categories. (Lindquist, 1959, p. 23) Furst also comments on and supports Tyler's research and he presents two educational implications:

1. It is necessary in teaching to aim explicitly at each of the major objectives, rather than to assume that the development of ability to think arises from the acquisition of information.

2. It is necessary in evaluation to develop tests for each of the important objectives in a course rather than to assume that an information test by itself will measure all important forms of intellectual ability. (Furst, 1958, p. 49)

An examination of the first and second editions of the comprehensive tests for THE WORLD OF CONSTRUCTION shows that a majority of the items were selected from knowledge and comprehensive type educational objectives. The third edition of the comprehensive test includes a lower percentage of knowledge and comprehension type items, but these were still randomly selected from the periodic achievement tests
designed to measure daily operational objectives. Consequently, one could question whether they adequately represent all the major concepts of construction technology.

The problem then, is to develop a comprehensive achievement test which would:

1. Include items which cover all the major concepts of the construction technology course.

2. Include a majority of items designed to measure a student's grasp of relatively permanent knowledge, i.e., items based upon intermediate educational objectives which reflect the application, analysis, synthesis, and evaluation categories of Bloom's taxonomy.

Subordinate to this major problem are various sub-problems which may be stated as follows:

1. To identify the major concepts of construction technology as established by experts in the field.

2. To develop an outline of each major concept to show its principal sub-elements.

3. To develop a set of intermediate objectives related to the major concepts in order to bridge the gap between the broadly stated
course objectives and the specific daily operational objectives.

4. To establish a table of specifications for writing test items so that the achievement test will
   a) represent all the major concepts of construction technology,
   b) consist of a majority of items which reflect higher level objectives.

5. To establish criteria for writing multiple choice questions as outlined in current literature in the field of educational measurement.

6. To write test items for a comprehensive achievement test in construction technology according to the established criteria and the table of specifications.

7. To pilot test the first draft of the test.

8. To revise the first draft based upon information received from an item analysis.

9. To final test the revised edition of the test and record the results.
In summary, the research will be designed to determine three fundamental factors:

1. A rationale and structure for the development of a comprehensive achievement test in construction technology.

2. A set of criteria which reflects current techniques for constructing multiple choice test items.

3. A comprehensive achievement test to be developed, pilot-tested, revised, retested and analyzed.

**Significance of the Study**

The Industrial Arts Curriculum Project has gained national recognition for its development of a new curriculum in industrial arts. *The World of Construction* is the first part of this integrated two-year program to be published commercially for adoption or adaptation in the public schools. Statements of the overall objectives of this new curriculum indicate that students will be able to understand the broad concepts and principles of technology as they relate to life in an industrialized world.

A rationale and structure have not been prepared for the development of a comprehensive test in this area of
education. The development of such a rationale and structure and its implementation in devising a comprehensive achievement test will provide valuable insights into the students' attainment of praxiological knowledge. Such information can be helpful to administrators, teachers, students, and parents in assessing the merits of this new curriculum.

The following are also some of the expected dividends of this research effort:

1. It will identify a hierarchy of the major concepts of construction technology according to specific major topics.

2. An outline of these major topics will identify major sub-elements contained in each topic.

3. This outline will provide the structure for establishing a set of intermediate objectives for each major topic, to bridge the gap between the broadly stated course objectives and the specific daily operational objectives.

4. The identification of major topics and their intermediate objectives could provide a framework for tailoring this course in construction to meet the needs of various
school systems which do not wish to implement the entire program.

5. The rationale and structure developed for this course could also be used to develop a comprehensive achievement test in THE WORLD OF MANUFACTURING since the structure of both courses is very similar.

6. The methodology implemented in developing this comprehensive test could provide direction to teachers faced with the problem of developing comprehensive tests in other subject areas.

7. This comprehensive test could be used as an alternate to the one prepared for the IACP program and could also provide researchers an opportunity to determine test reliability through equivalence testing procedures.

Assumptions

The assumptions upon which this research is based have been derived from IACP publications and literature pertaining to educational measurement. These assumptions can also be considered as a series of hypotheses, although they are accepted here and are not empirically tested as such. These assumptions are as follows:
1. Man is curious about his man-made world.

2. The study of the man-made world is as important to general education as the study of the natural world.

3. Historically, man has changed the forms of materials by construction.

4. The construction industry is a major sub-element in the economic institution.

5. Historically, the construction industry has not been a major area of study in industrial arts.

6. The Industrial Arts Curriculum Project has organized a body of knowledge, a system of concepts, subconcepts and unifying themes which can be applied to all of industry.

7. This organized body of knowledge concerning construction technology can be taught in school.

8. The attainment of construction technology course objectives can be measured with achievement tests using multiple choice type questions.
Limitations

The scope of this research will be limited to the preparation of a rationale and structure for the development of a comprehensive achievement test in construction technology. Further limitations are as follows:

1. The body of knowledge concerning construction technology used for developing the test will consist of information obtained from A RATIONALE AND STRUCTURE FOR INDUSTRIAL ARTS SUBJECT MATTER, and the instructional materials prepared by the IACP staff for THE WORLD OF CONSTRUCTION. This includes the textbooks, laboratory manuals, and teacher's guides.

2. The selection of major topics to be covered by the test will be limited to those outlined on page vii of the Textbook, with one exception. The graphic presentation on that page will be revised by this author to include units dealing with community development, since the understanding of community development is expressed as one of the major objectives of the course. The remaining fifty units included in the course will be represented in the text only insofar as they relate to the various major topics.
3. A limitation in structuring the table of specifications and in writing high quality test items may include the imagination and creativeness of the writer.

4. The achievement test will not attempt to measure educational objectives in the affective or psychomotor domains.

5. The test that will be prepared according to the criteria outlined in this proposal will consist of fifty multiple choice type questions. Each question will contain a stem, a correct answer, and three distractors. The summary statistics for the final testing of this comprehensive test should meet these standards:
   a. The mean item difficulty will be less than .60.
   b. The mean item discrimination will not be less than .30.
   c. The reliability estimated according to Kuder-Richardson 20 will not be less than .80.

6. The pilot testing and the final testing will be limited to those students who are completing the one-year course, THE WORLD OF
CONSTRUCTION, in IACP field evaluation centers.

**Definition of Terms**

It is impossible at this time to list all technical terms which may appear in the various items written for the comprehensive test. However, technical terms used in the test can be found in the Textbook, Laboratory Manual, or Teacher's Guide for THE WORLD OF CONSTRUCTION. Other words and phrases used in this study are defined as follows:

**Industry** is defined as that subcategory of the economic system which substantially changes the form of materials in response to man's wants for economic goods. (Towers, 1965, p. 40)

**Technology** is defined as the knowledge of techniques, the science of efficient action.

**Construction industry** is defined as that facet of the economic system concerned with changing the form of materials on-site to satisfy human wants. The construction industry includes activities in producing buildings, roads, towers, dams, tunnels, bridges, and utilities.

**Industrial arts** is defined as the organized study of practices of how man changes the forms of materials to satisfy human wants. Industrial arts includes construction and manufacturing as the fundamental industries which change
the shapes of materials.

**Achievement test** is defined as a test which measures the extent to which an individual has acquired certain knowledge, skills, concepts, and data as a result of instruction. (Ahmann, 1967, p. 127)

**Comprehensive achievement test** is defined as an end-of-course test which covers all the major topics that were considered during the course. (Gronlund, 1968, p. 6)

**Educational objective** is defined as an intent communicated by a statement describing a proposed change in a learner — a statement of what the learner is to be like when he has successfully completed a learning experience. (Mager, 1962, p. 3)

**Item analysis** is defined as the statistical analysis of each test item according to these factors: relative difficulty, phi coefficient, point biserial correlation coefficient, discrimination index, and efficiency. (Sax, 1968, p. 233)

**Methods of Obtaining Data**

Several means of obtaining data may be distinguished at this point. Information dealing with the identification of the major topics will be obtained from IACP literature and dissertations written by research associates about various facets of the project.
A graphic presentation of major topics in THE WORLD OF CONSTRUCTION Textbook will serve as a guideline in identifying the structure of construction technology, with the exception noted above in number two of "Limitations." Each major topic will be analyzed and the principal construction concepts will be listed in outline form. This information will be used to develop a set of intermediate educational objectives for each major topic. The purpose of these objectives is to bridge the gap between the overall, broadly-stated objectives of the course, and the daily, operational objectives. These intermediate objectives will provide the basis for development of test items which will reflect the major concepts of construction technology and the interrelationship of these concepts.

One test item will be written on each major topic to assure complete coverage of major concepts taught in the course. A table of specifications will be constructed to provide guidelines for writing test items. Random selection techniques will be followed to identify which specific objectives will be tested under each major topic. Emphasis will be placed upon writing test items which reflect the application, analysis, synthesis, and evaluation categories of Bloom's taxonomy.

A review of the literature in the field of educational measurement will be conducted to establish some basic
principles of achievement testing. This information will be used to identify a set of criteria to be followed in writing the test items. Each item will be reviewed and critiqued by four members of the IACP staff before it is included in the pilot test.

The first draft of the comprehensive test will be pilot-tested with approximately fifty students enrolled in a construction course in one of the field evaluation centers.

An item analysis will be conducted at the Center for Measurement and Evaluation at The Ohio State University. Each analysis will include these factors: relative difficulty, phi coefficient, point biserial correlation coefficient, a discrimination index, and item efficiency. Summary statistics for the test will show the mean, median, mode, standard deviation, skewness, kurtosis, and an index of internal consistency.

The first draft of the test will be revised and poor items will be improved if possible. If this writer decides that a poor item cannot be changed or improved, a new item will be written which will reflect the same major concept of construction technology which was contained in the original item.

The final draft of the test will be tested with at least one hundred students enrolled in an IACP construction
course. The item analysis and summary statistics obtained from this final testing will be presented in the last chapter and will conclude this research effort.
CHAPTER II

A CONCEPTUAL FRAMEWORK OF CONSTRUCTION TECHNOLOGY

The information presented in this chapter provides an overview of the conceptual framework of construction technology as it was developed by the Industrial Arts Curriculum Project (IACP). This conceptual framework provided the basis for developing the educational materials for The World of Construction. The structural body of knowledge presented in these materials will be used in developing a comprehensive achievement test in construction technology, which is the objective of this research effort.

Assumptions

Educators in the field of industrial arts generally agree that there are advantages of focusing industrial arts courses on generalizable concepts of industry rather than on isolated facts. However, major problems are encountered when one attempts to answer such questions as: "Which concepts should be taught?", "In what order should they be taught?", and "Do they together present a unified idea of industry?"
In approaching these problems, the IACP staff began by making three assumptions as to the nature of industrial arts:

1. Industrial arts is a study of industry. It is an essential part of the education of all students in order that they may better understand their industrial environment and make wise decisions affecting their occupational goals.

2. Man has been and remains curious about industry, its materials, processes, organization, research, and services.

3. Industry is so vast a societal institution that it is necessary, for instructional purposes, to place an emphasis on conceptualizing a fundamental structure of the field, i.e., a system of basic principles, concepts and unifying themes. (A Brief, 1965, p. 4)

Additional assumptions were made as the research progressed:

1. For purposes of analysis, man's knowledge can be logically categorized and ordered.

2. To provide for the most effective and efficient transmission of knowledge, the educator should codify and structure disciplined bodies of knowledge.

3. The structure of a body of knowledge can be developed before the total curriculum is designed.

4. All domains of man's knowledge must be included in an effective general educational program. (A Brief, 1965, p. 4)

In carrying on the Project, these assumptions dictated a search to determine if there exists an identifiable body of industrial knowledge and, if so, to conceptualize its structure.
To structure a body of knowledge requires that: "(1) the context must be defined, i.e., the boundaries or limitations must be established; (2) the elements of the context must be discrete, i.e., the elements should have relatively little overlap; (3) the sum of the elements must equal the context; and (4) the relationship among the elements must be discernible and operationally adequate." (A Brief, 1965, p. 5) Structuring the body of knowledge led the Project staff to the fundamental question of "into what divisions might men's knowledge be categorized?" (A Brief, 1965, p. 6)

The Project staff consulted with educators, psychologists, philosophers, and other experts in an attempt to conceptualize four domains of man's knowledge. These were found to be: (1) formal knowledge -- those disciplines of logic, math, and linguistics which serve as tools to order all knowledge; (2) descriptive knowledge -- the sciences establishing facts and describing interrelationships, included are the biological, physical, and social sciences; (3) prescriptive knowledge -- the humanities, which provide a basis for value judgments, and (4) praxiological knowledge -- the applied sciences deriving knowledge from the other three as necessary but insufficient for full professional status of a field such as law, education, engineering, marketing, dentistry, etc. This body of knowledge encom-
passes man's ways of doing which bring about, through action, what is valued. (A Brief, 1965, p. 7)

**Major Societal Institutions**

Man's patterns of practices in society have developed into major clusters of activities known as institutions. These institutions are fundamental to the development of man as he progressed from his primitive way of life to his present status in a technologically oriented society. Sociologists have attempted to categorize man's practices as they relate to social development according to five basic institutions, namely: the family, religion, government, education, and the economic institution. (Towers, 1965, p. 69) If we assume that these five institutions are fundamental, then they may be used as valuable constructs in conceptualizing man's practices. The interrelationships between and among these institutions are complex and the functions often overlap. However, the IACP staff selected the economic institution for analysis to determine the place of industry within its framework.

**The Economic System**

Economic activity, taken collectively, generally includes such categories as agriculture, business, and industry. This concept, however, does not provide an accurate base for
precise analysis. Consequently, the Project staff divided the economic system into material production and other economic activity. In other words, the economic institution provides man with economic goods through material production and economic services through other economic activity. These elements are exemplified in Figure 1, page 27.

Within the economic institution, industry was conceived as being that institutional element which substantially changes the form of materials to satisfy man's material wants. Industry essentially includes construction and manufacturing since all of the man-made world is either constructed at a site or produced in a plant. All materials used by man are either extracted from the earth's environment or are genetically produced. Mining and agriculture are examples of man's activities engaged in this type of material production. But since they do not substantially change the form of the materials produced, they are excluded from the concept of industry adopted by the IACP program.

The Material Production Continuum

Figure 2, page 28, traces the flow of material through the production continuum. This graphic presentation of the continuum illustrates that some materials that are genetically

Figure 1: (Source: IACP Rationale, 1968, p. 11)
THE MATERIAL PRODUCTION CONTINUUM

Genetic

Extractive

Manufacturing

Construction

Consumer

Figure 2: (Source: IACP Rationale, 1968, p. 14)
reproduced or are extracted are provided directly to the consumer. Other materials may be processed (the form of the material is changed) through manufacturing or construction before they are sent to the consumer. For example, vegetables may be sold directly to the consumer, or they may be processed in industry and then distributed to the consumer. Similarly, gravel may be sold directly to a consumer, or it may be processed by manufacturing and construction into concrete and then provided to a consumer. (A Brief, 1965, p. 14)

Matrices of Industrial Technology

A matrix approach was devised by the IACP staff in order to conceptualize the body of knowledge contained in industrial technology. This scheme provides a unique way of looking at the multi-dimensional elements which apply to all industries. "Only the practices employed in the management and the production of industrial material goods constitute the elements of the body of knowledge which is industrial praxiology. The subject matter of industrial arts should be selected from this body of knowledge." (A Brief, 1965, p. 15)

Essentially, industry consists of:
1. Industrial management practices affecting humans and materials.

2. Industrial production practices affecting humans and materials.

3. Industrial material goods. (See Figure 3, page 31)

Industrial management practices consist of planning, organizing, and controlling. Industrial production practices consist of pre-processing, processing, and post-processing. (See Figure 4, page 32). Industrial material goods consist of manufacturing (in a plant) and construction (on a site). In this conceptual model, eighteen separate dimensions of industry have been identified.

Levels of specificity may be added to the model on all or on selected dimensions. It is possible, for example, to expand the "industrial production" axis to a high level of refinement, while retaining the generality of the "industrial goods" and the "industrial management" dimensions. If all three dimensions were extensively developed, it would be theoretically possible to select an infinite number of "tailor made" combinations of subject matter from the matrix. Thus, while the primary responsibility of the Industrial Arts Curriculum Project is directed toward industrial arts at the junior high school level, the principal analytical device (the matrix of industrial praxiology) has potential applicability at all grade and sophistication levels. (A Brief, 1965, p. 22)

The second-order matrix shown in Figure 4 demonstrates also how one of the dimensions (blocks) can be selected for further analysis. In this case, the block itself has three
FIRST-ORDER MATRIX OF INDUSTRIAL TECHNOLOGY

Figure 3: (Source: IACP Rationale, 1968, p. 16)
SECOND-ORDER MATRIX OF INDUSTRIAL TECHNOLOGY AFFECTING MATERIALS

Figure 4: (Source: IACP Rationale, 1968, p. 18)
dimensions which are further expanded, namely: planning, processing, and constructed. A third-order matrix shown in Figure 5, page 34, further illustrates the development of the conceptual framework of this particular block. Each of the eighteen blocks can be further developed in this manner. Industrial practices affecting humans consist of hiring, training, working, advancing, and retiring. (See Figure 6, page 35)

These matrices of industrial technology represent the most advanced and most promising conceptual construct the IACP staff has been able to conceive. The structure was submitted to peers for review, and through feedback procedures, information was further refined.

**Course Development and Major Units**

Following this stage in the development of the structure of the body of knowledge came the implementation phase. Instructional materials were prepared to accurately reflect the major concepts of industry which were identified in the matrices of industrial technology. Taxonomies were developed which expanded the sub-elements of these major concepts. (Hauenstein, 1968, p. 2) Ninety-seven "units" were identified and treated as chapters in the Textbook entitled:
SAMPLE THIRD ORDER MATRIX OF INDUSTRIAL TECHNOLOGY
AFFECTING CONSTRUCTED MATERIALS

Figure 5: (Source, IACP Rationale, 1968, p. 19)
SECOND-ORDER MATRIX OF INDUSTRIAL TECHNOLOGY AFFECTING HUMANS

INDUSTRIAL MANAGEMENT PRACTICES

Planning
Organizing
Controlling
Hiring
Training
Working
Advancing
Retiring

INDUSTRIAL MATERIAL GOODS

Manufactured (in plant)  Constructed (on site)

Figure 6: (Source: IACP Rationale, 1968, p. 20)
THE WORLD OF CONSTRUCTION. This Textbook was written by experts in the field of construction and also by educators who adapted the materials for instructional purposes, so that they could be used in teaching concepts about industrial technology in the schools. THE WORLD OF CONSTRUCTION is the first part of an integrated two-year program. The second year course deals with manufacturing technology.

The developers of the instructional materials for THE WORLD OF CONSTRUCTION have arranged the listing of units in the table of contents in hierarchical order. The highest-order concept is closest to the left-hand margin of the page. As concepts become more specific, their numbers are indented further to the right.

In order to show this conceptual framework as it is presented in the table of contents of THE WORLD OF CONSTRUCTION, the units which constitute the course are presented below.

Units of Study for Construction Technology

Unit
1. Man and Technology
   2. Construction Technology
      3. Applying Technology to People
      4. Managing Construction
         5. Beginning the Project
6. Selecting a Site
7. Buying Real Estate
8. Surveying and Mapping
9. Soil Testing
10. Designing and Engineering the Construction Projects
11. Identifying the Design Problem
12. Developing Preliminary Ideas
13. Refining Ideas
14. Engineering the Design
15. Selecting the Design
16. Making Working Drawings
17. Writing Specifications
18. The Designing and Engineering Cycle
19. Selecting a Builder
20. Contracting
21. Estimating and Bidding
22. Scheduling
23. Working as a Contractor
24. Collective Bargaining
25. Hiring Construction Personnel
26. Training and Educating for Construction
27. Working Conditions
28. Advancing in Construction
29. Construction Production Technology
30. Getting Ready to Build
31. Clearing the Site
32. Locating the Structure
33. Earthmoving
34. Handling Grievances
35. Stabilizing Earth and Structures
36. Classifying Structures
37. Setting Foundations
38. Building Forms
39. Setting Reinforcement
40. Mixing Concrete
41. Placing and Finishing Concrete
42. Completing Foundations
43. Building Superstructures
44. Building Mass and Masonry Superstructures
45. Erecting Steel Frames
46. Erecting Concrete Frames
47. Building Wood Frames
48. Installing Utilities
49. Installing Heating, Cooling, and Ventilating Systems
50. Installing Plumbing Systems
51. Installing Piping Systems
52. Installing Electrical Power Systems
53. Installing Electrical Communications Systems
54. Making Inspections
55. Mediating and Arbitrating
  56. Enclosing Framed Superstructures
    57. Roofing
    58. Enclosing Exterior Walls
  59. Striking
    60. Insulating
    61. Applying Wall Materials
    62. Applying Ceiling Materials
    63. Laying Floors
  64. Finishing the Project
    65. Painting and Decorating
    66. Installing Accessories
  67. Completing the Site
  68. Transferring the Project
  69. Servicing Property
  70. Building Dams
  71. Bridge Building
  72. Road Building
  73. Building Skyscrapers
  74. Constructing in the Future
  75. Constructing Housing
    76. Your Dream House
      77. Selecting and Purchasing a Lot
      78. Planning the Living Space
This one-year course in construction technology is divided into three major sections: an analysis of the managed-personnel-production system of construction, a synthesis of housing construction practices, and a synthesis of city and regional planning practices. (See Figure 7 on page 41)
The analysis of the managed-personnel-production system begins with an introduction to construction technology (8 assignments). Then management practices (47 assignments) and production practices (82 assignments) are described. Personnel practices are treated of throughout the 129 assignments, wherever they are most relevant. This 185 day course provides a basic understanding of the common construction system for building any structure, whether it is a dam, building, tower, tunnel, bridge, utility network, or marine project. (IACP, Teacher's Guide, 1969, p. v)

The housing construction section (29 assignments) is a synthesis of construction practices applied to a specific structure: a house. Each student designs and builds his own model dream house or commercial housing, thus reinforcing knowledge of major construction practices. The city and regional planning section (19 assignments, introduces the impact of construction technology upon society and the effects of large-scale decision-making in urban and suburban development. (IACP Teacher's Guide, 1969, p. v)
The analysis of a managed-personnel-production system is reflected in the carefully structured body of knowledge found in the construction textbook. Particular attention was given to organizing and structuring the Textbook so that the student would be provided with a mental image of construction concepts. A conceptual model appears at the end of each reading, to help the student understand the context and relationships of concepts he has read about. A Laboratory Manual was also developed which exposes the student to activities which reinforce each concept. Activities in the Laboratory Manual are keyed with a number which corresponds to the Reading (Unit) number in the Textbook.

All learning experiences are designed to accomplish carefully outlined behavioral changes in students in the cognitive, affective, and psychomotor domains. These behavioral changes which can be expected to result from reading, discussion, and laboratory performance are listed in the Teacher's Guide for each day of class.

Educational Objectives of Construction Technology

The IACP staff has developed three levels of objectives intended to suggest evidences of learning on the part of the student concerning construction technology. The first level pertains to the overall objectives of industrial arts:
A study of industrial arts serves these purposes:

1. Enables students to understand the concepts, principles, generalizations, problems, and strategies of industrial technology.

2. Encourages an interest in and an appreciation for industry as that element of the economic system that provides industrial material goods for the satisfaction of human wants for those goods.

3. Provides knowledge and skills that will be useful in life situations of occupational, recreational, consumer, and socio-cultural significance. (IACP, Textbook, 1969, p. x)

The broad scope of these objectives encompasses major goals of industrial arts as it is taught at all levels in the educational system.

Wherever industrial arts is taught, one would find essentially these same objectives being stated as the overall goals of the program. The point made here is that the content of these first level objectives would be practically the same for both traditional and innovative programs in industrial arts. Both types of programs usually claim to foster an understanding of industry, its techniques and problems; both types usually attempt to provide varying degrees of knowledge and skills pertaining to occupational, recreational and consumer competencies. Consequently, these broad objectives of industrial arts must be further developed and refined if they are to provide guidelines for the development of a comprehensive achievement test in construction technology.
There are twelve course objectives for THE WORLD OF CONSTRUCTION which begin to narrow the focus of the three broad objectives of industrial arts toward specific objectives pertaining to construction technology. These twelve objectives are as follows:

This course will enable the student to do the following:

1. Place construction technology in the broader context of industrial technology and all of technology.

2. Appreciate, understand, and perform selected management practices in planning, organizing, and controlling as they relate to construction production systems.

3. Appreciate, understand, and perform selected personnel practices as they relate to a managed production system in construction.

4. Appreciate, understand, and perform selected production practices in pre-processing, processing, and post-processing or servicing as they apply to construction production systems.

5. Appreciate and understand the interrelationships within and between management, personnel, and production practices.

6. Appreciate and have some understanding of constructed projects and the tools and materials utilized in their construction.

7. Utilize knowledge of construction techniques outside the classroom, currently and in the future.

8. Understand the interrelationship of construction technology and community development.
9. Develop an awareness of vocations in construction technology.

10. Develop an awareness of the significance of construction technology in the past, present, and future.

11. Develop responsible and safe work attitudes and the ability to function as a member of a group.


(IACP, Textbook, 1969, p. xi)

These twelve objectives provide general guidelines which establish the basis for the instructional content of the course in construction technology. The words "appreciate," "understand," and "perform" appear in several of these objectives, which indicates that the affective, cognitive, and psychomotor domains are represented within the scope of this course.

The third level of objectives which were developed by the IACP staff are daily operational objectives -- statements of behavioral objectives which appear each day as they relate to the text review, discussion, and laboratory activity. The entire construction course was designed to facilitate the achievement of the daily behavioral objectives which build toward the twelve course objectives.

No attempt will be made here to present the daily operational objectives for the entire construction course.
which involves about 800 objectives. Instead, Unit 41, "Placing and Finishing Concrete" was selected as a typical example of the content and format of the daily operational objectives.

PLACING AND FINISHING CONCRETE

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Text Review)
1. Given a series of review questions,
   a. Name five ways that concrete is transferred from mixers or trucks to the forms.
   b. Explain how a concrete surface is made level with the top of the form.
   c. Identify another term used for "smooth finish" application.

2. Given one's own home site, identify the type of concrete finishes found on a number of concrete surfaces.

(Laboratory Activity)
3. Given the problem of constructing a reinforced-concrete column,
   a. Tie the reinforcement rods and set the column forms.
   b. Mix and place the concrete in the forms.
   c. Set the anchor bolt in the forms.
   d. Finish the concrete in the form.

(Source: IACP, Teacher's Guide, 1969, p. 244)

The three levels of educational objectives discussed above provide the basis for instruction in construction technology. Each level becomes more specific in explicating the educational outcomes to be attained by the students in their study of construction concepts.
The first level objectives encompass the major goals of industrial arts which pertain to cognitive, affective and psychomotor learning experiences related to industry as a whole. On the second level are 12 course objectives which more specifically relate these first level objectives to broad aspects of the construction industry. They also provide general guidelines used in developing the instructional content of the construction course. The third level objectives are a further breakdown of the 12 course objectives into daily operational objectives. These provide the teacher and students with day-by-day educational goals.

The theory of educational measurement presented in the next chapter will deal with techniques for implementing educational objectives in the design and development of comprehensive achievement tests.
CHAPTER III

BASIC PRINCIPLES OF ACHIEVEMENT TESTING

The purpose of this chapter is to explore the basic principles of achievement testing, the importance of testing in the teaching-learning situation, the relationship of tests to educational objectives, and techniques for developing achievement tests to meet established criteria.

For many years achievement tests have played an important role in the school. Standardized tests have been used by administrators to group students according to ability, to place transfer students, to evaluate the curriculum, to identify exceptional children, and to interpret the school program to the community. Guidance counselors have used tests as one basis for assisting students to make more realistic educational and vocational decisions. The most significant role of testing, however, is in the instructional program of the school. It is here that achievement testing becomes an integral part of the teaching-learning process and has the most direct influence on student development. (Gronlund, 1968, p. 1)
Testing in the Teaching-Learning Process

The relationship between achievement testing and instruction can be seen clearly by noting the nature of the instructional process. Basically, instruction is the process by which desirable changes are made in the behavior of students. The term "behavior" is used here in the broad sense to include thinking, feeling, and acting. Instruction is not effective, therefore, unless some changes in the behavior of students have actually taken place. (Tyler, 1942, p. 47)

Thus, in a course about construction technology, instruction may be aimed at developing an understanding of certain important concepts about construction, an ability to utilize basic principles in solving construction problems, and the development of some skills in performing certain construction activities. The instruction in this course of construction technology will not have been effective unless changes of these kinds actually take place in the students.

Rational planning is required to prevent instruction from becoming merely a haphazard process. Viewed in this way, instruction involves several steps. The first of these is to decide what goals are to be attained, what changes in students' behavior will be accomplished as a result of the teaching-learning experience. The second step is to determine what content and learning experiences can be used to
attain these changes in student behavior. The third step is to organize these learning experiences so that their cumulative effect will be such as to bring about the desired behavior changes in an efficient manner. Finally, the fourth step is to appraise the effects of the learning experience to find out in what ways the experience was effective and in what respects it did not produce the desired results. Obviously, this fourth step is educational measurement, or achievement testing. It is an essential part of instruction because without appraisal, the instructor has no adequate way of checking the validity of his judgments regarding the values of particular learning experiences and the effectiveness of their organization in attaining the ends of education.

(Lindquist, 1959, p. 48)

Tests must be evaluated if the effects of learning experiences are to be properly assessed. The term "evaluation" designates a process which involves the acceptance of specific values and the use of a variety of instruments of observation, including testing, as the basis for value judgments. From the point of view of its functions, it involves the identification and formulation of a comprehensive range of major objectives of a curriculum such as the course in construction technology. Each major objective should be defined in terms of pupil behavior in the classroom or
laboratory which is measured by the use of practical, valid, and reliable instruments. Any learning situation has multiple outcomes. While the student is acquiring information, knowledge, and skills, he is also developing attitudes, appreciations, and interests. This view indicates a shift from a narrow conception of subject-matter outcomes such as grades, to a broad conception of growth and development of students. (Lindquist, 1959, p. 49)

All too frequently, testing is thought of as an end-of-the-unit activity which serves the sole purpose of determining students' grades. Granted that this is a necessary and useful function of testing, it is just one of many. Like teaching itself, the main purpose of testing is to improve learning, and within this larger context, there are a number of specific contributions it can make. For example, testing can help the teacher to make numerous instruction decisions. Some of the more obvious ones are listed below:

1. To what extent are the students ready for the learning experiences to be provided?

2. How quickly can the students grasp the meaning of basic concepts in this course?

3. At what point would it be beneficial to provide a general review of the course material?
4. How can students be grouped according to various levels of ability?

5. Which students are having such severe learning difficulties that they require individual instruction and special help?

6. Which students are proceeding so rapidly that they could benefit from an accelerated program?

7. Which students can be promoted?

8. Which students should be encouraged to take more courses in this area with the possibility of making it their major field of endeavor?

Testing can improve the effectiveness of making decisions by providing more objective information than can be gained through intuition or other subjective means. (Gronlund, 1968, p. 2)

In addition to the more general influence of testing through improved instructional decisions, the use of tests can have an immediate effect on student motivation, the retention and transfer of learning, and the development of greater self-understanding.

Research conducted by Buffer (1966) indicates that providing test information to students can improve students'
future achievement performance and may help mold their self-perception of what they can achieve in school. (Buffer, 1970, p. 23) These findings are in agreement with those reported by Gehrman (1965) for elementary school students and by Zansitis (1965) for college students.

Motivation of Students. If achievement tests are prepared and administered at critical periods throughout the course, they may serve to motivate students by providing them with short-term goals toward which to work, by clarifying for them what learning outcomes are expected, and by providing them with feedback concerning their learning progress. Such periodic tests have to be carefully prepared to reflect the important concepts contained in the specific area to be covered. Students should be made aware of the objectives to be covered before the test is administered so that they know what is expected of them. Therefore, clearly stated objectives are needed to direct student attention toward the important concepts to be studied and tested.

The anticipation of a test arouses greater learning activity, and the nature of the test channels and directs the type of learning that takes place. Thus, if the test prepared for the course measures the recall of facts, students will tend to place the most emphasis on studying facts. Improved learning, however, can result if the teacher emphasizes higher levels of learning beyond the mere
recall of facts. Furthermore, if the test results are discussed with students, this feedback concerning their strengths and weaknesses will clarify the nature of the task and indicate what changes are needed for effective performance. Thus, properly constructed tests can motivate students to work toward the instructional objectives of a course by directing learning activity toward the desired learning outcomes, and by providing students with prompt knowledge of results which contribute to positive reinforcement of desired behavioral changes. (Gronlund, 1968, p. 3)

Retention and Transfer of Learning. Studies on the retention value of various levels of learning were conducted several years ago by Tyler at The Ohio State University. In Tyler's study, a test in zoology measuring five objectives was administered to eighty-two students at the beginning of the course, at the end of the course, and fifteen months later. The amount of loss or gain on each part of the test during the fifteen-month period was computed in relation to the amount gained during the course. On the part of the test requiring: (1) names of organs identified from pictures, the loss was 22 percent; (2) recognition of technical terms, the loss was 72 percent; (3) recall of facts, the loss was 88 percent; (4) application of principles, there was no loss or gain; (5) interpretation of new experiments, there was a gain of 126 percent. (Tyler, 1942, p. 38)
These findings suggest that the latter two types of ability, because of their more enduring value, are as much worth cultivating, or more so, as is the acquisition of information. (Furst, 1958, p. 49)

A vast amount of research spread out over several decades has helped to clarify how transfer of learning takes place and what kinds of learning transfer best. Generally speaking, the more widely useful an outcome of instruction, the greater its transfer value. Hence, priority should be given to those facts, concepts, principles, skills and attitudes which are applicable to a wide variety of life situations and which emphasize generalized modes of thinking. Consequently, learning which involves problem-solving relationships and the operation of higher mental processes is relatively permanent, and unrelated facts and mere information are relatively temporary. "Unless learning involves differentiation and integration of old and new responses into a problem-solving type of mental process or into an organized behavior pattern, it has little permanence or value." (Lindquist, 1959, p. 23)

If measures of the more complex learning outcomes are included in achievement tests, the students' attention can be directed toward their importance. Thus, students receive encouragement to pay particular attention to the knowledges,
skills, applications and interpretations that the course is designed to develop. Well constructed tests can be used to "supplement and complement teaching efforts in these areas and thereby increase the likelihood that the learning will be of greater permanent value to the student." (Gronlund, 1968, p. 3)

**Self-Understanding.** One of the main goals of education is to help a student to investigate and determine his talents and potential as they relate to various fields of endeavor. Essential to the development of one's talents is self-understanding, a true assessment of strengths and weaknesses. Periodic testing and feedback of the results can help students gain insight into the things they can do well, the misconceptions that need correction, and the degree of skill they have in various areas. A well-planned and executed testing program can provide a student with a more objective basis for planning his study program, for selecting future educational goals and experiences, and for developing self-evaluation skills. A sensible use of test results will avoid alienating and discouraging students regarding scholastic performance and potential. On the other hand, if tests are used to threaten or label students, they do little toward the development of true self-understanding. (Shertzer and Peters, 1965, pp. 281-283)
Tests also provide feedback concerning teaching effectiveness. Information provided by test results can be used to evaluate various facets of the instructional program. It can help determine the extent to which the instructional objectives were realistically selected for the course, whether the teacher used effective methods and materials for instruction, and how well the learning experiences were organized. Thus, poor results which appear on an achievement test can not always be attributed to pupil weakness; it may very well indicate weakness in the program itself. This is especially true when a majority of the students do poorly on the same test. The fault may lie in the teacher who is striving for learning outcomes which are unattainable by the students, or the teacher may be using ineffective methods for bringing about the desired changes. The students' responses to the test and the post-test discussion of the results should provide clues to an alert teacher about the source of difficulties so that corrective steps can be taken.

The principles underlying the development of an achievement test determine to a great extent what influence that test might have on improved learning and instruction in the course. Tests can direct students' attention toward the objectives of the course, or away from them. They can encourage students
to focus their attention on limited aspects of the course content or direct their attention to the major concepts of the course. Tests can reward superficial learning or require depth of understanding. They can provide dependable information for instructional decisions or they can provide biased and distorted information. (Gronlund, 1968, p. 5) The following principles of achievement testing provide a firm base for constructing tests which can become a positive force in the teaching-learning situation.

1. Achievement tests should measure clearly defined learning outcomes that are in harmony with the instructional objectives. Achievement tests measure those specific behaviors students are expected to demonstrate at the end of a learning experience. These learning outcomes should be clearly defined and should accurately reflect the instructional objectives of the course, if they are to benefit both students and teachers who intend to use the test results.

2. Achievement tests should measure an adequate sample of the learning outcomes and subject matter content of the course. Sampling is always a problem in constructing achievement tests. An infinite variety of topics present themselves
to the test constructor who must limit the scope of the questions to the important concepts covered in the course. Methods of adequately sampling course content for testing purposes will be presented later in this chapter under the title, "Tables of Specifications."

3. Achievement tests should include the types of test items which are most appropriate for measuring the desired learning outcomes. The major classifications of achievement test items are as follows:

a. Supply type (Student supplies answer)
   1. Essay-extended response
   2. Essay-restricted response
   3. Short answer (word or phrase)
   4. Completion (fill in blanks)
   5. Oral

b. Selection type (Student selects answer)
   1. True-false
   2. Matching
   3. Multiple choice

(Source: Gronlund, 1968, p. 7)

4. Achievement tests should be designed to fit the particular use to be made of the results. The construction of pre-tests, mastery tests, and diagnostic tests follow the same general principles
as achievement tests, but each must be modified according to the particular uses to be made of the results. General achievement tests are designed to measure broad ranges of learning outcomes and to rank pupils in the order of their achievement. Comprehensiveness and representativeness of sampling are essential as is the difficulty of the test.

5. Achievement tests should be made as reliable as possible and should be interpreted with caution. Reliability can be determined if the students' scores are compared to scores received on a second administration of the same test or an equivalent form of the test, and are found to agree closely. A statistical analysis of split-halves of the same test or a comparison of odd-even items can also be used as a measure of reliability. Coefficients of equivalence, stability, equivalent stability, and internal consistency are methods of reporting their different measures of reliability. (Shertzer and Peters, 1965, p. 130) Usually the reliability of a test can be increased by lengthening the test, by constructing a test with items at the 50 per
cent level of difficulty, and by improving the quality of each test item. A further discussion of this point appears later in this chapter.

All test scores contain some error and this fact must be taken into account during test interpretation. Errors in test scores may be attributed to a wide range of variables: guessing, the reading level of the questions, and inevitable flaws in the design and administration of the test. The following table provides an estimate of the amount of error to be expected in tests of different lengths.

<table>
<thead>
<tr>
<th>Number of Items in the Test</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 24</td>
<td>2</td>
</tr>
<tr>
<td>24-47</td>
<td>3</td>
</tr>
<tr>
<td>48-89</td>
<td>4</td>
</tr>
<tr>
<td>90-109</td>
<td>5</td>
</tr>
<tr>
<td>110-129</td>
<td>6</td>
</tr>
<tr>
<td>130-150</td>
<td>7</td>
</tr>
</tbody>
</table>

(Source: Diederich, p. 28)

These estimated standard errors of test scores provide a rough indication of the amount of error to expect in tests of different lengths and it illustrates the importance of allowing for error during test interpretation.
6. Achievement tests should be made as valid as possible. Validity refers to the extent to which a test does what it was designed to do. To determine test validity, scores are correlated with a criterion such as scores on a separate test, ratings by experts, a student's success in school, and logical assumptions based on what the test is measuring. The purpose for which the test will be used determines which type of validity coefficient will be considered in evaluating the particular achievement test.

Four types of validity coefficients can be considered:

a. **Content validity** is usually determined by experts and is used primarily to evaluate how adequately the test represents the actual content of the course.

b. **Predictive validity** helps to determine future performance of students by estimating how well present test scores will predict future success.

c. **Concurrent validity** determines how closely present scores in one area agree with students' scores in other areas.

d. **Construct validity** determines how well a test measures a particular facet (construct) of learning and achievement. The technique most commonly used to determine construct validity is factor analysis. (Sax, 1968, pp. 168-169)
7. Achievement tests should be used to improve student learning. Results of testing provide a basis for the instructor for restudy, replanning, and modification in the subject matter content and instructional materials and procedures. As an example, a detailed analysis of test results may help to determine whether the failure to attain the results desired may be attributed to inadequate instructional materials or procedures, or whether the very theories or hypotheses upon which the instructional plan was based were not appropriate.

In summary, achievement tests will have the greatest positive influence on the teaching-learning process when they accurately reflect major instructional objectives, when they measure an adequate sample of desired learning outcomes, when they are constructed to serve the purposes for which they will be used, and when they are designed to yield reliable and valid scores.

In addition to the above factors, it is important that students be made aware of the great potential that properly constructed tests have for improving learning. Pre-test preparation and post-test discussion should point out the relationship between course objectives and items which ap-
pear on the test. These and similar procedures should cause students to view tests in a positive light and increase the extent to which testing reinforces other experiences in the teaching-learning process. (Gronlund, 1968, p. 11)

Educational Objectives and Testing

It has been impossible to present the conceptual framework of construction technology (Chapter II) and to discuss basic principles of achievement testing without reference to educational objectives. The purpose of this section of Chapter III is to define what is meant by educational objectives, to discuss their strengths and weaknesses, to present a classification of educational objectives and to relate these factors to the development of achievement tests.

Mager defines an objective as "an intent communicated by a statement describing a proposed change in a learner -- a statement of what the learner is to be like when he has successfully completed a learning experience." (Mager, 1962, p. 3) When clearly defined goals are lacking in a teaching-learning situation, there is no rational basis for determining content and for selecting appropriate instructional materials and methods; furthermore, it is practically impossible to evaluate whatever content, materials, and methods are used in the course. Tests should indicate to the teacher and the student the degree to which both have been successful
in achieving course objectives. But unless these objectives have been clearly stated and organized, it would be most difficult for anyone to determine whether an achievement test truly reflects the important aspects of the course and whether a student has attained the course goals or not.

An additional advantage of clearly stated objectives is that the student will know specifically what is expected of him in the course and he will be able to direct his efforts accordingly. (Mager, 1962, p. 4)

The next step is to determine what is meant by the term "meaningful." Mager states that a meaningful objective is the one that excludes the greatest number of possible alternatives toward a specific goal. He lists these characteristics to serve as guidelines in devising meaningful objectives:

First, identify the terminal behavior by name; we can specify the kind of behavior which will be accepted as evidence that the learner has achieved the objective.

Second, try to further define the desired behavior by describing the important conditions under which the behavior will be expected to occur.

Third, specify the criteria of acceptable performance by describing how well the learner must perform to be considered acceptable.

(Mager, 1962, p. 12)

Ebel points out a very important limitation to writing all the course objectives according to such specific guidelines. He implies that general statements of educational
objectives are required to identify the major goals of the course and that specific statements based upon these general objectives are then useful in determining important concepts to be taught and measured. This limitation grows out of the very large number of things to be learned and abilities to be acquired in a given course. To attempt to list them all would be a tremendous task and would discourage many teachers from writing objectives according to Mager’s system (Ebel, 1965, p. 33)

Fortunately, the task of writing broadly stated objectives and also behaviorally stated objectives has already been accomplished for the course in construction technology. This task no longer remains as a problem in developing an achievement test in this area.

The planning of an achievement test can take many forms but in each case the major consideration is to determine what is to be measured and to describe it in such concise terms that test items can be constructed that call forth the desired behavior.

A useful guide for approaching the task is the Taxonomy of Educational Objectives (Bloom, 1956). This is a comprehensive system for classifying objectives within each of three domains: (1) the cognitive domain which is concerned with intellectual outcomes; (2) the affective domain which is concerned with interests and attitudes; (3) the psycho-
motor domain which is concerned with motor skills.

Since the purpose of this research is to develop an achievement test to measure intellectual outcomes, the classification system presented here will be limited to the cognitive domain. A further discussion of the rationale for eliminating the affective and psychomotor domain from this study will be presented later in this chapter.

Intellectual outcomes in the cognitive domain are divided into two major classes: Knowledge, and Intellectual Abilities and Skills. These are further subdivided into six main areas as follows:

Knowledge
1.00 Knowledge (Remembering previously learned material)
   1.10 Knowledge of specifics
      1.11 Knowledge of terms
      1.12 Knowledge of specific facts
   1.20 Knowledge of ways and means of dealing with specifics
      1.21 Knowledge of conventions
      1.22 Knowledge of trends and sequences
      1.23 Knowledge of classifications and categories
      1.24 Knowledge of criteria
      1.25 Knowledge of methodology
   1.30 Knowledge of the universals and abstractions in a field
      1.31 Knowledge of principles and generalizations
      1.32 Knowledge of theories and structures

Intellectual Abilities and Skills
2.00 Comprehension (Grasping the meaning of materials)
   2.10 Translation (Converting from one form to another)
   2.20 Interpretation (Explaining or summarizing material)
   2.30 Extrapolation (Extending the meaning beyond the data)
3.00 Application (Using information in concrete situations)

4.00 Analysis (Breaking down material into its parts)
   4.10 Analysis of elements (Identifying the parts)
   4.20 Analysis of relationships (Identifying the relationship)
   4.30 Analysis of organizational principles (Identifying the way the parts are organized)

5.00 Synthesis (Putting parts together into a whole)
   5.10 Production of a unique communication
   5.20 Production of a plan or proposed set of operations
   5.30 Derivation of a set of abstract relations

6.00 Evaluation (Judging the value of a thing for a given purpose using definite criteria)
   6.10 Judgments in terms of internal evidence
   6.20 Judgments in terms of external criteria

(Source: Bloom, 1956, pp.201-207)

As can be seen in this outline, the outcomes are arranged in an order of increasing complexity. They begin with the relatively simple recall of factual information. The second step is to the comprehension of facts whereby the individual knows what is being communicated and can make use of this knowledge. The third step is to application whereby facts are not only remembered and understood but are applied to new situations. The fourth step is to analysis whereby a communication is broken down into its constituent parts and the relations between ideas are made explicit. The fifth step is to synthesis in which elements and parts are assembled and put together to form a whole. Finally, there is evaluation in which judgments are made about the value of material and methods for specific purposes.
The subdivisions within each area are also in order of increasing complexity. The result, then, is a hierarchical arrangement of student behavior.

The instructional objectives for a particular course will depend on the specific nature of the course, the attitude and experience of the teacher, the philosophy of the school, the particular needs of the students, and numerous other factors which influence an educational program. But regardless of the type of course, most lists of educational objectives can be divided into the cognitive, affective and psychomotor domains.

Some instructors have attempted to measure all three domains in achievement testing programs. There is, however, an abundance of information in the literature concerning educational measurement that achievement tests of the paper-and-pencil type should be limited to the cognitive domain.

It is in the first two areas (knowledge and intellectual abilities and skills), covered by the cognitive domain of the taxonomy, that achievement testing is most useful. Learning outcomes in the other areas are typically evaluated by rating scales, checklists, anecdotal records, inventories, and similar non-test evaluation procedures.

(Gronlund, 1968, p. 15)

Lindquist states that there has been extremely heavy reliance placed upon paper-and-pencil techniques of measurement in education and that other techniques should be developed and used. He further states that: "Written examinations in
general are well-adapted only to the measurement of intellectual aspects of the student's educational development, or of his rational behavior." (Lindquist, 1959, p. 157) Lindquist goes on to say that a student may be questioned on an achievement test about his attitudes or his overt behavior, but that the paper-and-pencil test cannot give accurate evidence that he actually possesses such attitudes or could act the way he says he could. The suggestion is made that objectives in the affective and psychomotor domains be measured through the use of observational devices. (Lindquist, 1959, p. 157)

Ebel approaches the problem from essentially the same point of view:

...any paper-and-pencil test, however it may be labeled, is likely to be perceived and dealt with by an examinee essentially as a cognitive task. The examinee simply cannot behave noncognitively in responding to it....A cognitive task is poorly adapted to the measurement of non-cognitive characteristics. (Ebel, 1965, p. 50)

In view of the difficulties, the prospects are not bright for measuring noncognitive outcomes of education; at least for purposes of ranking and awarding of grades.

Furst alludes to the problem when he discusses the usefulness of Bloom's classification system: "No doubt such a classification could work tolerably well throughout a good part of the range of educational objectives, but
especially the cognitive, for these can be pinned down to specific paper-and-pencil test situations." (Furst, 1958, p. 95) He thereby implies that the affective and psychomotor domains are not easily included in a paper-and-pencil type test.

It cannot be denied that there exists an underlying and essential relationship between and among the cognitive, affective and psychomotor domains. Knowledge is essential to appreciating something and it is required in the development of motor skills. Another major thread which runs through all the taxonomy appears to be a scale of consciousness or awareness. Thus, the behaviors in the cognitive domain are largely characterized by a high degree of consciousness on the part of the individual exhibiting the behavior, while behaviors in the affective domain are more frequently exhibited with a low level of awareness. (Bloom, 1956, p. 1a) But such traits are difficult to distinguish in paper-and-pencil type tests. It seems that more research is needed to establish and clarify the relationships between the cognitive, affective, and psychomotor domains before accurate paper-and-pencil tests can be devised in which all three are measured.

The use of Bloom's Taxonomy in classifying educational objectives is not as simple as it may appear at first glance. This is due mainly to the blurring of concepts and the overlap which exists in the taxonomy itself. In other words, the
categories are not totally inclusive and mutually exclusive and this fact presents problems in classifying objectives. It becomes apparent that one must know or assume something about the nature of the students' prior experiences before one can classify a test item in a particular category. Thus, while it may appear on the surface that a particular item deals with the application of a principle, in the actual situation one could not be sure unless one knew whether the situation was in fact new to the students or whether it had been discussed previously. If the particular item were not new to the students, then it would merely fall in the recall of information category.

Although classification by objective has possibilities, there are two serious limitations. One is that the classification of any situation is not fixed but is relative to the nature of the instruction. The other is that most situations involve more than one type of behavior, so that classification is relative to the behavior considered critical in the situation. (Furst, 1958, p. 95)

It may be concluded, then, that although the cognitive domain of Bloom's Taxonomy provides a valuable guide for identifying learning outcomes, it is not necessary that a particular test cover all of the categories listed. The classification scheme is actually neutral concerning the relative importance of the learning outcomes listed. Thus, it is the classroom teacher who must decide which learning outcomes will guide
his teaching and his testing, and how much emphasis each outcome will receive. The Taxonomy merely serves as a convenient checklist of outcomes which prevents relevant areas of student behavior from being overlooked during the planning for an achievement test. (Gronlund, 1968, p. 16)

Lindquist presents an interesting argument about the relationship of educational objectives to testing when he states: "Whether or not an educational objective has been realized in any individual can be ascertained only through his overt behavior." (Lindquist, 1959, p. 142) He describes an educational achievement test as a device which assigns a rank to individuals in a given group according to the degree to which each individual has attained a particular educational objective or set of objectives. But, he says: "It is only rarely possible, and even then not always practicable, to secure direct measures of the attainment of an educational objective for students yet in school." (Lindquist, 1959, p. 143) The important terminology in this statement seems to be "direct measures." The implications of the use of this terminology will be briefly explored here in order to clarify just what it is that achievement tests are supposed to measure.

In general terms, the purpose of an educational objective is to condition or predispose an individual so that he
will behave in a certain way in a certain situation. It follows then that a test or measurement of this objective consists in placing the student in a situation which will elicit the desired behavior, or some other behavior which is presumably related to the desired behavior and will accurately predict the desired behavior. The only perfectly valid measurement of the attainment of an educational objective would be based on direct observation of the real life behavior of the individual, or the products of that behavior. (Lindquist, 1959, p. 144)

One of the broad objectives of the construction course (number 7) will serve to illustrate the point: "(the student will be able to) utilize knowledge of construction techniques outside the classroom, currently and in the future." (IACP, Textbook, 1959, p. xi) The ultimate and conclusive test of the effectiveness of instruction in relation to this objective would require direct observation of the number of times that the student used his knowledge of construction techniques outside the classroom for the rest of his life. This observation would be the only wholly direct or perfectly valid measure of the attainment of this objective. Obviously, such observation and measurement in this situation would be ridiculous.

The point is that direct measurement of certain educational objectives is impractical if not impossible. Indirect
measurement of such an objective is the only alternative and is accomplished by attempting to measure behavior which is presumed to be related to that particular objective. An indirect measure of the IACP objective stated above would be to observe the student's application of construction techniques in the laboratory and thereby assume that his overt behavior in school would be carried over and exhibited in his behavior outside the classroom.

This and other reasons why direct observation cannot always be used are presented below since they contain suggestions for the improvement of indirect measurement procedures:

1. The direct measurement of educational achievement is often impossible or impractical because of the nature of the objective to be measured, or because the desired behavior does not appear until after the student leaves school. The objective stated above, falls into this category as well as number 12: "(the student will) develop an awareness of self-realization and generate self-actuating behaviors." (IACP, Textbook, 1969, p. xi). Such behaviors may be exhibited in the classroom to some degree, but sometimes they are delayed for various reasons and may not be exhibited until the individual has matured or left school. Teachers cannot wait for direct measurement of
such behavior so an attempt must be made to utilize whatever indirect measures are available to predict now what each individual's behavior may eventually be like.

2. Natural behavior is often inaccessible to an examiner or cannot be observed by him in a testing situation. Objective number 11 falls into this category: "(the student will be able to) develop responsible and safe work attitudes and the ability to function as a member of a group." (IACP, Textbook, 1969, p. xi) The teacher should be able to make first-hand observations of a student's work attitudes and his participation in group activities in the laboratory, but such characteristics are not easily measured on a paper-and-pencil test. The student could answer test questions which relate to safe work habits, but his overt behavior in the laboratory (psychomotor domain) may not reflect what he holds to be true in the cognitive domain.

3. Another reason why it is difficult to directly measure educational achievement is that some specified behavior may occur infrequently in the classroom. An example of such an objective would be number one: "(the student will be able
to place construction technology in the broader context of industrial technology and all of technology. (IACP, Textbook, 1969, p. xi) Few instances of overt behavior which reflect this objective would be observed in ordinary classroom activity. The indirect method of asking questions about the place of construction in industry would be the logical way to attempt to measure this type of objective.

4. Another obstacle to direct measurement of educational achievement is that the contribution of an individual to a group project is not readily discernible. The house module constructed by a team of students in the construction course is an example of this. Obviously, the end product can be easily observed and even measured against a checklist of criteria. But the individual contribution of each member of the team is less certain and not easily measured. Teachers report that there is a tendency for the more skilled students to perform the more difficult operations while the less skilled perform easier tasks. Certainly this procedure is not objectionable and is a realistic approach to a
construction problem. Nonetheless, the fact remains that direct measurement of individual performance is difficult to obtain.

5. The difficulties presented in the previous section indicate that direct measurement of some educational objectives is not only costly in time and effort, but it is otherwise nondiscriminating for measurement purposes. Thus, the performance of one student in laying brick cannot be compared to the performance of another team mate who is mixing mortar. Nor can the intellectual requirements for performing one task be compared to the knowledge required to perform the other. Related to this consideration is the relative complexity of most overt behavior, and the difficulty of analyzing out, or of isolating for observation and measurement, those elements of the total complex that are relevant to a given measurement purpose. Factor analysis techniques can be utilized in separating certain "factors" from others, but this type of analysis is not germane to this research report.

The implications of these five considerations indicate for the purpose of achievement test construction, direct measurement of overt behavior is difficult to obtain. "Instead of observ-
ing the examinee's behavior in a sample of the situations which present themselves to the examinee in the natural course of events, the examiner must, in most cases, present to the examinee a number of situations especially selected or designed to elicit such behavior." (Lindquist, 1959, p. 145) Lindquist believes that the restrictions and controls required for a paper-and-pencil test create an artificial situation which can be considered at best, an indirect measurement of educational objectives. Therefore, the problem for the test constructor is to devise test items which will closely reflect and represent those learning outcomes which are sought in the expression of educational objectives.

Tables of Specifications

One way to provide greater assurance that an achievement test provides a representative sample of the desired behavior is to construct a table of specifications. This is usually constructed as a two-way grid on which learning outcomes (objectives) are listed along one side of the grid and the subject matter topics are listed along the other. The intersecting cells on the table make it possible to indicate the number of test items to be directed toward each learning outcome and each subject matter topic. Table 1 below illustrates a simple version of this procedure.
<table>
<thead>
<tr>
<th>Subject Matter topics</th>
<th>Learning Outcomes</th>
<th>Knowledge of facts and principles</th>
<th>Understanding facts and principles</th>
<th>Application of facts &amp; principles</th>
<th>Total number of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tools</td>
<td></td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>2. Equipment</td>
<td></td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3. Materials</td>
<td></td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4. Processes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Planning</td>
<td></td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>b. Laying-out</td>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>c. Cutting to size</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>d. Assembling</td>
<td></td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>e. Finishing</td>
<td></td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Total number of items</td>
<td></td>
<td>26</td>
<td>7</td>
<td>17</td>
<td>50</td>
</tr>
</tbody>
</table>
Although the table of specifications is a useful device, its effectiveness depends largely on how adequately the learning outcomes and subject matter topics have been described. The table of specifications illustrated above provides the test constructor with nothing more than a bare outline. The listing of topics on the left-hand side of the table tells nothing about the course objectives which apply to these topics. Thus, no one can tell from this table of specifications what emphasis has been placed in the course on the development of skills in the use of tools and equipment; what the students are expected to know about the materials used in the course; what processes are included under the term "planning," etc. The use of a simple table such as this is definitely limited in its illustrations of what educational objectives are being measured. Consequently, more complex tables of specifications have been developed which expand both levels of the two-way grid.

Table 2 illustrates a table of specifications developed by the IACP staff for a periodic achievement test (Achievement Test III in Construction). The table is not presented here in its entirety.
### TABLE 2

<table>
<thead>
<tr>
<th>Unit</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Synthesis</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>1, 2</td>
<td>3, 4, 5, 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>1, 2</td>
<td>3, 4, 6</td>
<td>5</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>2</td>
<td>4</td>
<td>3, 5</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>1</td>
<td>2, 3, 4</td>
<td>5, 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>1, 2</td>
<td>3</td>
<td>5, 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1, 2</td>
<td>3, 4</td>
<td>3, 4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>1, 2</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>1, 2</td>
<td>1, 3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>1, 2</td>
<td>1, 3</td>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>4, 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Objectives</th>
<th>17</th>
<th>19</th>
<th>14</th>
<th>0</th>
<th>4</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>31%</td>
<td>35%</td>
<td>27%</td>
<td>0</td>
<td>7%</td>
<td>0</td>
</tr>
<tr>
<td>Questions</td>
<td>8</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Source: Unpublished IACP materials)
The numbers which appear under the heading "Unit" (42-53) indicate the unit numbers covered in the test. The numbers which occur under the major classifications of knowledge, comprehension, etc., refer to the identifying number of the daily operational objective listed in the Teacher's Guide for that day. These objectives are also separated according to their relationship to the 10 broadly stated objectives of the construction course. (There were only 10 major objectives stated when this table was prepared in 1968.)

An explanation of the meaning of the objective numbers in this table is as follows, starting in the upper left hand part of the table: in Unit 42, the first and second objectives stated in the Teacher's Guide are knowledge type objectives and reflect the educational outcomes which are expressed in objective 2 of the broadly stated objectives of the course. Daily objectives 3, 4, 5, and 6 are comprehension type objectives and they too reflect major objective 2. Moving down to Unit 48, one can see that daily operational objective 2 is a comprehension type objective which reflects course objective 3.

The totals at the bottom of the table indicate that 17 daily operational objectives are knowledge type objectives which represent 31 per cent of the total, and that 8
of these objectives will be randomly selected for writing 8 test items for a 25 item test. Subsequently, there are 19 daily objectives of the comprehension type which represent 35% of the total, and 9 of these will be randomly selected for writing 9 test items.

On other tables of specifications prepared by the IACP staff, the affective and psychomotor domains were also included. The weighting of the comprehensive achievement test for construction in 1968 was determined by the following chart which illustrates the total number of daily operational objectives as they are classified according to the cognitive, affective, and psychomotor domains.

Figure 8 shows that the majority of objectives were classified in the cognitive domain under the knowledge and comprehension categories of Bloom's Taxonomy. Since objectives used for constructing test items were randomly selected from this totality of objectives, the conclusion is drawn that the majority of test items would be in the knowledge and comprehension categories. Furthermore, a random selection would require that all of the 383 daily objectives for that semester had an equal chance of being selected for the comprehension achievement test. At the time that this particular table of specifications was prepared, no attempt was made to weight the number of items written on a specific topic according to the relative importance of that topic in construction technology.
TOTAL OBJECTIVES FOR THE FIRST SEMESTER OF CONSTRUCTION

(C 1968 )

COGNITIVE DOMAIN

<table>
<thead>
<tr>
<th>Skill</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>128</td>
</tr>
<tr>
<td>Comprehension</td>
<td>115</td>
</tr>
<tr>
<td>Application</td>
<td>34</td>
</tr>
<tr>
<td>Analysis</td>
<td>11</td>
</tr>
<tr>
<td>Synthesis</td>
<td>23</td>
</tr>
<tr>
<td>Evaluation</td>
<td>12</td>
</tr>
</tbody>
</table>

AFFECTIVE DOMAIN

<table>
<thead>
<tr>
<th>Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

PSYCHOMOTOR DOMAIN

<table>
<thead>
<tr>
<th>Skill</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imitating</td>
<td>14</td>
</tr>
<tr>
<td>Practicing</td>
<td>44</td>
</tr>
</tbody>
</table>

Figure 8

(Source: unpublished IACP materials)
The intent of this presentation of tables of specifications is to show that they can be constructed in a variety of ways to serve various purposes. Thus, a periodic type achievement test might require a different type of table of specifications from that required for the development of a comprehensive test. In the former, the test writer may wish to randomly sample the totality of daily objectives; in the latter case, it may be more important to limit the scope of the test to the major concepts covered in the course.

Where an achievement test is to serve as a comprehensive measure of achievement in a course, the learning outcomes should cover all instructional objectives that can be tested, and the subject matter content should include all of the major topics that were considered during the course. These can then be weighted in terms of importance and a corresponding number of items allotted to each cell. Thus, to adequately sample the achievement in a course, the test should reflect the emphasis in the table of specifications, which in turn should reflect the emphasis during instruction.

(Gronlund, 1968, p. 6)

In assigning relative weights to each learning outcome and each content area, a number of factors should be considered:

1. The importance of each area in the total learning experience.

2. The amount of time devoted to each area during instruction.
3. Which educational outcomes have the greatest retention and transfer value.

4. The relative importance placed on each area by curriculum specialists. (Gronlund, 1968, p. 20)

In summary, then, the table of specifications may be considered as the test-writer's blueprint which specifies the nature of each item on the test. If the table has been carefully prepared, the quality of the test will be determined on how closely the test-writer can match the specifications and how skillfully he can construct test items which call forth the specific behavior described in the learning experience.

Criteria for Writing Multiple Choice Test Items

At the beginning of this chapter, the major classifications of achievement tests were presented without discussion of their distinguishing characteristics. Emphasis will be placed here on exploring the characteristics of multiple choice type questions and the development of criteria for writing test items of this classification. This type of question will be used exclusively in the comprehensive achievement test for construction for two reasons: (1) All of the achievement tests developed for use in the IACP program are of the multiple choice type; (2) It is the intent of this writer to develop a comprehensive test which can be
used as an alternate form of the comprehensive test already in use in the construction course. Such a test would provide researchers an opportunity to compare the two tests for purposes of determining test reliability through equivalence testing procedures.

The format used by the IACP staff for writing multiple choice test items consists of a stem or lead, and a list of four suggested answers, one of which is correct or clearly best. The alternatives which are incorrect, or not clearly best, will be referred to as "distractors" in this report.

The stem can take a variety of forms but usually falls in the category of a direct question or an incomplete statement. The direct-question form is easier to write, whereas the incomplete-statement form takes a greater degree of skill. (Furst, 1958, p. 250)

The alternatives may also take a variety of forms: letters, numbers, single words, phrases, clauses, sentences, etc. In short, they may take any form that logically supplies the answer to the question that is posed.

A common practice in writing multiple choice items is to construct the item with three distractors and one correct answer. If good distractors are selected, the larger the number of alternatives, the more highly discriminating the item is likely to be. However, good distractors are usually
difficult to write so the more one writes, the more chance there is that each additional one is likely to be somewhat weaker. Consequently, the goal to be sought in the development of this test is to construct items with one correct answer and three distractors. An analysis of the pilot test will help to eliminate poor distractors or point out those which need to be improved.

Some educators question whether multiple choice items can actually test complex thinking:

One must not confuse end point -- the recording of a choice -- with the sequence of thinking that preceded it. Nor must one assume that a simple process necessarily goes with a simple format. How well a multiple choice item tests complex thinking depends to a great extent on the ingenuity of the examiner. (Furst, 1958, p. 251)

Ebel cautiously agrees that multiple choice questions can be designed to test complex thinking, but he believes that the testing of a complex situation often requires a complex presentation of the problem, which lowers the effectiveness of the item.

Attempts to write test items which will require the highest levels of mental processes involve several hazards. One is that they may be quite difficult and thus call for more than ordinary examinees are capable of delivering. Such items are not likely to contribute much effective measurement. Another is that they may involve fairly complex situations, which require many words to describe and may present the examinee with problems of comprehension and interpretation which may be irrelevant to the main purpose of the examination. Characteristics of this kind are likely to lower the precision and the efficiency of the test question. (Ebel, 1965, p. 52)
Regardless of these limitations, the multiple choice item has several advantages over other types of questions. It is very adaptable and lends itself to a wide range of uses; it provides high test reliability per item; it is easy to grade; it provides more analytic data than other types of questions. (Furst, 1958, p. 252) If the test items are carefully constructed, they can provide the teacher with some basis for assessing errors in thinking on the part of the students. Students often find multiple choice questions less ambiguous than completion or true-false items.

There are some critics who claim that all objective type tests are ambiguous, superficial, and conducive to guessing. It is true that a student may sometimes arrive at the correct answer to a multiple choice test item through a process of elimination. It may seem that a student is, therefore, rewarded for knowing something that he really does not know. "Most specialists in test construction, however, do not disapprove of the process of answering by elimination and do not regard the process as a sign of weakness in multiple choice type items in general, or in an item where the process is particularly useful." (Ebel, 1965, p. 165)

In support of this contention, it may be argued that the knowledge and ability required to properly eliminate
incorrect alternatives can be, and usually is, closely related to the knowledge or ability that the student would have to demonstrate in selecting the correct answer to an open-ended or essay question. Real life situations often require that the solution to problems be attained through a process of elimination, so the use of such skills in a testing situation cannot be entirely wrong.

In practice, few multiple choice questions are likely to be answered solely by eliminating incorrect choices. Usually the student who does not immediately choose a correct response will have to make comparative judgments about the relative merit of plausible answers. For this reason, it can be concluded that guessing is not a serious problem in multiple choice questions. (Ebel, 1965, p. 166) If guessing actually does become a problem, the scores can be "corrected for guessing" by subtracting a fraction of the number of wrong answers from the number of right answers. If that is to be the case, the teacher should warn students that their grades will suffer if they guess blindly in the test. A correction for guessing will not be applied to the comprehensive achievement to be developed in this study, so there is no need further to discuss the correction for guessing procedure.

The difficulties of multiple choice testing presented above are far outweighed by its advantages. However, a test
writer should try to keep the limitations of the test in mind as he writes items so that a constant effort will be put forth to minimize the weaknesses that exist.

The following suggestions for preparing good multiple choice test items have been compiled from writings by Ebel, Furst, Lindquist, Ahmann, and Gronlund. These suggestions provide excellent criteria to be followed in preparing the comprehensive achievement for construction.

1. **Multiple choice test items should be developed from valid statements of important topics covered in the course.** The preparation of test items based upon clearly stated educational objectives will help the test writer to select appropriate statements for the stem and should suggest various distractors. Laws, principles, and generalizations tend to be more important than specific incidents or details. The wording of the stem should not duplicate exactly statements made in textbooks and lectures because verbal memory could provide as good a basis for correct response as would clear understanding. Stems should be rephrased so that sheer recall of the conventional verbal expression of the idea does not provide an immediate clue to the correct response. (Ebel, 1965, p. 153)

2. **A single, definite problem should be presented in the stem.** This helps the student to grasp the problem quickly so that he can go on to consider the various answer
alternatives. It is easier for the test writer to construct single problem items if he bases the item on a clearly stated objective. If the writer attempts to include more than one problem, or various facets of the same problem in a single item, he is likely to confuse the student. (Furst, 1958, p. 253) The result would probably be that a good student would spend an undue amount of time trying to decipher the meaning of the question; the poor student will probably guess at the answer or skip the item entirely.

3. The stem should include as much of the item as possible. Time and space are conserved if the stem presents the problem in such a way that short, alternative answers can be presented. The longer the alternatives are, the more difficult it is for the student to remember distinguishing characteristics as he reads down through the list. (Ahmann, 1960, p. 93) Other things being equal, the multiple choice test items having the shorter responses will be better than one with long responses. But a test composed largely of items using one-word responses, or very short phrases is likely to place more emphasis on vocabulary and factual knowledge than on higher level learning. The item writer should not sacrifice importance and significance in the questions to gain brevity in the responses. (Ebel, 1965, p. 162)
4. The stem should be listed in positive terms if possible. Negative statements tend to confuse students since most questions in the teaching-learning process are presented in a positive manner. However, there are times when an educationally significant question can be posed most logically in a negatively stated stem. If a negative statement must be used, it is advisable to underline or capitalize words such as not and never. Nedelsky defends the use of negative stems in multiple choice items on the basis that the ability to reject certain untruths is educationally significant and in many cases does differentiate the better from the poorer student. (Ebel, 1965, p. 461)

5. The stem can be stated as a question or as an incomplete statement. Authors are divided in their opinions about which form is better. Ebel presents a strong case for using questions. "Not only does a direct question tend to present the student with a more specific problem, it also may focus the item writer's purposes more clearly and help him to avoid irrelevance or unrelatedness in the distractors." (Ebel, 1965, p. 158) When an incomplete sentence is used as the item stem, the problem will be more clearly stated if the omitted part comes at the end of the sentence, not the beginning or a middle portion.

6. The alternatives should be logically and grammatically consistent with the stem. Single word alternatives
should not be mixed with long sentences as alternatives. Stems which are incomplete sentences and end with singular or plural forms of a verb, should be followed by alternatives which are consistently singular or plural. Certain words give clues as to which is the correct answer. For example, use of "a" or "an" when some options begin with vowels and some do not. Words like "never," "always," etc., in an option immediately make it implausible. (ACME, 1969, p. 6)

7. Alternatives should be made reasonably similar. Students may determine a correct answer by becoming test-wise to such things as:

a. The relative length of alternatives (if only one is a long alternative, it is usually correct).

b. The correct alternative may repeat part of the stem.

c. Indefinite pronouns may appear in all but the correct alternative.

d. The use of mutually exclusive alternatives (students tend to assume that one of them is correct).

e. Implausible or irrelevant alternatives narrow the choice of possible or correct answers. (Gronlund, 1968, p. 86)

8. Alternatives such as "all of the above" or "none of the above" should be used with caution. The use of these responses are appropriate only when all of the preceding alternatives are thoroughly correct or incorrect answers to the stem. Some authors reject this type of item because a
student may be able to answer on a basis of knowing that just two of the other responses apply. The test writer must be careful that these options are not always used as the correct answer. (ACME, 1969, p. 8)

9. Randomly select the position of the right answer below the stem. The test writer may unconsciously develop a pattern of stating the correct alternative at a specific place in the list of alternatives. One way to avoid this problem is to prepare a random sequence of the digits one to four and use it as a guide to placement of correct responses among the four alternatives.

10. Alternatives should be selected so that all of them are reasonably plausible and appealing to those students who do not possess the knowledge demanded by the item. Few written words are read with such careful attention to meaning, expressed and implied, as those in objective test items. Precision and definiteness of expression are required in constructing good test items so that only one of the alternatives is clearly correct and the others are clearly incorrect. A review of the first draft of the test by other competent persons who are knowledgeable in the field can help to point out errors, ambiguities, or idiosyncrasies which are not apparent to the test writer. (Ebel, 1965, p. 169)

The criteria for writing multiple choice items listed above touches upon the major concerns to be followed in
developing the comprehensive test for THE WORLD OF CONSTRUCTION. There are, however, other aspects of test construction that must be considered by the test writer which are difficult to classify as criteria. The reason is that although they are essential to test construction, they vary from test to test according to the purpose of the test and cannot be considered as standards to be attained. A brief discussion of these considerations will be presented here as an adjunct to the criteria.

**Item Difficulty.** An item so easy that all students answer it correctly, or so difficult that all miss it, yields no information about relative levels of achievement. However, an item in the midrange of difficulty (from 30% to 70% success) yields a maximum amount of information about levels of student achievement.

No item writer can predict precisely how many students will give the correct answer to a specific item. Generally speaking, a good test should include some easy and some difficult items along with many which fall in an intermediate range. The ingenuity, skill, and experience of the test writer are factors which contribute to his ability in producing items of different ranges of difficulty. Research has shown that items of the same average difficulty for a group of students provide widely differing results for
specific students. Thus, an item that is missed by the best student in the class might be answered correctly by an average student. Consequently, the best student is determined not by his ability to answer the most difficult questions, but by his ability to answer more questions correctly at all levels of difficulty. (Ebel, 1965, p. 168)

There are several techniques which may be used by the writer to control the difficulty of the items he produces. He can usually make the stem easier by asking for information about general principles, or harder by asking for more specific information. The more homogeneous the alternatives are, the harder the item is to answer and vice versa. So an item that initially appears to be too difficult or too easy, can be changed by making adjustments in the stem or the alternatives without changing the basic concept that is being measured. (Lindquist, 1959, p. 272)

Item Discrimination. The basis on which an item discriminates is extremely important and is closely allied to item difficulty. "The discriminating power of a test item is the difference between the number of correct and incorrect discriminations expressed as a percentage of the maximum possible correct discriminations." (Ahmann, 1960, p. 188) The job of the item is to discriminate different levels of achievement in the area covered by the course. Most students
of high achievement should answer it correctly, while low achievers should miss it. The item writer has to choose topics and ideas for testing which are likely to discriminate between the high and low achievers. The wording of distractors and the correct answer will also contribute to discrimination. Caution should be taken that the item tests knowledge of subject matter rather than intelligence or reading ability. (Ebel, 1965, p. 154)

The Number of Items on the Test. Objective tests with numerous questions provide a more reliable sample of the subject area than do tests of fewer questions. "In general, the larger the number of independent elements in the sample of tasks used in an achievement test, the more accurately performance on those tasks will reflect achievement in the whole field." (Ebel, 1965, p. 88) However, there is a definite limit to the number of questions that can be asked on a given test. For various reasons, there is a growing trend to make tests include few enough questions so that most students have time to read and answer all of them when working at their own normal speed. Some reasons are:

First, the reliability of the item analysis data pertaining to any given item is a function of the number of examinees who mark it; second, the functions measured by items for which it is appropriate to obtain individual item analysis data are not ordinarily speeded functions but are power functions; third, the behavior of examinees who know they are faced with more items than they can seriously consider within the time limit varies considerably. (Lindquist, 1959, p. 273)
The number of questions that a student can answer per minute varies according to various factors such as: the kind of questions used; the complexity of the thought processes required to answer it; the student's work habits, etc. Consequently, the fastest student in a class is likely to finish the test in half the time it takes a slow student. "Experience with similar tests in similar classes is the best guide. Lacking that, the test constructor might assume that typical multiple choice items can be answered by even slower students at the rate of one per minute...." (Ebel, 1965, p. 67)

The literature in the field of achievement testing is quite extensive and deals with all aspects of educational evaluation. The writer of this report has attempted to summarize the basic principles of achievement testing as they apply to the development of multiple choice test items. These techniques and criteria for writing test items will be employed in the next chapter to prepare a comprehensive achievement test for THE WORLD OF CONSTRUCTION.
CHAPTER IV

THE DESIGN OF THE ACHIEVEMENT TEST

The purpose of this chapter is to synthesize the essential elements of the preceding chapters into a logically defensible system for developing a comprehensive achievement test in construction technology. Various methods could be used to select material for such a test. Items could be developed by selecting material from the totality of the topics contained in the table of contents for THE WORLD OF CONSTRUCTION. Another method would be to randomly select material from the daily operational objectives listed in the Teacher's Guide. The latter technique was used to develop periodic tests in the IACP program and it was also used to develop semester tests during the first year of field evaluation.

The contention is made in this study that a comprehensive test made up of items randomly selected from the totality of the table of contents or from the totality of the daily operational objectives might not be as "comprehensive" as one would hope. The problem does not lie in the theory of random selection but rather in the material that is being sampled. The rationale for supporting this contention is as follows:
Regarding the technique of random sampling the totality of Units of Study:

1. Experts in the field of educational measurement (Gronlund, Ebel, and Lindquist) indicate that comprehensive tests should be developed to represent all of the major topics covered in a course.

2. But not all topics covered in the construction course are necessarily major topics nor do they all merit equal emphasis in the teaching-learning situation. Some topics in the table of contents are more important than others.

3. Thus, random selection of test items from the totality of course topics as they are listed in the table of contents would provide some items based on relatively insignificant topics. Hence, random selection of test items material from the table of contents is inappropriate for constructing a comprehensive achievement test.

Regarding Random Selection from the Daily Operational Objectives:

1. Each unit of the construction course has several educational objectives which are listed in the Teacher's Guide. A survey of the first semester
of construction shows that a total of 396 objectives are listed. These represent objectives written in the cognitive, affective, and psychomotor domains.

2. Of the 396 objectives in the first semester, 126 (or about one-third) are in the psychomotor domain as they relate to skill development and performance in laboratory activities.

3. But experts in educational measurement (Ebel, Furst, Lindquist and Cronbach) suggest that paper and pencil achievement tests are not well suited to measuring the psychomotor domain.

4. Consequently, a random selection from the totality of the educational objectives of the construction course would produce almost one-third which are inappropriate for use in a comprehensive achievement test. This is to say nothing about an indefinite number of daily operational objectives which relate to the affective domain. Hence, a random selection of daily operational objectives seems inappropriate for developing a comprehensive test in construction technology.
The first step, then, in developing a comprehensive achievement test will be to arrange the units of study of THE WORLD OF CONSTRUCTION (as presented in Chapter II) into a conceptual framework which will identify the major topics of construction technology.

A Hierarchical Presentation of Major Topics

Although the table of contents of THE WORLD OF CONSTRUCTION is hierarchically arranged, the major topics in the course are not readily identified. A contributing factor is that some of the ninety-seven units which make up the course treat of similar construction concepts as they relate to both the analysis and synthesis aspects of the program. For example, Unit 16 is entitled "Making Working Drawings," and Unit 79 is entitled "Preparing Working Drawings." Unit 16 is studied in the first semester of the course and the students learn the general concepts which make up working drawings in construction technology. Unit 79 is studied in the second semester when students are ready to prepare working drawings for their "dream home." It is here that the various types of drawings are studied and each student develops a set of working drawings which he will use in planning his house. Other units in the course show comparable similarities.

Another factor which makes it difficult to identify major topics from the table of contents is that various
units which deal with applying technology to people are interspersed among the other units. Thus, Unit 55 "Mediating and Arbitrating" is separated from "Striking" by three units which deal with enclosing framed superstructures. This approach is logically sound in presenting the world of work to the students but it points out the fact that the table of contents is not designed to present the major concepts of construction as they relate one to another. Consequently, the IACP staff developed this structure:
<table>
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<tr>
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<th>2-CONSTRUCTION TECHNOLOGY</th>
<th>29-CONSTRUCTION PRODUCTION TECHNOLOGY</th>
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<td></td>
<td><strong>35-STABILIZING EARTH &amp; STRUCTURES</strong></td>
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<tr>
<td>15-Selecting the Design</td>
<td></td>
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<tr>
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<td><strong>40-MIXING, PLACING, AND FINISHING CONCRETE</strong></td>
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<td><strong>22-SCHEDULING</strong></td>
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<td>25-HIRING CONSTRUCTION PERSONNEL</td>
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<td><strong>29-CONSTRUCTION PRODUCTION TECHNOLOGY</strong></td>
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<tr>
<td><strong>39-SETTING REINFORCEMENT</strong></td>
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</tr>
<tr>
<td><strong>44-BUILDING MASS AND MASONRY SUPERSTRUCTURES</strong></td>
<td><strong>46-ERECTING CONCRETE FRAMES</strong></td>
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<td><strong>47-BUILDING WOOD FRAMES</strong></td>
<td><strong>48-INSTALLING UTILITIES</strong></td>
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<td><strong>49-INSTALLING HEATING, COOLING, &amp; VENTILATING SYSTEMS</strong></td>
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<td><strong>51-INSTALLING PIPING SYSTEMS</strong></td>
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<td><strong>53-INSTALLING ELECTRICAL COMMUNICATIONS SYSTEMS</strong></td>
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<td><strong>58-ENCLOSING EXTERIOR WALLS</strong></td>
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<tr>
<td><strong>60-CUTTING AND UNIONING</strong></td>
<td><strong>61-APPLYING WALL MATERIALS</strong></td>
<td><strong>66-INSTALLING ACCESSORIES</strong></td>
</tr>
</tbody>
</table>

Figure 9
(Source: (IACP Textbook, 1969, p. vi)
The illustration presented above identifies the major topics of construction technology by arranging them under the headings of managing construction, applying technology to people, and construction production technology. Similar topics are represented only once in the schema with the result that of the ninety-seven units included in the course, sixty-eight appear in this graphic presentation. Those which do not appear are either lower order sub-elements, or are already represented by those which do appear. Note also that of the sixty-eight presented in the schema, forty-two are typed in capital letters, signifying that they have been selected by the IACP staff as the major topics of the course. These major topics will provide the basis for developing test items for the comprehensive test.

It should be pointed out here that no attempt was made to position topics in this schema according to their order of importance; nor do all topics which appear therein merit the same amount of emphasis in the construction course. Thus, Unit 23, "Working as a Contractor" is conceptualized under "Applying Technology to People" on the same hierarchical level as Unit 10, "Designing and Engineering Construction Projects," as it appears under its heading of "Managing Construction." Nevertheless, Unit 10 and its subsidiary units merit and receive a relatively more prominent place
in construction technology. Despite these limitations, the schema is helpful in identifying major concepts in a hierarchical order as they relate to each other and to the whole of construction technology.

**An Outline of Principal Construction Concepts**

The major topics of construction technology have now been identified and arranged in hierarchical order. Every part of the construction course is represented by one of these major topics since every unit in the course can be categorized under one or more of these headings.

An achievement test which would include at least one question derived from each one of these major topics could be termed "comprehensive" in that every part of the course would be represented in the test. But before test items can be written on the major topics, educational objectives should be identified which reflect the major concepts of each selected topic.

A review of the 12 broad course objectives presented in Chapter II shows that these do not adequately identify educational outcomes in terms of the major topics listed above. It is true that a comprehensive study of the cognitive, affective, and psychomotor aspects of the major topics of construction technology would provide a sound basis for the development of the 12 broad objectives. But it is
another matter entirely to write test items on the 12 objectives and hope that the resulting test will truly reflect all of the major topics. More specific objectives are needed to provide subject matter to be measured in a comprehensive achievement test.

A possible source of material to be sampled for the test could be the daily operational objectives listed in the Teacher's Guide. However, examination of the sample presented in Chapter II (see p. 46) illustrates the major difficulty encountered in attempting to write test items from these objectives.

Of the eight objectives listed for that particular unit, only objectives 1a, 1b, and 1c readily lend themselves to a paper-and-pencil test designed to measure cognitive learning. It could be argued that the other five objectives listed for that unit require a knowledge of "how to do" (cognitive domain) before the student can adequately carry out the psychomotive functions involved in the activities. This implies that a certain amount of learning in the cognitive domain must take place through text review, discussion, demonstration, etc., before such knowledge is implemented in psychomotive activity. But the objectives for this unit do not include statements which refer to the attainment of such knowledge. Consequently, there appears to be a gap between the overall objectives of the course and the specific daily operational objectives.
Therefore, an attempt will be made here to develop intermediate objectives, relating to the cognitive domain, which will bridge the gap between the 12 broad objectives of the course and the specific daily operational objectives.

To assist in the development of such objectives, an outline was made of each major topic in order to identify its component parts. The outline which appears below was developed by analyzing the readings which pertain to the major topics in the Textbook of THE WORLD OF CONSTRUCTION.

1-Man and Technology

1. Because early man had the ability to think, the use of tools evolved and there was introduced the beginnings of technology.

2. Technology uses tools, materials, and techniques to produce:
   a. Material goods
   b. Non-material goods

3. The four sources or ways of getting material things are:
   a. Extraction
   b. Reproduction
   c. Construction
   d. Manufacture

4. Industrial arts is the study of processes, skills and abilities, and tools used to construct, manufacture, and service goods.

2-Construction Technology

1. GNP (gross national product) is the sum total of goods and services produced in the United States.
2. Construction technology, which produces that which is built on a site, is an important part of our total GNP.

3. To produce and maintain structures, the following basic steps are involved:
   a. A need for the structure must be expressed
   b. Plans must be developed
   c. Construction contracts are let
   d. Site must be selected and prepared
   e. The structure is built and finished
   f. Landscaping is provided
   g. Maintenance is planned

4. Construction technology is made up of:
   a. Management technology
   b. Personnel technology
   c. Production technology

4-Managing Construction

1. The major management functions in construction technology are:
   a. Planning
      (1) Formulating
      (2) Researching
      (3) Designing
      (4) Engineering
   b. Organizing
      (1) Structuring
      (2) Supplying
   c. Controlling
      (1) Directing
      (2) Monitoring
      (3) Reporting
      (4) Correcting

5-Beginning the Project

1. Initiation
   a. Private initiation must follow state and local laws
   b. Public initiation must follow the same laws and requires public support
2. Feasibility
   a. How the study is made and by whom
   b. Facts are collected and analyzed

3. Decision is made at the highest level of authority

6-Selecting a Site

1. Major emphasis in choosing a site for construction is the usefulness of the location for the intended purpose of the project.

2. Restrictions, imposed by governmental agencies, sometimes prevent the use of a good site, e.g.,
   a. Zoning laws
   b. Local taxes

3. Two ways of acquiring sites are:
   a. Negotiation
   b. Condemnation

7-Buying Real Estate

1. Real estate ownership records are maintained by a county registrar or recorder of deeds and generally kept in the county courthouse.

2. Records of land ownership include:
   a. Dates
   b. Names of owners
   c. Location of land
   d. Legal description
   e. Plats or maps
   f. Titles
   g. Deeds

3. Conditions relating to the ownership of property are known as:
   a. Easements
   b. Encroachments
   c. Mortgages
   d. Restrictions
4. Transferring ownership of real estate involves:
   a. A title search and survey
   b. Payment for the property
   c. Transfer of the deed from seller to buyer
   d. Recording of the deed by new owner

8 - Surveying and Mapping

1. Topography
   a. Surveyed and mapped showing natural and man-made features of a site.

2. Research
   a. Finding known and recorded information
   b. Most surveys are actually resurveys
      (1) Resurveys are usually done for a purpose other than the original survey and in more detail.

3. Elevations
   a. Points above or below sea level

4. Monumenting
   a. For important surveys monuments or bench marks are placed indicating location and elevation.

5. Instruments and their uses:
   a. Transit
   b. Level

6. Procedures used in surveying

7. Recording and plotting data
   a. Topographic map
   b. Grid system
   c. Contour lines

8. Methods used in surveying large areas
   a. Aerial photography
9-Soil Testing

1. Load-bearing surface of soil upon which a foundation rests is related to the following characteristics:
   a. Cohesiveness
   b. Plasticity
   c. Looseness
   d. Density
   e. Compressibility
   f. Water content
   g. Frost or freezing conditions

2. To determine stability and composition of soil
   a. A soil analysis may be required
   b. Soil testing may be necessary

10-Design and Engineering Construction Projects

1. Defining design and identifying the nature of problems that are dealt with in designing

2. Examples of factors of good design and an understanding of how they are applied:
   a. Function
   b. Appearance
   c. Cost
   d. Construction materials
   e. Strength

3. An understanding of the steps in the design process:
   a. Problem identification
   b. Preliminary ideas
   c. Refinement
   d. Analysis
   e. Decision
   f. Implementation

11-Identifying the Problem

1. Identifying needs

2. Gathering data

3. Evaluation of data
14-Analyzing the Design

1. Engineering is utilized in analyzing refined designs through:
   a. Structural analysis
   b. Site analysis
   c. Functional analysis

91-City and Regional Planning Factors

1. Primary construction
   a. Demand factors
   b. Service factors
   c. Site factors

2. Housing People
   a. Housing density
   b. Future construction

3. Planning Business Facilities
   a. Central business facilities
   b. Site location and costs

4. Planning Schools and Recreational Facilities
   a. Location
   b. Service needs

19-Selecting a Builder

1. Primary ways of initiating construction work
   a. Owner-builder
   b. Architect-engineer-structor
   c. General contractor-sub-contractors

2. The general contractor is most commonly used

3. Four general kinds of contracts:
   a. Fixed price
   b. Cost plus fixed fee
   c. Cost plus a percentage of cost
   d. Incentive
4. Types of contracts
   a. Advertised
   b. Negotiated

20-Contracting
   1. Selection of the construction contractor
   2. Method of bidding
   3. Bonding
      a. Protection and guarantee
   4. Awarding contracts

21-Estimating and Bidding
   1. Should the contractor bid
      a. Know how to do the job
      b. Chance of low bid
      c. Facilities and finances
   2. How the contractor arrives at the figure he will submit as a bid:
      a. Material
      b. Labor
      c. Equipment
         (1) Own
         (2) Rented
      d. Prices per unit
         (1) Lineal
         (2) Square
      e. Subcontracting
      f. Overhead
      g. Profit
   3. Review and Revision
      a. By top management

22-Scheduling
   1. The necessity for scheduling men, equipment and materials so work can proceed efficiently.
   2. Methods used by contractors to schedule work and how they are applied to actual situations.
3. How a progress chart is used and altered as construction progresses.

54-Making Inspections

1. Inspecting is part of the management function of controlling.

2. Types of Inspections
   a. Those made during the design cycle
   b. Those made by the contractor's employees
   c. Those made by people not working for the contractor

3. Duties of Inspectors
   a. Materials
   b. Methods
   c. Quality of work

68-Transferring the Project

1. Inspection

2. Releases
   a. Claims
   b. Liens

3. Warranties

4. Final Payment

3-Applying Technology to People

1. Personnel technology can be called "ways of causing people to do things."

2. Personnel technology is used to cause workers to:
   a. Work safely
   b. Work efficiently
   c. Feel fairly treated
   d. Find jobs they like
3. Personnel technology involves practices which are directed toward efficient
   a. Hiring
   b. Training
   c. Working
   d. Advancing
   e. Retiring of personnel

23-Working as a Contractor

1. A Contractor's Responsibilities are to
   a. Provide manpower and materials
   b. Provide supervision

2. An Owner's Responsibilities to Contractor are to
   a. Provide real estate and money

3. The Responsibilities of the Architect-Engineer are to
   a. Supervise construction for the owner

24-Collective Bargaining

1. Unions represent workers in dealing with management.

2. AFL, representing skilled craftsmen, merged with CIO, representing industry-wide employees, into AFL-CIO in 1955.

3. Welfare of the building trades represented by the Building and Construction Trades Department of the AFL-CIO.

4. National laws such as the Wagner Act, the Taft-Hartley Act, and the Landrum-Griffin Act govern employer-Union working relationships.

5. Causes of disagreements between the unions and management may occur over: amount of wages, working conditions, hours, fringe benefits, and security rights.

6. Common goals such as training programs, work promotion, and safety, bring management and labor together on cooperative projects.
7. Membership requirements vary from union to union but generally start with a high school education.

8. Two basic steps in arriving at a working agreement:
   a. Negotiation
   b. Arbitration
      (1) Mediation very often occurs before arbitration is required.

25-Hiring Construction Personnel

1. Recruiting involves finding and attracting employees.

2. The selection of personnel is primarily a screening process.

3. Inducting new employees involves orientation to their job.

4. Job applications should be carefully completed.

26-Training and Educating for Construction

1. Construction requires skilled workers

2. Job preparation provided through:
   a. Technical schools
   b. Engineering colleges
   c. Apprenticeship programs

27-Working Conditions

1. Physical working conditions relate to lighting, safety conditions, dust conditions, etc.

2. Working conditions related to social environment: working hours, after work social events, etc.

3. Economic rewards include pay, insurance benefits, vacations, etc.

28-Advancing in Construction

1. Personnel advancement practices affect employee retention
2. Career Progression
   a. Lateral
   b. Positive
   c. Negative

3. Advancement Practices:
   a. Promoting
   b. Demoting
   c. Transferring
   d. Separating
   e. Retiring

4. Effects of Advancement
   a. Economic
   b. Social

34-Handling Grievances
1. After a collective bargaining agreement has been drawn up, grievance procedures define ways for representatives of unions and management to handle workers' complaints.

2. Most grievances involve working conditions which affect the worker at his job.

3. Grievance procedures should:
   a. Begin at the lowest level of management
   b. Be written out if not settled at the lowest level of management
   c. May involve mediation or arbitration in extreme cases

4. Grievance procedures are needed to prevent minor problems from growing into larger problems that lead to strikes and dissatisfied workers.

55-Mediating and Arbitrating
1. Differences between mediation and arbitration
   a. Voluntary arbitration
   b. Compulsory arbitration
2. Jurisdictional disputes involve claims by more than one craft that they should perform a particular job.

3. Matters referred to arbitration:
   a. Disputes over the meaning of the collective bargaining agreement
   b. Disputes over matters which are not covered in the agreement

59-Striking

1. The strike puts pressure on both labor and management to reach an agreement.

2. Causes of strikes
   a. The meaning of the agreement
   b. A claim by a union that the employer is not following the agreement or labor legislation
   c. Grievances

3. Government intervention occurs when the strike:
   a. Causes great inconvenience to the public
   b. Is harmful to the local or national economy
   c. Is harmful to the defense program
   d. Has a harmful effect on countries outside the U.S.

29-Construction Production Technology

1. Industrial production technology -- the process of efficiently changing materials into something which has more value for the buyer.

2. Construction production technology -- that group of practices which are used to efficiently change materials on a site.

3. All production practices may be classified into three divisions:
   a. Pre-processing -- getting materials ready for and to the point of processing
   b. Processing -- separating, combining, and forming materials
c. Post-processing -- the practices of installing, maintaining, repairing, or altering material goods or products.

4. Construction -- the assembling of raw materials and manufactured products on a site.

5. Sequence of construction
   a. Prepare the site
   b. Set the foundation
   c. Erect the superstructure
   d. Install plumbing, heating and airconditioning
   e. Enclose the superstructure
   f. Finish the interior
   g. Landscape the grounds

30-Getting Ready to Build

1. Laws relating to construction are set up on a national, state and local level for the protection of the public.

2. Construction activities must provide for the safety and protection of:
   a. The general public
   b. Property close to the site
   c. The site itself
   d. Equipment and materials
   e. Employers and employees

3. Temporary facilities such as offices and storage space, and utilities such as electricity, telephones, and water are usually needed at construction sites.

31-Clearing the Site

1. Factors important in clearing the site include:
   a. Size
   b. Time of year
   c. Weather
   d. Location
   e. Natural and man-made obstacles
2. Common major site clearing operations
   a. Demolishing
   b. Salvaging
   c. Cutting
   d. Burning
   e. Earthmoving
   f. Disposing

3. Most often, more than one clearing operation is used to prepare a site for construction.

4. Special solutions are occasionally needed to prepare a site for construction such as:
   a. Diverting rivers
   b. Use of helicopter
   c. Cofferdams
   d. Caissons

32-Locating the Structure

1. Surveying is employed to accurately locate highways and structures such as houses, bridges, and dams at the site.

33-Earthmoving

1. Earthmoving equipment, varying in size according to the job to be done, is employed for:
   a. Excavating (digging material)
   b. Transferring (moving excavated material called spoil from one place to another)
   c. Disposing (piling or storing for future use, using as a fill material, or spreading thinly over an area)

35-Stabilizing Earth and Structures

1. To make the excavation ready for a foundation, it may be necessary to trim and stabilize the bed and walls of the excavation.

2. Four major processes used for trimming and shaping the excavation bed and wall are:
   a. Cleaning and washing
   b. Grading
3. Stabilizing earth work is accomplished in five main ways:
   a. Compacting
   b. Sheathing
   c. Bracing and shoring
   d. Piling
   e. Coffer-damming

36-Classifying Structures

1. Construction works, such as dams, roads, bridges, monuments, and buildings may be thought of as structures.

2. Structures are made up of two parts, namely:
   a. Substructures or foundations which rest on bearing surfaces and in some cases footings walls and piers
   b. Superstructures which rest on substructures

3. Superstructures generally fall into three classifications:
   a. Mass superstructures, such as dams, highways, and monuments
   b. Bearing wall superstructures, such as unframed buildings of brick, block, or concrete walls
   c. Framed superstructures, that is, buildings which have a steel skeleton

37-Setting Foundations

1. To support the weight of a structure, foundations are required to transfer the weight of a structure, plus its own weight, to the earth on which it rests.

2. The three elements which make up foundations are:
   a. A bearing surface
   b. A footing
   c. Upright supports
3. The bearing surface of the earth must support the weight of the whole structure and may be:
   a. Rock or soil at the surface
   b. A few feet below the surface
   c. Many feet under a swamp or water

4. Footings, usually made of concrete, steel rods, or crushed rock, which support the substructure are classified as:
   a. Spread footings
   b. Floating or raft footings
   c. Pile cap footings

43-Building Superstructures

1. Superstructures may be divided into three groups.
   a. Mass superstructures
      (1) Materials used
          Earth
          Brick and stone
          Concrete
   b. Load-bearing superstructures
      (1) Materials used
          Masonry
          Other load-bearing wall materials
   c. Framed superstructures
      (1) Materials used
          Concrete
          Steel
          Wood

48-Installing Utilities

1. Utilities are services such as:
   a. Water
   b. Waste disposal
      (1) Sanitary sewers
      (2) Storm sewers
   c. Electricity
   d. Gas
   e. Communications
   f. Others

2. Utility lines must:
   a. Operate satisfactorily and safely
b. Not interfere with each other
c. Generally be hidden or blended into the floors, walls and ceiling

56-Enclosing Framed Structures

1. Who encloses framework
   a. Carpenters
   b. Masons
   c. Roofers
   d. Sheet metal workers
   e. Painters
   f. Ironworkers
   g. Others

2. Exterior
   a. Roof
   b. Walls

3. Interior
   a. Floors
   b. Ceilings
   c. Partitions

4. Insulation is used to prevent the passage of heat and sound.

5. A vapor barrier, either separate or included in the insulation also may form a part of the flooring and exterior walls.

64-Finishing the Project

1. Finish work can be divided into four parts:
   a. Trimming
   b. Painting
   c. Installing Accessories
   d. Cleaning up

2. Since finish work will be visible, it must be done carefully and skillfully.

3. The order in which finish work is done depends upon:
a. The type of building  
b. The finishes chosen  
c. The availability of subcontractors and craftsmen  
d. How the general contractor schedules his work

67-Completing the Site

1. Finish work includes:
   a. Providing access such as driveways, roads and sidewalks  
   b. Building exterior features such as patios and fences  
   c. Sloping and finishing the earth  
   d. Planting vegetation such as trees, shrubs and lawn  
   e. Final cleaning up

2. Who may help to complete a site
   a. A landscape architect  
   b. An agricultural engineer  
   c. An agronomist

69-Servicing Property

1. Servicing property includes:
   a. Operating  
   b. Maintaining  
   c. Repairing  
   d. Altering  
   e. Installing

2. Servicing is a post-processing activity of construction production technology

Intermediate Objectives of Construction Technology

It is now possible to develop intermediate objectives based upon the outline of the major topics listed above. The intermediate objectives will be developed to encompass the
important concepts which were identified under each major topic with emphasis being placed on the cognitive domain of knowledge. The affective and psychomotor domains will be incorporated only insofar as they relate to the cognitive domain. The guidelines which will provide a basis for developing these intermediate objectives include one or more of the following elements:

1. A clarification of terminology which refers to a particular major topic.

2. The identification of occupations and personnel involved in specific facets of construction and a delineation of the proper function of each occupation in the accomplishment of construction goals.

3. The identification of tools, equipment and materials and their association with appropriate construction practices.

4. An organization (analysis and synthesis) of construction techniques and procedures followed in constructing a project.

5. The identification of commonalities and differences which exist between and among the various facets of construction technology.

6. The relationship of construction sub-elements to each other and to the whole.

Not all of these guidelines could be included in the development of each major topic. For example, the topic "Collective Bargaining" does not have particular tools, equipment or materials associated with it. Consequently, the following presentation of intermediate objectives for
construction technology includes whatever criteria are applicable to each major topic. The number and title which precede the statement of objectives coincide with the unit numbers and titles presented in the hierarchical schema on page 104 of this study.

1. **Man and Technology**

   As a result of their learning experiences, the students should be able to do the following:

   1. Clarify terminology (referring to man and technology).
   2. Show the relationship between the two major parts of industry.
   3. Distinguish between constructed products and manufactured products.
   4. Explain how specialized tools and technology lead to the development of an economic system.
   5. Identify two basic sources of materials for construction.

2. **Construction Technology**

   As a result of their learning experiences, the students should be able to do the following:

   1. Clarify construction terminology.
   2. Show the relationship of the main branches of construction technology to each other and to the whole field of construction.
   3. Relate concepts of management, personnel and production technology to specific practices.
   4. Explain why construction should be a managed production system.
4. Managing Construction

As a result of their learning experiences, the students should be able to do the following:

1. Clarify construction management terminology.

2. Distinguish the relationship among the various management functions in construction.

3. Apply the concepts of planning, organizing and controlling to specific construction practices.

4. Determine the importance of efficient management practices in all phases of construction.

5. Identify and organize in sequential order the sub-elements of each major management practice.

5. Beginning the Project

As a result of their learning experiences, the students should be able to do the following:

1. Identify who is involved in initiating a project.

2. Determine the chief elements of a feasibility study for a specific project.

3. List in sequential order the steps to be followed in beginning a project.

6. Selecting a Site

As a result of their learning experiences, the students should be able to do the following:

1. Recognize the need for careful study before selecting a site.

2. Identify restrictions which are placed on the use of a construction site and explain why they exist.

3. Identify and distinguish between personnel involved in selecting a site.
4. List in sequential order procedures followed in selecting a site.

7. **Buying Real Estate**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology used in buying real estate.

2. Identify and explain the use of various types of documents relating to buying real estate.

3. Identify and distinguish between the responsibilities of personnel involved in real estate transactions.

4. Recognize the need for accurate real estate records and explain where they are kept.

8. **Surveying and Mapping**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify surveying and mapping terminology.

2. Explain why accurate surveying techniques are required in beginning the project.

3. Identify and determine the use of tools and equipment used in surveying and mapping.

4. Understand the concept of scaled drawings and explain their importance in topography.

9. **Soil Testing**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify soil testing terminology.

2. Relate the importance of soil testing in constructing various types of projects.
3. Explain how these characteristics of various kinds of soil affect the type of structure to be built.

4. Identify occupations related to soil testing activities in construction.

5. Explain soil testing procedures as applied to both simple and complex construction.

10. **Designing and Engineering the Project**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify designing and engineering terminology.

2. Identify and distinguish between personnel involved in designing and engineering construction projects.

3. Determine the steps to be followed in solving a design problem.

4. Explain the universality of the design process in all types of construction projects.

11. **Identifying the Design Problem**

As a result of their learning experiences, the students should be able to do the following:

1. List the steps to be followed in identifying a design problem.

2. Recognize the design process as the most creative step in beginning the project.

14. **Engineering the Design**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify engineering terminology.
2. Identify and distinguish between various types of working drawings.

3. Recognize the value of accuracy in making and using working drawings.

4. Determine the procedures to be followed in writing specifications for a particular project.

5. List the various kinds of specifications.

91. **City and Regional Planning Factors**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify community planning terminology.

2. Determine the relationship of various personnel and occupations involved in community planning.

3. Identify major problems encountered in community planning and suggest possible solutions to specific problems.

4. Determine factors which contribute to the deterioration of a given community.

5. Explain the need to apply efficient construction technology principles to meet community development needs.

6. Determine the relationship and interdependence of services and primary construction in satisfying community needs.

7. Explain the significance of construction technology in the past, present and future development of housing, business and community projects.

19. **Selecting a Builder**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify contracting terminology.
2. Identify and distinguish between personnel and occupations involved in contracting construction projects.

3. List advantages and disadvantages of various types of contracts.

4. List steps to be followed in selecting a construction contractor.

20. Contracting

As a result of their learning experiences, the students should be able to do the following:

1. Determine the qualifications required of a contractor.

2. List responsibilities of contractors in constructing projects.

21. Estimating and Bidding

As a result of their learning experiences, the students should be able to do the following:

1. Clarify estimating and bidding terminology.

2. Identify the most important factors to be considered in estimating project costs.

3. Explain how bids are made and awards given in construction.

4. Recognize the importance of accurately estimating the cost of a project.

22. Scheduling

As a result of their learning experiences, the students should be able to do the following:

1. Clarify scheduling terminology.

2. Identify the techniques used in scheduling construction work.
3. Explain how scheduling errors can cause expensive mistakes.

54. **Making Inspections**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology used in making inspections.

2. List organizations or individuals for whom inspections are made.

3. Recognize the importance of inspecting as essential to efficient management of construction projects.

68. **Transferring the Project**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology used in transferring a project.

2. List the activities involved in transferring a project from a contractor to an owner.

3. State the conditions to be fulfilled before a contract can be closed.

3. **Applying Technology to People**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify personnel technology terminology.

2. List in sequential order the chief personnel practices.

3. Explain how personnel practices are applied to all types of workers.

4. Recognize the importance of industrial workers in the labor force.
23. **Working as a Contractor**

As a result of their learning experiences, the students should be able to do the following:

1. Identify responsibilities of a construction contractor and tell how they differ from those of the architect-engineer.

2. Outline techniques used by contractors in solving construction problems.

3. Identify occupations of workers employed by contracting firms.

24. **Collective Bargaining**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify collective bargaining terminology.

2. Explain the advantages and disadvantages of labor unions in the construction industry.

3. Identify causes of conflict between labor and management.

4. List in sequential order the procedures followed in settling labor-management disagreements.

5. Identify areas of labor-management cooperation.

6. List the principal requirements for joining a labor union.

25. **Hiring Construction Personnel**

As a result of their learning experiences, the students should be able to do the following:

1. List procedures used to hire construction personnel.

2. Recognize the importance of a job interviewer.
26. **Training and Educating for Construction**

As a result of their learning experiences, the students should be able to do the following:

1. Explain why training and educating are essential in all areas of construction.
2. Identify the kind of program in which craftsmen usually receive their training.
3. List requirements for entering a training program.
4. Indicate the type of training required of architects, engineers, and managers.

27. **Working Conditions**

As a result of their learning experiences, the students should be able to do the following:

1. Identify the main aspects of the working environment and give examples of each.
2. Explain procedures for improving working conditions.

28. **Advancing in Construction**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology which refers to advancing in construction.
2. Identify advancement practices and list them in sequential order.
3. Show how advancement practices affect worker effectiveness.
4. Identify common career patterns of various occupations involved in construction.
34. **Handling Grievances**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology related to handling grievances.
2. State reasons why grievance procedures are needed.
3. List the principal factors involved in grievance procedures.
4. Identify what problems are covered by grievance procedures.

55. **Mediating and Arbitrating**

As a result of their learning experiences, the students should be able to do the following:

1. Distinguish and show the relationship between mediation and arbitration.
2. Recognize the importance of mediating and arbitrating procedures.
3. Select qualifications for mediators and arbitrators.

59. **Striking**

As a result of their learning experiences, the students should be able to do the following:

1. List reasons for striking.
2. Explain the advantages and disadvantages of strikes as they affect both labor and management.
3. Explain what circumstances will require the government to intervene in a strike.

29. **Construction Production Technology**

As a result of their learning experiences, the students should be able to do the following:
1. Clarify construction and production terminology.

2. Associate and discriminate between the three stages of construction production technology.

3. Given specific construction practices, classify each one as pre-processing, processing or post-processing.

4. State the general procedure for constructing a structure.

5. Explain the relationship of production technology to all areas of the construction industry.

30. Getting Ready to Build

As a result of their learning experiences, the students should be able to do the following:

1. Identify the problems and considerations of temporary facilities.

2. Explain the need for temporary facilities and utilities.

3. Indicate the protection needed for personnel and material.

4. State the main reason for laws about construction.

31. Clearing the Site

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology which refers to clearing the site.

2. Identify the tools and equipment used in clearing the site and explain how each is used to accomplish a specific task.

3. Determine appropriate practices for clearing a given site.
4. Identify personnel and the occupations represented in clearing the site.

5. Comprehend the universality of clearing practices as they apply to all areas of construction.

32. Locating the Structure

As a result of their learning experiences, the students should be able to do the following:

1. Clarify surveying terminology.

2. Explain the need for accurately laying out a site.

3. List in sequential order the procedures followed in laying out a site.

4. State what tools and equipment are used by surveyors for a particular task.

33. Earthmoving

As a result of their learning experiences, the students should be able to do the following:

1. Clarify earthmoving terminology.

2. Explain the use of tools and equipment associated with various earthmoving practices.

3. Given a particular site condition, determine the equipment and sequence of practices for earthmoving.

4. Relate earthmoving to other construction production practices.

35. Stabilizing Earth and Structures

As a result of their learning experiences, the students should be able to do the following:
1. Clarify terminology used in stabilizing practices.

2. State why excavation sites are trimmed and shaped.

3. Select equipment and materials required to perform various shaping and stabilizing operations.

4. List in sequential order shaping and stabilizing practices.

36. Classifying Structures

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology which refers to classifying structures.

2. Identify occupations associated with building structures and explain the relationships among these occupations as they cooperate to build a structure.

3. Distinguish between and give examples of two major parts of a structure.

4. Determine safety procedures for various building practices and explain their importance.

5. List in sequential order the major steps followed in constructing a structure.

37. Setting Foundations

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology which refers to foundations.

2. Explain the need for foundations and relate the purposes behind the various elements to specific foundation requirements.
3. Select materials used to construct various foundations.

4. Distinguish between types of forms used in constructing foundations.

5. State the practices of placing and finishing concrete and indicate their application to the various stages of building a structure.

42. Building Superstructures

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology related to building superstructures.

2. Identify the tools, equipment and materials used in building superstructures and associate them with the appropriate practices.

3. Classify given structures according to the major types of superstructures and point out commonalities and differences.

4. Outline safety procedures followed in building various superstructures.

47. Installing Utilities

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology which refers to installing utilities.

2. Explain the interrelationship of occupation and personnel involved in installing utilities and point out organizational principles followed in coordinating their efforts in installing utilities.

3. Identify various types of utility systems and give examples of each.
4. Associate the proper tools, equipment and materials with practices of installing utilities.

5. List utility plants common to most cities and explain how they provide service to a given structure.

56. **Enclosing Framed Structures**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology which refers to enclosing framed structures.

2. Identify the tools, equipment and materials used in enclosing framed structures and associate them with appropriate practices.

3. List in sequential order the practices followed in enclosing framed structures.

4. Distinguish commonalities and differences of practices used in enclosing exterior and interior parts of a structure.

64. **Finishing the Project**

As a result of their learning experiences, the students should be able to do the following:

1. Clarify finishing terminology.

2. Identify the tools, equipment and materials used in finishing a project and associate them with appropriate practices.

3. Recognize the need for increased accuracy of the production practices as they relate to the use of tools and materials in finishing a project.

4. Explain the relationship of various personnel and their occupations as they coordinate their efforts to finish a project.
67. Completing the Site

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology which refers to completing a site.

2. Identify the tools, equipment and materials used in completing a site and associate them with appropriate practices.

3. Explain the need for various types of accesses that may be constructed to complete a site.

4. Recognize the universality of production practices which relate to completing all construction sites.

5. Identify personnel and occupations involved in completing the site.

69. Servicing the Property

As a result of their learning experiences, the students should be able to do the following:

1. Clarify terminology which refers to servicing property.

2. Explain the interrelationship of various occupations and personnel involved in servicing property.

3. Distinguish commonalities and differences among the practices of servicing property.

4. Identify factors which create the need for servicing property.

5. Recognize servicing as a post-processing practice and explain its relationship to production processes.
A Table of Specifications

In Chapter III, two tables of specifications were presented to show that there are numerous techniques used to select material for writing test items. The first table of specifications listed major topics on one axis and learning outcomes on the other. (see p. 80) This table has serious drawbacks as a guideline for developing a comprehensive test for these reasons: (1) the subject matter topics are broad areas of study (e.g., tools, equipment, materials, processes) with no indication of the educational objectives to be measured; (2) the numbers in the grid refer to the number of items to be written on that particular topic. No explanation is given about how the material to be tested will be identified. Consequently this table of specifications seems inappropriate for use in developing a comprehensive test.

The second method for designing a table of specifications presented in Chapter III (see p. 82) is more precise in identifying which educational outcomes are to be covered in the test and on what level of Bloom's Taxonomy they will be tested. However, it incorporates a method of random sampling of all daily objectives to determine what material will be tested. Hence, it appears to be inadequate for the development of a comprehensive test for reasons stated at the beginning of this chapter.
An attempt will now be made to develop a table of specifications which will overcome these problems and provide an accurate guideline for writing test items appropriate for a comprehensive achievement test. These criteria will be followed in designing the table:

The table of specifications should:

1. Include all the major topics of construction technology.

2. Refer to objectives which can be measured in a paper-and-pencil test, i.e., those categorized in the cognitive domain.

3. Provide for the selection of objectives in all categories of the cognitive domain so that higher levels of learning are measured along with factual knowledge.

4. Indicate precisely which objectives are to be measured and show which major topic each represents.

In the following table of specifications, the major topics of construction technology are listed with their identifying unit numbers. The top axis of the grid presents Bloom's classification of educational objectives in the cognitive domain. The affective and psychomotor domains are also included to show that various intermediate objectives in the cognitive domain also have affective and psychomotor overtones. The numbers in the grid represent the identifying numbers of the intermediate objectives. The location of each number in the grid indicates where the objectives are classified in Bloom's taxonomy.
Systematic sampling techniques were used to assure that each major topic will have at least one test item written about it. Since each major topic is represented by at least three and sometimes as many as seven intermediate objectives, random sampling techniques were used to determine which of the objectives relating to that topic would be selected for measurement purposes. The circled numbers indicate which intermediate objectives were selected.

In some cases, more than one number is circled. This indicates that two objectives relating to a specific topic were selected. The reason for selecting more than one objective under certain major topics is twofold:

1. The total number of major topics is 42. The total number of items to be pilot-tested is 60. Therefore, 18 additional objectives had to be selected from the list for measurement.

2. These 18 additional test items will allow certain topics to be measured by two or more items. Thus, more important topics can be weighted more than those of less importance. The weighting of topics was accomplished in consultation with developers of the IACP program.
### TABLE 3

<table>
<thead>
<tr>
<th>Unit</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Synthesis</th>
<th>Evaluation</th>
<th>Affective</th>
<th>Psychomotor</th>
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<tr>
<td>1. Man and Technology</td>
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**Total**: 15 8 10 14 6 10

* Numbers in the grid refer to the objective number. Circled numbers refer to objectives about which items were written.
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<tr>
<th>Unit</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Synthesis</th>
<th>Evaluation</th>
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<th>Psychomotor</th>
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### TABLE 5

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<th>Unit</th>
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<td><strong>Application</strong></td>
<td><strong>Analysis</strong></td>
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<td>29. Construction Production Technology</td>
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<td>30. Getting Ready to Build</td>
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<tr>
<td>31. Clearing the Site</td>
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<tr>
<td>32. Locating the Structure</td>
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<td>33. Earthmoving</td>
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<td>35. Stabilizing Earth and Structures</td>
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<td>36. Classifying Structures</td>
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<td>37. Setting Foundations</td>
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<td>42. Building Superstructures</td>
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<td>47. Installing Utilities</td>
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<td>56. Enclosing Framed Structures</td>
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<td>64. Finishing the Project</td>
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<tr>
<td>66. Completing the Site</td>
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<tr>
<td>69. Servicing the Property</td>
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Test Item Construction

The guidelines for developing a comprehensive achievement test for construction technology have now been established. The educational objectives to be measured on the test have been identified. The task now is to devise multiple choice test items which will reflect the major topics of construction. The criteria established in Chapter III for the writing of multiple choice test items will be followed as closely as possible.

Each multiple choice test item will include a stem and four alternatives, one of which is the correct or best answer. The correct answer will be identified in this study by an asterisk (*). The test items will be organized under the unit number and corresponding major topic titles so that one can determine which question(s) refer(s) to which major topic.

The pilot test as it is presented on the following pages is a revised copy. The original was presented to five members of the IACP staff for review and criticism. The feedback obtained from this review was used to revise the original and prepare it for pilot testing. The reviewers provided criticism about: (1) the content of the test as it reflects major topics of construction technology; (2) the structure of the stems and the alternatives; (3) the reading level of each item on the test.
A COMPREHENSIVE ACHIEVEMENT TEST
FOR THE WORLD OF CONSTRUCTION

1 - Man and Technology

What effects do specialization and technology have on our society?

A. They increase the national debt.
*B. They raise our standard of living.
C. They lower the number of skilled workers.
D. They lower the national average income.

Which of the following most clearly states the differences between construction and manufacturing?

A. Constructed products are made of wood; manufactured products are made of metal.
*B. Construction is building something at a site; manufacturing is producing something in a plant.
C. Construction industry employs more men than manufacturing industry.
D. Constructed products are made from naturally reproduced materials; manufactured products are made from extracted materials.

2 - Construction Technology

The knowledge of how to efficiently build and maintain structures on a site is called

A. economic technology
B. management technology
C. personnel technology
*D. construction technology

Planning, organizing and controlling are the main divisions of

A. economic technology
B. production technology
C. personnel technology
*D. management technology
The three main technologies in construction are

A. men, tools, and equipment
*B. management, personnel, and production
C. materials, practices, and processes
D. economic goods, material goods, and labor

4 - Managing Construction

The man who directlysupervises the work of several carpenters who are building forms is performing what part of management technology?

A. Planning
B. Organizing
*C. Controlling
D. Engineering

The man on a construction job who supervised the workers in their use of proper tools, equipment and materials is the

*A. foreman
B. contractor
C. architect
D. engineer

5 - Beginning the Project

Which of the following is usually the first step in beginning a project?

A. Buying real estate
B. Surveying and mapping
*C. Selecting a site
D. Soil testing

The answers to questions about the need for a project, if it will work, and if it will make money, would be stated in

*A. a feasibility study
B. the contract between the owner and the engineer
C. the contractor's schedule
D. the deed to the property
Which of these structures would be built by a private initiator?

A. A missile base  
B. A state capital  
*C. A restaurant  
D. A freeway

6 - Selecting a Site

Most communities try to avoid building factories in residential areas by

A. negotiating with owners  
B. condemning property  
C. lowering income taxes  
*D. passing zoning laws

If you were to choose the site of a new 2000 car parking garage, which would probably be the best choice?

A. The lowest priced land available  
*B. The center of a business district  
C. A site in the country  
D. A residential area

7 - Buying Real Estate

A written legal document by which a person proves his ownership of land is

A. a survey  
*B. a deed  
C. a mortgage  
D. an abstract

8 - Surveying and Mapping

One of the first tasks of a surveyor who wishes to find the elevation of a certain piece of property is to

A. locate a corner of the property  
B. measure the distance around the outside of the property  
C. drive level rods into the ground  
*D. locate a bench mark
9 - Soil Testing

Large cracks have appeared in the concrete foundation and walls of a new factory. Which is the most likely cause of the cracks?

A. The concrete was cured too long.
B. There is no water table under the structure.
*C. The soil under the foundation has settled unevenly.
D. The utility system is too heavy for the foundation.

10 - Designing and Engineering the Project

When changes are made in the design cycle, the cost of designing the product is usually

A. decreased
B. the same
*C. increased
D. of no importance

The architect in charge of designing a shopping center will probably have an engineer design

A. the master plan
*B. the utility system
C. the specifications
D. the interior of the buildings

11 - Identifying the Problem

The first step in the design process is

A. analyzing the problem
B. making decisions
*C. identifying the problem
D. refining the problem

The rejection of a preliminary idea in the design process should be considered as

A. a complete failure of the design process
*B. a natural procedure in finding a solution to the problem
C. an indication that the designer should be fired
D. proof that the problem cannot be solved
14 - Analyzing the Design

Which of the following is not a part of working drawings?

*A. Liens  
B. Floor plans  
C. Elevations  
D. Sections

91 - City and Regional Planning Factors

Advances in construction technology that will be used in constructing buildings in the future are

A. the use of more unskilled workers  
*B. the use of prefabricated units and a modular system  
C. the use of more wood products and less concrete  
D. an increased use of hand tools in production processes

A costly water main is laid to service a small community. Within a year the water main must be replaced by a larger main because the community has grown. Who pays for this costly mistake in community planning?

A. The workmen who installed the main  
B. The engineer who designed the service  
*C. The people who pay the taxes in the community  
D. The mayor of the community

If a community planner wishes to design housing for a great number of low income families on high priced land, he would probably recommend

*A. high density housing  
B. low density housing  
C. single family units  
D. two single-family units to the acre

19 - Selecting a Builder

How does a subcontractor differ from a general contractor?

A. A subcontractor has to hire his workers from a general contractor.  
*B. A subcontractor is usually a specialist who does only one kind of work such as plumbing.
C. A subcontractor works only on small projects.
D. A subcontractor is the same as a general contractor except that he has a smaller company.

20 - Contracting

Four contractors are bidding on a contract to build a school. Which one would most likely be awarded the contract?

A. The contractor who had the most men and equipment to do the job
B. The contractor who submitted the highest bid and had the most experience in building schools.
C. The contractor who would use the least expensive material
D. The contractor who submitted the lowest bid and could meet the specifications

21 - Estimating and Bidding

A contractor who makes a careful analysis of what a job will cost is making

A. an estimate
B. a bid
C. a quotation
D. a takeoff

22 - Scheduling

A contractor made a mistake in scheduling and as a result a truck arrives with ready-mixed concrete before the forms are braced. What should the contractor do?

A. Send the truck back to the mixing plant and call for a new load when the forms are ready.
B. Place the concrete in the forms and then finish bracing them.
C. Dump the concrete on the ground and place it after the forms are braced.
D. Wait and add water to the concrete to keep it from hardening while the forms are braced.

54 - Making Inspections

Which of the following is a true statement?
A. Construction work is inspected only after all phases of the project are completed.
B. Inspections are made only at the beginning of construction work.
*C. Inspections are made on construction work from the time drawings are begun until the project is finished.
D. If a project is thoroughly inspected when it is begun, there is no need to inspect it again.

68 - Transferring the Project

If a contract between an owner and a contractor is closed, this means that

*A. The owner takes over all responsibility for the project
B. The contractor has not received final payment
C. Several defects on the job must still be corrected
D. The contractor refuses to release claims and liens

3 - Applying Technology to People

Technology used to cause workers to work safely, efficiently and happily is called

A. production technology
B. management technology
C. processing technology
*D. personnel technology

Which of the following is not a personnel technology practice?

A. Hiring
B. Training
C. Advancing
*D. Storing

23 - Working as a Contractor

What is the chief responsibility of a contractor?

A. To design the master plan of the project.
B. To test and approve working drawings.
*C. To get the job done according to the contract specifications.
D. To design the utilities system needed for the project.
24 - Collective Bargaining

Which of the following is a major source of conflict between labor and management?

A. Better training programs.
B. Better safety programs.
*C. Higher wages and better fringe benefits.
D. Creating support for new construction.

25 - Hiring Construction Personnel

Where does a union contractor usually hire his workers?

*A. From the union hiring hall.
B. From non-union labor pools.
C. From employment agencies.
D. From subcontractors.

26 - Training and Educating

If you dropped out of high school after taking industrial arts, could you get a job as a skilled tradesman? Why?

A. Yes, because unions accept a course in industrial arts as a substitute for an apprenticeship program.
B. No, because skilled tradesmen have to be college graduates.
*C. No, because you have to complete an apprenticeship program.
D. Yes, because anyone who is willing to work can be hired as a skilled tradesman.

27 - Working Conditions

Which of the following is an example of a social working condition?

A. Poor lighting in an office area.
*B. The attitude of workers toward each other.
C. Exposure to cold weather.
D. Low wages.

28 - Advancing in Construction

Which of the following job positions requires the most knowledge about construction costs?

*A. An estimator.
B. A journeyman.
34 - Handling Grievances

If a carpenter is unhappy with his working conditions, his first step in the grievance process would be to:

A. talk to the contractor
B. consult the architect
C. present his grievance to a mediator
*D. talk to his foreman

55 - Mediating and Arbitrating

What is the difference between a mediator and an arbitrator in solving a labor and management disagreement?

A. The mediator has the power to force one of the parties to follow his decisions.
B. The arbitrator can make decisions that must be followed by both parties.
C. The arbitrator has no power at all in solving the dispute.
D. There is really no difference.

An arbitrator who is settling a dispute between labor and management should be:

A. a union member selected by the union
B. an employer selected by other employers
C. an employee selected by management
*D. a neutral outsider selected by both sides

59 - Striking

Do labor and management both try to avoid strikes? Why?

A. No, labor likes strikes because they are the only way to increase salaries.
B. No, management prefers to settle disputes only after a strike is called.
*C. Yes, because both lose money during a strike.
D. Yes, because nothing is ever settled in a strike.

29 - Construction Production Technology

All production may be classified into three practices called
A. pre-processing, processing, and post-processing
B. planning, organizing and controlling
C. researching, analyzing and producing
D. hiring, training, and advancing

The activity which usually takes place immediately following the clearing of a site is

A. erecting the superstructure
B. installing utilities
C. setting foundations
*D. locating the structure

30 - Getting Ready to Build

If a contractor is constructing a building in a downtown area, what would be the best way to protect bystanders from being hurt by falling objects?

A. By telling people to stay away
B. By setting up picket lines
*C. By erecting barricades around the site
D. By asking his workers to watch out for people on the sidewalks

If a city wishes to make sure that each project follows the laws for a certain site, it will require the owner to obtain

A. A mortgage
B. A lien
*C. A building permit
D. A zoning permit

31 - Clearing the Site

Demolishing, salvaging, cutting, burning, and disposing are practices of

A. management technology
B. servicing
C. piling and shoring
*D. site clearing

32 - Locating the Structure

A surveyor wishes to measure 100 feet from a monument to the center of a lot where a foundation for a house will be constructed. He would probably use
A. a level and a level rod  
B. a transit and a measuring tape  
*C. a level rod and a measuring tape  
D. a transit and a level

33 - Earthmoving

The kind of excavation which deals with the removal of soil or other materials from under way is called

*A. dredging  
B. bulk pit excavating  
C. trenching  
D. bulk wide-area excavating

35 - Stabilizing Earth and Structures

Why is it necessary to stabilize excavation walls?

A. To provide drainage for the site.  
B. To provide a firm base for the installation of utilities.  
*C. To make them hold their form and keep them from falling in.  
D. To keep unauthorized personnel from the excavated site.

36 - Classifying Structures

What are the two major parts of every structure?

A. The bearing surface and the footings  
*B. The substructure and the superstructure  
C. The piers and the utility networks  
D. Bearing walls and framed walls

37 - Setting Foundations

Why do all structures need a foundation?

A. It provides a bearing surface for the flooring.  
B. It keeps the floor of the structure dry.  
*C. It distributes the weight of the structure to keep it from sinking into the ground.  
D. It provides a framework for installing utilities.

If you wished to construct a building on wet, marshy soil, what could you do to keep the foundation from settling?
A. Use reinforcing rods to strengthen the foundation.
B. Use narrow footings under the foundation.
C. Trim and grout the foundation walls.
*D. Drive piles down to the firm earth below the marsh.

42 - Building Superstructures

If an architect-engineer is designing a building that will be 1,000' tall, what material would he use for the framework of the superstructure?

A. Wood
B. Masonry
C. Concrete
*D. Steel

48 - Installing Utilities

The three most common types of network for distributing utilities are:

*A. ducts, pipes and wires
B. pipes, conduits and tubes
C. registers, ducts and dampers
D. cables, wires and outlets

The statements below refer to craftsmen who use special tools to install utilities. In which statement are craftsman, tool, and job properly coordinated?

A. A sheetmetal worker uses a pipe wrench when he installs sewer pipe.
B. A plumber uses a crosscut saw when he installs electrical wiring.
*C. An electrician uses a hack saw when he installs conduit.
D. A carpenter uses a pipe die when he installs ductwork.

56 - Enclosing Framed Superstructures

The main reason for insulating the outside walls of a house is to

A. make the walls fireproof
*B. control the passage of heat and sound through the walls
C. strengthen the space between the walls
D. provide a base for applying plaster to the walls
The words gable, hip, mansard and gambrel are types of

*A. roofs
B. floors
C. exterior walls
D. interior walls

64 - Finishing the Project

How does the building of a wood frame by a carpenter differ from interior finish work?

A. Wood superstructures are erected by hand, and interior finish work is done by machines.
B. The carpenter does not work under the supervision of a foreman on superstructures.
*C. Interior finish work requires greater skill and accuracy.
D. Only union labor can be used to do finish work.

67 - Completing the Site

Who may help an architect-engineer in designing where trees and grass will be planted to complete a site?

*A. A landscape architect.
B. An operating engineer.
C. A mason.
D. A civil engineer.

69 - Servicing the Property

Post-processing activities such as maintaining and repairing a project after it is built are the responsibility of the

A. contractor
*B. owner
C. architect
D. supplier
CHAPTER V
PILOT TESTING

The comprehensive achievement test for Construction Technology has now been developed according to specifications and guidelines presented in previous chapters. Just as any prototype must be field-tested before it is produced for general use, so must this test be tried and its strengths and weaknesses evaluated. The purpose of this chapter is to present the method used in pilot testing the instrument and the results of that testing.

Selection of the Sample

The Industrial Arts Curriculum Project established field evaluation centers in six widely scattered cities across the country. Junior High schools were selected in each center to represent a cross-section of students from various socioeconomic neighborhoods. During the school year 1967-68, THE WORLD OF CONSTRUCTION was field-tested for the first time in twelve schools in Ohio, Florida, and New Jersey. In the next school year, twelve more schools were added in Texas, California, and Illinois. In this last year, 1969-70, over 6,000 junior high school students
participated in the field testing of IACP materials. Of this number, 2924 were involved in the study of construction and comprise the total population which could be sampled in pilot testing the achievement test. Table 6 below, lists the cities and the schools involved in teaching THE WORLD OF CONSTRUCTION.

Random selection procedures were followed in identifying the schools where the pilot testing would take place. The cities selected were Evanston, Illinois, and Cincinnati, Ohio. Then the schools within these centers were randomly selected for the administration of the tests. The construction classes conducted by Mr. Ronald Mackert at Skiles Junior High in the Evanston Center and the classes of Mr. Russell Henderly at Gamble Junior High in Cincinnati were selected. Since the schools in Evanston were scheduled to close three weeks before the schools in Cincinnati, it was decided to conduct the pilot test in Evanston and the revised test in Cincinnati.

On June 1, 1970, Mr. Ronald Mackert administered the pilot test to his first and second period classes at Skiles Junior High in Evanston. There were 66 seventh grade students (all boys) who participated in the test.
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Total 2924

* Schools selected for testing
Item Analysis

The answers provided by students to the pilot test were recorded on standard forms for machine scoring. The scanning of these forms and the item analysis were performed by the Center for Measurement and Evaluation at The Ohio State University. The item analysis and summary statistics presented on the following pages are xeroxed copies of the original computer print-out, as it was produced by the Center.
TOTAL TEST STATISTICS -- TEST DISTRIBUTION

NUMBER OF STUDENTS TAKING TEST = 66
NUMBER OF ITEMS IN TEST = 60
MEAN TEST SCORE = 40.38
MEDIAN = 45
MODE = 27
MAXIMUM = 57
MINIMUM = 13

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RELIABILITY ESTIMATES

Kuder-Richardson 20 = G.945
Kuder-Richardson 21 = G.938

ITEM ANALYSIS

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KURTOSIS = -.97
RANGE = 44

ITEM DISCRIMINATION DISTRIBUTION

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**Notes:**
- **n** indicates the number of responses.
- **PCT** indicates the percentage of correct responses.
- **UPPER** and **LOWER** denote the upper and lower indices, respectively.
- **SIG** indicates the significance level.
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<td>.303</td>
</tr>
<tr>
<td>57</td>
<td>28 PCI=42.4</td>
<td>.376</td>
</tr>
<tr>
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<td>39 PCI=49.1</td>
<td>.409</td>
</tr>
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<td>59</td>
<td>46 PCI=49.7</td>
<td>.303</td>
</tr>
<tr>
<td>60</td>
<td>40 PCI=60.6</td>
<td>.394</td>
</tr>
</tbody>
</table>

**Correct Responses and Percentages**

<table>
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<tr>
<th>Item</th>
<th>N=</th>
<th>PCI=</th>
<th>Phi=</th>
<th>CR Phi=</th>
<th>PCT=</th>
<th>Phi=</th>
<th>CR Phi=</th>
<th>PCT=</th>
<th>CR Phi=</th>
<th>PCT=</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>28</td>
<td>16</td>
<td>14</td>
<td>.887</td>
<td>.001</td>
<td>.433</td>
<td>.001</td>
<td>.50</td>
<td>.17</td>
<td>.02</td>
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<tr>
<td>56</td>
<td>28</td>
<td>16</td>
<td>14</td>
<td>.930</td>
<td>.001</td>
<td>.619</td>
<td>.001</td>
<td>.50</td>
<td>.17</td>
<td>.02</td>
</tr>
<tr>
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<td>28</td>
<td>16</td>
<td>14</td>
<td>.770</td>
<td>.001</td>
<td>.458</td>
<td>.001</td>
<td>.50</td>
<td>.17</td>
<td>.02</td>
</tr>
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<td>28</td>
<td>16</td>
<td>14</td>
<td>.956</td>
<td>.001</td>
<td>.645</td>
<td>.001</td>
<td>.50</td>
<td>.17</td>
<td>.02</td>
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<td>16</td>
<td>14</td>
<td>.918</td>
<td>.001</td>
<td>.725</td>
<td>.001</td>
<td>.50</td>
<td>.17</td>
<td>.02</td>
</tr>
<tr>
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<td>28</td>
<td>16</td>
<td>14</td>
<td>.933</td>
<td>.001</td>
<td>.597</td>
<td>.001</td>
<td>.50</td>
<td>.17</td>
<td>.02</td>
</tr>
</tbody>
</table>
The overall statistics for this pilot test appear to be very good. There is a wide range of scores (44) which produces a high standard deviation (13.08). Consequently, the shape of the curve is very flat (Kurtosis = -0.97). The mode varies greatly from the median (mode = 27, median = 45), and the shape of the curve is far from being symmetrical. The test was easier than anticipated. It was designed to produce a mean item difficulty of approximately .50. In fact, the mean item difficulty for this test is .327. This accounts for the curve being skewed negatively (-0.64). Reliability estimates are excellent (Kuder Richardson 20 = 0.945 and Kuder Richardson 21 = 0.938). The mean item discrimination is also quite acceptable (.530)

**Revision**

At the outset of the development of this test, the intention of this writer was to discard ten items which showed the poorest statistics and to utilize the item analysis in revising the remaining items which might have been weak in some way or another. According to this plan, then, the items to be dropped as poor items are: 14, 15, 16, 17, 23, 24, 26, 28, 39, and 47. The statistics on the remaining 50 items are good and show that the items are
working well. Consequently, a decision was made not to revise these remaining items in any way. The decision was made for two reasons:

1) Changing the wording in stems and/or alternatives could drastically change the characteristics of the items. Since the remaining 50 items are working well, it seems superfluous to make minor adjustments which may or may not improve the items.

2) If the remaining 50 items are unchanged and are administered as such to more students, the results of individual items can be examined in terms of a larger sample of students.

Obviously, the summary statistics of both tests cannot be compared since one is a 60-item test and the other a 50-item test. Nevertheless, a comparison of individual items can be made since the 50 items on the revised edition are identical with 50 items on the pilot test. It is not the purpose of this study to make a comparison of results between the pilot test and the revised test. However, anyone wishing to use this achievement test in the future could examine the statistical data of particular items on both tests and thereby gain a deeper insight into the characteristics of the item. Anyone who makes such a comparison should exercise caution in reading the item analysis for the tests
because the identifying numbers of the items do not coincide on the pilot test with the items on the revised test.
CHAPTER VI

RETESTING AND ANALYSIS OF DATA

The pilot test discussed in the preceding chapter was revised only to the extent that 10 items showing the poorest statistics were eliminated. On June 15, 1970 this revised edition of the test was administered by Mr. Russell Henderly to four of his classes at Gamble Junior High School in Cincinnati, Ohio. The purpose of this chapter is to describe the sample of students taking the test and to present the statistical results of the test.

The Sample

Gamble Junior High is a school of 850 students located in the suburbs of Cincinnati. It is one of the first schools to participate in field testing the instructional materials for THE WORLD OF CONSTRUCTION. All seventh and eighth grade boys in the school must take industrial arts. At Gamble Junior High all seventh grade boys are enrolled in the Construction class. The I.Q.'s of these students are graphically presented in Figure 10. The scores are the result of the Lorge-Thorndike I.Q. Test Form 3AV which
was administered to the students in December, 1968. Seven scores of the 116 boys in the class are not available.

Further insight into the background of these students is provided in Table 7 which shows the occupations of the fathers of 59 of the students who took the test. A record of the father's occupation for all students was not available at the time that this report was written. However, those which were available provide a good cross-section of parents' occupations in this neighborhood as judged by Mr. Henry Schroeder, Principal of Gamble Junior High. No attempt is made here to categorize the occupations nor will comparisons be made with other groups. Those interested in the socio-economic implications which might be deduced from these findings are left to draw their own conclusions.

Analysis of Data

The results of the revised achievement test were processed in the same manner as the pilot test, namely, an item analysis was performed by the Center for Measurement and Evaluation at The Ohio State University. The statistical data which appear on the following pages are xeroxed copies of the original computer print-out.

The summary statistics for the revised achievement test are not quite as good as those for the pilot test.
I.Q. SCORES OF 7th GRADE BOYS AT GAMBLE JUNIOR HIGH

(Lorge - Thorndike Form 3 AV)

Number of Students = 109
Mean = 99
Median = 98
Mode = 96
Maximum = 146
Minimum = 70
Range = 76
<table>
<thead>
<tr>
<th>Occupation</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck drivers</td>
<td>5</td>
</tr>
<tr>
<td>Business managers</td>
<td>5</td>
</tr>
<tr>
<td>Factory machine operators</td>
<td>4</td>
</tr>
<tr>
<td>Carpenters</td>
<td>4</td>
</tr>
<tr>
<td>Auto mechanics</td>
<td>3</td>
</tr>
<tr>
<td>Salesmen</td>
<td>3</td>
</tr>
<tr>
<td>Refrigerator repairmen</td>
<td>2</td>
</tr>
<tr>
<td>Restaurant owners</td>
<td>2</td>
</tr>
<tr>
<td>Store owners</td>
<td>2</td>
</tr>
<tr>
<td>Bakers</td>
<td>2</td>
</tr>
<tr>
<td>Electricians</td>
<td>2</td>
</tr>
<tr>
<td>Post office workers</td>
<td>2</td>
</tr>
<tr>
<td>Maintenance men</td>
<td>2</td>
</tr>
<tr>
<td>Credit manager</td>
<td>1</td>
</tr>
<tr>
<td>Teacher</td>
<td>1</td>
</tr>
<tr>
<td>Tax accountant</td>
<td>1</td>
</tr>
<tr>
<td>Dairy worker</td>
<td>1</td>
</tr>
<tr>
<td>Interior decorator</td>
<td>1</td>
</tr>
<tr>
<td>Probation officer</td>
<td>1</td>
</tr>
<tr>
<td>Policeman</td>
<td>1</td>
</tr>
<tr>
<td>Engineer</td>
<td>1</td>
</tr>
<tr>
<td>Foreman (brick layers)</td>
<td>1</td>
</tr>
<tr>
<td>Telephone installer</td>
<td>1</td>
</tr>
<tr>
<td>Railroad worker</td>
<td>1</td>
</tr>
<tr>
<td>Gas station attendant</td>
<td>1</td>
</tr>
<tr>
<td>Butcher</td>
<td>1</td>
</tr>
<tr>
<td>Fireman</td>
<td>1</td>
</tr>
<tr>
<td>Steel worker</td>
<td>1</td>
</tr>
<tr>
<td>Meat packer</td>
<td>1</td>
</tr>
<tr>
<td>Bus driver</td>
<td>1</td>
</tr>
<tr>
<td>Barber</td>
<td>1</td>
</tr>
<tr>
<td>Maintenance supervisor</td>
<td>1</td>
</tr>
<tr>
<td>Secretary (Plasterer's Union)</td>
<td>1</td>
</tr>
<tr>
<td>Taxi driver</td>
<td>1</td>
</tr>
</tbody>
</table>
There was less deviation among the mean, the median and the mode. The calculated standard deviation is high (10.81) but not quite as high as the pilot test. The range of scores is very great (Maximum = 47; Minimum = 4). This might be attributed to the wide range in student ability as is suggested in the wide range of I.Q. scores.

The frequency distribution or curve is positively skewed (0.59) which indicates that it departs from a symmetrical shape with the median and mode occurring below the mean. The kurtosis is -0.64 which indicates a very flat curve. The mean item difficulty is higher than that of the pilot test (.522 vs. .327). The mean item discrimination is very acceptable (.519). The reliability estimates are very good (Kuder-Richardson 20 = 0.915 and Kuder-Richardson 21 = 0.911).

The overall statistics of this revised test compare favorably with those of the pilot test. However, there are some interesting variabilities which occur as one compares the item analysis of individual test items on the pilot test and the revised test. For example, number 17 on the revised test has very poor statistics, whereas the identical item on the pilot test (number 24) showed very good statistics. The poor statistics on the revised test occur because 16 in the lower group of students answered the item correctly and only 18 in the upper group got it right. On the pilot test
only 4 of the lower group answered it correctly versus 17 of the upper group. One might conjecture then that the learning which took place in one school concerning this one concept dealing with contractors and subcontractors varied from the learning which took place in the other school. Of course, there might be other explanations which account for the difference in the answers of the two groups. It is most difficult for anyone outside the classroom to make judgments about why the learning of a particular concept did or did not take place. But a classroom teacher who has taught the construction course should be able to obtain valuable information about his teaching of particular concepts by examining the results of the item analysis. The point to be emphasized here is that those who read this report should be very cautious in making comparisons between the pilot test and the revised test as they reflect learning between two different groups of students. Such interpretations are better left to individual teachers who might use this achievement test in the future. What is more important for the purpose of this study is the fact that items 17 and 30 are the only ones which show widely differing statistics on the two tests.

It will be recalled that the items which appear on the revised test are identical to items on the pilot test, the only difference being that 10 of the poorer items were
dropped to produce the "revised" test. Since there were 66 students who took the pilot test and 115 who took the revised edition, each item was, in effect, tested on a total of 181 students.

The statistics which appear on the following pages are xeroxed copies of the original computer print-out for the revised test.
### Test Score Distribution

**All Items, Unweighted**

<table>
<thead>
<tr>
<th>RAW SCORE</th>
<th>FREQUENCY</th>
<th>CUMULATIVE FREQUENCY</th>
<th>PERCENTILE RANK</th>
<th>STANDARD SCORE</th>
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<td>704.7</td>
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<td>45</td>
<td>4</td>
<td>111</td>
<td>94.8</td>
<td>695.4</td>
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<td>107</td>
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<td>686.2</td>
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<td>ITEM</td>
<td>STATISTICS</td>
<td>MULTIPLE CHOICE RESPONSES AND PERCENTAGES (%)</td>
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<td>------------</td>
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<td></td>
</tr>
<tr>
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<td>TOTAL CORRECT</td>
<td>REL DIFF</td>
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</tr>
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<td>N=61 PCT=53.0</td>
<td>.470 Upper</td>
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<tr>
<td></td>
<td>CORR PHI= .649 (SIG= .001) (PCT)</td>
<td>(3)</td>
<td>(18)</td>
<td>(6)</td>
</tr>
<tr>
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<td>RPBIS= .373 (ITEM-TOTAL) Lower</td>
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<td>9***</td>
<td>6</td>
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<tr>
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<td>DISCRIMINATION INDICES (PCT)</td>
<td>(18)</td>
<td>(27)</td>
<td>(36)</td>
</tr>
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<td>OBTAINED D= 45.5</td>
<td>TOTAL</td>
<td>11</td>
<td>61***</td>
</tr>
<tr>
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<td>MAX= 100.0</td>
<td>EFF= 45.5 (PCT)</td>
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<td>REL DIFF</td>
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<td>2</td>
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<td>CORR PHI= .685 (SIG= .001) (PCT)</td>
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<td>(88)</td>
<td>(3)</td>
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<tr>
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<td>14***</td>
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<tr>
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<td>DISCRIMINATION INDICES (PCT)</td>
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<td>(27)</td>
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<td>OBTAINED D= 45.5</td>
<td>TOTAL</td>
<td>13</td>
<td>77***</td>
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<td>MAX= .697</td>
<td>EFF= 65.2 (PCT)</td>
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<td>(67)</td>
</tr>
<tr>
<td>3</td>
<td>TOTAL CORRECT</td>
<td>REL DIFF</td>
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<tr>
<td></td>
<td>N=62 PCT=53.9</td>
<td>.461 Upper</td>
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<td>3</td>
</tr>
<tr>
<td></td>
<td>CORR PHI= .696 (SIG= .001) (PCT)</td>
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<td>(6)</td>
<td>(16)</td>
</tr>
<tr>
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<td>RPBIS= .380 (ITEM-TOTAL) Lower</td>
<td>4</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>DISCRIMINATION INDICES (PCT)</td>
<td>(12)</td>
<td>(39)</td>
<td>(24)</td>
</tr>
<tr>
<td></td>
<td>OBTAINED D= 45.5</td>
<td>TOTAL</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>MAX= .909</td>
<td>EFF= 53.3 (PCT)</td>
<td>(10)</td>
<td>(16)</td>
</tr>
<tr>
<td>ITEM TOTAL CORRECT REL DIFF</td>
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<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>N  68 PCT=59.1 CORR PHI = .643 DISCRIMINATION INDICES</td>
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<td>2</td>
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<td>4</td>
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<td>1 3 28*** 1 0</td>
<td>1 0 1 3 0</td>
<td>1 0 1 0 0</td>
<td>1 0 1 0 0</td>
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<td>CORR PHI = .643 DISCRIMINATION INDICES</td>
<td>1 3 28*** 1 0</td>
<td>1 0 1 0 0</td>
<td>1 0 1 0 0</td>
<td>1 0 1 0 0</td>
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<tr>
<td>RPBIS = .549 (ITEM-TOTAL)</td>
<td>4 9 13*** 7 0</td>
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<td>(9)</td>
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ITEM STATISTICS

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### Item Statistics

**Multiple Choice Responses and Percentages**

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**Job Number:** 0786  
**Date:** 06/17/70  
**Department:** C000  
**Instructor:** Peter—Ind. Tech.

**N = 66**  
**PCT = 57.4**  
**CORR PHI = .836 (SIG = .001) (PCT) **  
**RPBIS = .493 (ITEM-TOTAL) LOWER**  
**DISCRIMINATION INDICES (PCT) **

- Obtained: 60.6  
- Total: 12  
- 19  
- 18  
- 66***  
- MAX: .72  
- EFF: 83.3 (PCT)

**N = 38**  
**PCT = 33.0**  
**CORR PHI = .549 (SIG = .001) (PCT) **  
**RPBIS = .365 (ITEM-TOTAL) LOWER**  
**DISCRIMINATION INDICES (PCT) **

- Obtained: 36.4  
- Total: 38***  
- 22  
- 32  
- 21  
- MAX: .84  
- EFF: 42.9 (PCT)

**N = 43**  
**PCT = 37.4**  
**CORR PHI = .861 (SIG = .001) (PCT) **  
**RPBIS = .582 (ITEM-TOTAL) LOWER**  
**DISCRIMINATION INDICES (PCT) **

- Obtained: 63.6  
- Total: 20  
- 32  
- 19  
- 19  
- MAX: .75  
- EFF: 84.0 (PCT)

**N = 61**  
**PCT = 53.0**  
**CORR PHI = .891 (SIG = .001) (PCT) **  
**RPBIS = .594 (ITEM-TOTAL) LOWER**  
**DISCRIMINATION INDICES (PCT) **

- Obtained: 69.7  
- Total: 21  
- 61***  
- 20  
- 13  
- MAX: .87  
- EFF: 79.9 (PCT)

**N = 62**  
**PCT = 53.9**  
**CORR PHI = .869 (SIG = .001) (PCT) **  
**RPBIS = .480 (ITEM-TOTAL) LOWER**  
**DISCRIMINATION INDICES (PCT) **

- Obtained: 66.7  
- Total: 23  
- 19  
- 62***  
- 10  
- MAX: .97  
- EFF: 68.7 (PCT)

**N = 68**  
**PCT = 59.1**  
**CORR PHI = .696 (SIG = .001) (PCT) **  
**RPBIS = .374 (ITEM-TOTAL) LOWER**  
**DISCRIMINATION INDICES (PCT) **

- Obtained: 48.5  
- Total: 10  
- 15  
- 23  
- 68***  
- MAX: .84  
- EFF: 57.1 (PCT)
## Item Statistics

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<th>Total Correct</th>
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<th>N</th>
<th>PCT</th>
<th>Upper</th>
<th>Lower</th>
<th>RPBIS</th>
<th>Discrimination Indices</th>
<th>Obtained</th>
<th>Max</th>
<th>Eff</th>
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<td>.818 (SIG=.001)</td>
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NOTE: All Phi coefficients are significant at .001 level.
### TOTAL TEST STATISTICS

**Number of Students Taking Test**: 115  
**Number of Items in Test**: 50

- **Mean Test Score**: 23.88  
- **Median**: 21  
- **Mode**: 13

- **Maximum**: 47  
- **Minimum**: 4

### GROUP STATISTICS

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<th>MEAN SCORE</th>
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<td>23.878</td>
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<td>UPPER 28.70</td>
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<td>38.485</td>
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<tr>
<td>LOWER 28.70</td>
<td>33</td>
<td>12.515</td>
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### RELIABILITY ESTIMATES

- **Kuder-Richardson 20**: \( \alpha = 0.915 \)  
- **Kuder-Richardson 21**: \( \alpha = 0.911 \)

### ITEM ANALYSIS

#### ITEM DIFFICULTY DISTRIBUTION

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<th>RANGE</th>
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<td>0.61-0.80</td>
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<tr>
<td>0.41-0.60</td>
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<td>78</td>
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<td>0.21-0.40</td>
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<td>0.00-0.20</td>
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**Mean Item Difficulty**: \( \mu = 0.522 \)
### Item Statistics

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<td>Upper 27*** 2 3 1 0</td>
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<td>RPBIS = .481 (ITEM-TOTAL)</td>
<td>Lower 7*** 9 8 8 0</td>
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<td>OBTAINED D = 60.6</td>
<td>TOTAL 55*** 23 18 17 0</td>
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<td>MAX = .970 EFF = 62.5</td>
<td>(PCT) 148 120 116 15 1 0</td>
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<tr>
<td>50</td>
<td>N = 51 PCT = 44.3</td>
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<tr>
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<td>CCRR PHI = .575 (SIG = .001)</td>
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<td>RPBIS = .345 (ITEM-TOTAL)</td>
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<td>OBTAINED D = 39.4</td>
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<td>MAX = .939 EFF = 41.9</td>
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### Summary Statistics

- **Standard Deviation**: 10.81
- **Skewness**: 0.59
- **Kurtosis**: -0.64
- **Range**: 43

### Item Discrimination Distribution

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<td>.00-.20</td>
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<tr>
<td>BELOW .00</td>
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**Mean Item Discrimination**: .519
The statistics which appear on the preceding pages need no further explanation other than that given in the first part of this chapter. Those who are interested in the working of individual items can readily compare the item analysis with the appropriate test item. The entire comprehensive achievement test appears as Appendix A in this paper.

The next chapter will be the final chapter of this paper. A summary will be given of the problems encountered and the manner in which the writer attempted to solve these problems. Finally, recommendations will be made regarding further research that is needed in the area of educational measurement that has been the subject of this paper.
CHAPTER VII

SUMMARY AND RECOMMENDATIONS

Summary of the Research

The purpose of this research effort was to develop a rationale and structure for constructing a comprehensive achievement test in construction technology. The instructional content of the test was derived solely from the textbook entitled THE WORLD OF CONSTRUCTION which was prepared by the Industrial Arts Curriculum Project at The Ohio State University. This textbook and other instructional materials are being published for general use in junior high school programs in the 1970-71 school year.

The problem which became the focus of this study was to develop a comprehensive achievement test which would:

1. Include items which cover all the major concepts of the construction technology course.

2. Include a majority of items designed to measure a student's grasp of relatively permanent knowledge, i.e., items based upon intermediate educational objectives which reflect the application, analysis, synthesis, and evaluation categories of Bloom's taxonomy.
Various sub-problems related to this major problem were encountered and had to be solved as the work progressed. These sub-elements of the major task may be summarized as follows:

1. To identify the major concepts of construction technology as established by experts in the field.

2. To develop an outline of each major concept to show its principal sub-elements.

3. To develop a set of intermediate objectives related to the major concepts in order to bridge the gap between the broadly stated course objectives and the specific daily operational objectives.

4. To establish a table of specifications for writing test items so that the achievement test will
   a) represent all the major concepts of construction technology;
   b) consist of a majority of items which reflect higher level objectives.

5. To establish criteria for writing multiple choice questions as outlined in current literature in the field of educational measurement.
6. To write test items for a comprehensive achievement test in construction technology according to the established criteria and the table of specifications.

7. To pilot test the first draft of the test.

8. To revise the first draft based upon information received from an item analysis.

9. To final test the revised edition of the test and record the results.

The solution to these problems was facilitated by the highly structured format of the IACP instructional materials. This format was presented in Chapter II because it provided the basis for identifying the major concepts to be measured by the achievement test. The conceptual framework of construction technology was outlined and the development of the major units of study for a course in construction were presented as they appear in the textbook. The general course objectives were listed, along with a sample of the daily operational objectives. A chart was made to illustrate the categorization of the daily objectives as they relate to the cognitive, affective, and psychomotor domains of Bloom's taxonomy of educational objectives.

Chapter III was devoted primarily to a review of literature concerning the theory of educational measurement.
Specifically, the basic principles of achievement testing were explored as they apply to the development of multiple choice tests. The criteria to be followed in writing multiple choice test items according to experts in the field are summarized below:

1. Multiple-choice test items should be developed from valid statements of important topics covered in the course.

2. A single, definite problem should be presented in the stem.

3. The stem should include as much of the item as possible.

4. The stem should be stated in positive terms if possible.

5. The stem can be stated as a question or as an incomplete statement.

6. The alternatives should be logically and grammatically consistent with the stem.

7. Alternatives should be made reasonably similar.

8. Alternatives such as "all of the above" or "none of the above" should be used with caution.
9. The position of the right answer below the stem should be randomly selected.

10. Alternatives should be selected so that all of them are reasonably plausible and appealing to those students who do not possess the knowledge demanded by the stem.

These criteria were closely followed in developing the individual items for the test.

The selection of the instructional material to be tested was made by analyzing the hierarchical schema of major construction concepts as they are presented in Chapter IV on page 104. Each major concept was outlined to show its principal sub-elements. This outline appears on pages 108-109 of this report.

The general course objectives proved to be too broadly stated to be of value in writing test items. On the other hand, the daily operational objectives were found to be too specific in most cases to be used for developing test items which would measure higher level learning outcomes. They also included numerous objectives in the psychomotor domain which cannot be efficiently measured in a paper-and-pencil achievement test. Consequently, it was necessary to develop a set of intermediate objectives which would bridge the gap between the general course objectives and the daily
operational objectives. The content of these intermediate objectives was derived from the outline of the major concepts mentioned above. Objectives for each major concept were judged to be "intermediate" if they incorporated one or more of the following elements:

1. A clarification of terminology which refers to a particular major topic.

2. The identification of occupations and personnel involved in specific facets of construction and a delineation of the proper function of each occupation in the accomplishment of construction goals.

3. The identification of tools, equipment and materials and their association with appropriate construction practices.

4. An organization (analysis and synthesis) of construction techniques and procedures followed in constructing a project.

5. The identification of commonalities and differences which exist between and among the various facets of construction technology.

6. The relationship of construction sub-elements to each other and to the whole.
When all the intermediate objectives were written, the next step was to categorize them in a table of specifications according to Bloom's taxonomy of educational objectives. The table of specifications appears on page 145 and was used as a blueprint for selecting which specific objectives were to be measured under each major topic. Since the pilot test was to have 60 items and there were only 42 major topics, it was necessary to select 18 additional objectives from the table of specifications. The selection of the additional items permitted certain topics to be weighed more heavily than others since two or more items were written on these weighted topics. Assistance was obtained from members of the IACP staff in determining which major topics merited weighting. The weighting procedure is explained on page 147 of this report.

Once the specific intermediate objectives to be measured had been identified, multiple choice items were written to reflect these objectives. The resulting 60 item test appears on pages 152-164. This 60-item test was pilot tested in construction classes in Evanston, Illinois. Complete pilot testing procedures and the item analysis of the test appear in Chapter V.

The pilot test was then revised by eliminating 10 of the items which showed the lowest statistics. The revised
edition was retested with 115 students who had completed the study of THE WORLD OF CONSTRUCTION at Gamble Junior High in Cincinnati, Ohio. A description of the sample and the statistical results of this retesting appear in Chapter VI.

Recommendations for Further Research

Based on the research in this study and the related structure for developing a comprehensive achievement test which evolved during the research, the writer suggests the following possibilities for further research.

1. The rationale and structure developed for this comprehensive achievement test in construction technology could be adapted for developing a comprehensive test in manufacturing technology.

2. This comprehensive achievement test could be given as an alternate form to various classes of students who have studied construction. The results of this test could be compared statistically with the results of the comprehensive test developed by the IACP staff. Such a comparison could provide deeper insight into the reliability of both tests.

3. This comprehensive test was developed entirely from instructional material contained
in the textbook. Feedback from the field evaluation centers indicates that a number of the students do not read the textbook. Perhaps different results could be obtained if a comprehensive test were to be developed solely from the student's laboratory manual which is designed to reinforce concepts contained in the text, through laboratory activities.

4. The techniques and guidelines used in the development of this test could be used for developing comprehensive exams in other subject matter areas.

5. The validity and reliability coefficients of this test could be strengthened by administering the test to a greater number of students of various backgrounds who have completed a course in construction.

6. This test was administered to students who had experienced the highly structured program in the IACP field evaluation centers. When THE WORLD OF CONSTRUCTION is adopted for general use in junior high schools throughout the United States during the 1970-71 school year,
individual teachers will be free to teach all, or selected parts of the course. The administration of this test to various experimental groups could provide valuable information about what parts of the course could be changed or eliminated, and which parts are essential for teaching the major concepts of construction technology.

7. Time did not permit the researcher to poll the teachers of THE WORLD OF CONSTRUCTION regarding the validity of the test. Such a poll could reveal strengths and weaknesses which are not apparent in the present examination of the item analysis and summary statistics.

Conclusion

In conclusion, this research attempted to develop a comprehensive achievement test which would measure student learning of the major concepts of construction technology. The statistical results of the pilot test and the revised test show that the minimum statistical requirements established in Chapter I have been exceeded in every regard. Perhaps further refinement of certain items would provide even better
statistical results. On the other hand, there is a certain amount of variability which occurs on individual items when the test is administered to different classes. This point was illustrated in Chapter VI. Thus, an item which works very well with one group may work poorly with another and vice versa. The value of this comprehensive test arises from the fact that a very high percentage of the items worked well on both the pilot and revised tests. This writer suggests that further refinement of the test would be premature at this time and should take place only after the test has been administered to a greater number of students representing a wide range of cultural and socioeconomic backgrounds. The sample of students in Evanston who took the pilot test was not described in this study since the test was administered on the last day of the school year and records were not available to this researcher. The sample of students in Cincinnati who took the revised test is described in Chapter VI. A profile of the students' I.Q. is provided along with a table which depicts the occupations of the students' parents.

The rationale and structure developed in the course of this research provides a logically defensible structure for the development of a comprehensive achievement test in construction technology. The statistical analysis of the
revised test suggests that the technique employed by the writer was successful in producing an achievement test with high discrimination, reliability, and validity factors.

It is the hope of this writer that the use of this test will be helpful to administrators, teachers, students, and parents in assessing the merits of this new curriculum in construction technology. In any event, the methodology devised in this study for developing comprehensive achievement tests may have contributed to the furtherment of test development in industrial arts and the field of education.
APPENDIX
APPENDIX A

A COMPREHENSIVE ACHIEVEMENT TEST
FOR THE WORLD OF CONSTRUCTION

1. What effects do specialization and technology have on society?
   A. They increase the national debt.
   B. They raise our standard of living.
   C. They lower the number of skilled workers.
   D. They lower the national average income.

2. Which of the following most clearly states the difference between construction and manufacturing?
   A. Constructed products are made of wood; manufactured products are made of metal.
   B. Construction is building something at a site; manufacturing is producing something in a plant.
   C. Construction industry employs more men than manufacturing industry.
   D. Constructed products are made from naturally reproduced materials; manufactured products are made from extracted materials.

3. The knowledge of how to efficiently build and maintain structures on a site is called
   A. economic technology
   B. management technology
   C. personnel technology
   D. construction technology

4. Planning, organizing, and controlling are the main functions of
   A. production technology
   B. personnel technology
   C. management technology
   D. economic technology

5. The three main technologies in construction are
   A. men, tools and equipment
   B. management, personnel and production
   C. materials, practices and processes
   D. economic goods, material goods, and labor

6. The man who directly supervises the work of several carpenters who are building forms is performing what management function?
   A. Planning
   B. Organizing
   C. Controlling
   D. Engineering

7. Which of the following is usually the first step in beginning a project?
   A. Buying real estate.
   B. Surveying and mapping.
   C. Selecting a site.
   D. Soil testing.

8. The answers to questions about the need for a project, if it will work, and if it will make money, would be stated in
   A. a feasibility study
   B. the contract between the owner and the engineer
   C. the contractor's schedule
   D. the deed to the property

9. Which of these structures would be built by a private initiator?
   A. A missile base.
   B. A state capital.
   C. A restaurant
   D. A freeway.

10. Most communities try to avoid building factories in residential areas by
    A. negotiating with owners
    B. condemning property
    C. lowering income taxes
    D. passing zoning laws

11. A written legal document by which a person proves his ownership of land is
    A. a survey
    B. a deed
    C. a mortgage
    D. an abstract
12. The first step in the design process is
A. analyzing the problem
B. making decisions
C. identifying the problem
D. refining the problem

13. The rejection of a preliminary idea in the design process should be considered as
A. a complete failure of the design process
B. a natural procedure in finding a solution to the problem
C. an indication that the designer should be fired
D. proof that the problem cannot be solved

14. Which of the following is not a part of working drawings?
A. Plans
B. Floor plans
C. Elevations
D. Sections

15. Advances in construction technology that will be used in constructing buildings in the future are
A. the use of more unskilled workers
B. the use of prefabricated units and a modular system
C. the use of more wood products and less concrete
D. an increased use of hand tools in production processes

16. A costly water main is laid to service a small community. Within a year the water main must be replaced by a larger main because the community has grown. Who pays for this costly mistake in community planning?
A. The workmen who installed the main
B. The engineer who designed the service
C. The people who pay the taxes in the community
D. The mayor of the community

17. How does a subcontractor differ from a general contractor?
A. A subcontractor has to hire his workers from a general contractor
B. A subcontractor is usually a specialist who does only one kind of work such as plumbing
C. A subcontractor works only on small projects
D. A subcontractor is the same as a general contractor except that he has a smaller company

18. Four contractors are bidding on a contract to build a school. Which one would most likely be awarded the contract?
A. The contractor who had the most men and equipment to do the job.
B. The contractor who submitted the highest bid and had the most experience in building schools.
C. The contractor who would use the least expensive materials.
D. The contractor who submitted the lowest bid and could meet the specifications.

19. If a contract between an owner and a contractor is closed, this means that
A. The owner takes over all responsibility for the project
B. The contractor has not received final payment
C. Several defects on the job must still be corrected
D. The contractor refuses to release claims and liens

20. Which of the following is a true statement?
A. Construction work is inspected only after all phases of the project are completed.
B. Inspections are made only at the beginning of construction work.
C. Inspections are made on construction work from the time drawings are begun until the project is finished.
D. If a project is thoroughly inspected when it is begun, there is no need to inspect it again.
21. Technology used to cause workers to work safely, efficiently, and happily is called
A. Production technology
B. Management technology
C. Processing technology
D. Personnel technology

22. Which of the following is not a personnel technology practice?
A. Hiring
B. Training
C. Advancing
D. Storing

23. What is the chief responsibility of a contractor?
A. To design the master plan of the project.
B. To test and approve working drawings.
C. To get the job done according to the contract specifications.
D. To design the utilities system needed for the project.

24. Which of the following is a major source of conflict between labor and management?
A. Better training programs.
B. Better safety programs.
C. Higher wages and better fringe benefits.
D. Creating support for new construction.

25. Where does a union contractor usually hire his workers?
A. From the union hiring hall.
B. From non-union labor pools.
C. From employment agencies.
D. From subcontractors.

26. Which of the following is an example of a social working condition?
A. Poor lighting in an office area.
B. The attitude workers have toward each other.
C. Exposure to cold weather.
D. Low wages.

27. If you dropped out of high school after taking industrial arts, could you get a job as a union tradesman? Why?
A. Yes, because unions accept a course in industrial arts as a substitute for an apprenticeship program.
B. No, because union tradesmen have to be college graduates.
C. No, because you have to complete an apprenticeship program.
D. Yes, because anyone who is willing to work can be hired as a union tradesman.

28. Which of the following job positions requires the most knowledge about construction costs?
A. An estimator.
B. A journeyman.
C. An apprentice.
D. A foreman.

29. If a carpenter is unhappy with his working conditions, his first stop in the grievance process would be to
A. Talk to the contractor.
B. Consult the architect.
C. Present his grievance to a mediator.
D. Talk to his foreman.

30. What is the difference between a mediator and an arbitrator in solving a labor and management disagreement?
A. The mediator has the power to force one of the parties to follow his decision.
B. The arbitrator can make decisions that must be followed by both parties.
C. The arbitrator has no power at all in solving the dispute.
D. There really is no difference.

31. An arbitrator who is settling a dispute between labor and management should be
A. A union member selected by the union.
B. An employer selected by other employers.
C. An employee selected by management.
D. A neutral outsider selected by both sides.
32. Do labor and management both try to avoid strikes? Why?
   A. No, labor likes strikes because they are the only way to increase salaries.
   B. No, management prefers to settle disputes only after a strike is called.
   C. Yes, because both lose money during a strike.
   D. Yes, because nothing is ever settled in a strike.

33. All production may be classified into three practices called
   A. processing, processing, and post-processing
   B. planning, organizing, and controlling
   C. researching, analyzing, and producing
   D. hiring, training, and advancing

34. The activity which usually takes place immediately following the clearing of a site is
   A. erecting the superstructure
   B. installing utilities
   C. setting foundations
   D. locating the structure

35. If a contractor is constructing a building in a downtown area, what would be the best way to protect bystanders from being hurt by falling objects?
   A. By telling people to stay away.
   B. By setting up picket lines.
   C. By erecting barricades around the site.
   D. By asking his workers to watch out for people on the sidewalks.

36. If a city wishes to make sure that each project follows the laws for a certain site, it will require the owner to obtain
   A. a mortgage
   B. a lien
   C. a building permit
   D. a zoning permit

37. Demolishing, salvaging, cutting, burning, and disposing are practices of
   A. management technology
   B. servicing
   C. piling and shoring
   D. site clearing

38. The kind of excavation which deals with the removal of soil or other materials from under water is called
   A. dredging
   B. bulk pit excavating
   C. trenching
   D. bulk wide-area excavating

39. Why is it necessary to stabilize excavation walls?
   A. To provide drainage for the site.
   B. To provide a firm base for the installation of utilities.
   C. To make them hold their form and keep them from falling in.
   D. To keep unauthorized personnel from the excavated site.

40. What are the two major parts of every structure?
   A. The bearing surface and the footings.
   B. The substructure and the superstructure.
   C. The piers and the utility networks.
   D. Bearing walls and framed walls.

41. Why do all structures need a foundation?
   A. It provides a bearing surface for the flooring.
   B. It keeps the floor of the structure dry.
   C. It distributes the weight of the structure to keep it from sinking into the ground.
   D. It provides a framework for installing utilities.

42. If an architect-engineer is designing a building that will be 1,000 ft. tall, what material would he use for the framework of the superstructure?
   A. Wood
   B. Masonry
   C. Concrete
   D. Steel
43. If you wished to construct a building on wet, marshy soil, what could you do to keep the foundation from settling?
A. Use reinforcing rods to strengthen the foundation.
B. Use narrow footings under the foundation.
C. Trim and grout the foundation walls.
D. Drive pilons down to the firm earth below the marsh.

44. The three most common types of network for distributing utilities are
A. ducts, pipes and wires
B. pipes, conduits and tubos
C. registers, ducts and dampors
D. cables, wires and outlets

45. The statements below refer to craftsmen who use special tools to install utilities. In which statement are craftsman, tool, and job properly coordinated?
A. A sheetmetal worker uses a pipe wrench when he installs sewer pipe.
B. A plumber uses a crosscut saw when he installs electrical wiring.
C. An electrician uses a hack saw when he installs conduit.
D. A carpenter uses a pipe die when he installs ductwork.

46. The main reason for insulating the outside walls of a house is to
A. make the walls fireproof
B. control the passage of heat and sound through the walls
C. strengthen the space between the walls
D. provide a base for applying plaster to the walls

47. The words gable, hip, mansard, and gambrel are types of
A. roofs
B. floors
C. exterior walls
D. interior walls

48. How does the building of a wood frame by a carpenter differ from interior finish work?
A. Wood superstructures are erected by hand, and interior finish work is done by machines.
B. The carpenter does not work under the supervision of a foreman on the superstructures.
C. Interior finish work requires greater skill and accuracy.
D. Only union labor can be used to do finish work.

49. Who may help an architect-engineer in designing where trees and grass will be planted to complete a site?
A. A landscape architect.
B. An operating engineer.
C. A mason.
D. A civil engineer.

50. Post-processing activities such as maintaining and repairing a project after it is built are the responsibility of the
A. contractor
B. owner
C. architect
D. supplier.
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