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STRUCTURE AND CONTENT FOUNDATIONS FOR CURRICULUM DEVELOPMENT.

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IT IS PROPOSED THAT AN INDUSTRIAL ARTS CURRICULUM BE BASED ON THE CONCEPT OF MAN AS A CREATOR OF TECHNOLOGY. TECHNOLOGY IS A MAJOR AMERICAN SOCIETAL BASE INVOLVING PRACTICALLY ALL CITIZENS AND SHOULD BE ESTABLISHED AS A DISCIPLINE TO ELIMINATE CONFUSION AND LACK OF DIRECTION IN THE CURRICULUM. A MACROTECHNOLOGICAL ANALYSIS IDENTIFYING A UNIVERSE OF CONTENT WHICH IS IN KEEPING WITH THE PRINCIPLES OF DISCIPLINE STRUCTURES AND GENERAL EDUCATION IS OFFERED AS A MEANS OF DEFINING A TAXONOMY TO SERVE CURRICULUM PLANNING. A TAXONOMY OF TECHNOLOGY CONSISTS OF BOTH TECHNICAL AND CULTURAL-SOCIAL ELEMENTS WITH THE MAJOR TECHNICAL AREAS BEING PRODUCTION, COMMUNICATION, AND TRANSPORTATION WHICH MEET TAXONOMETRIC SELECTION CRITERIA INCLUDING THAT OF UNIVERSALISM. ILLUSTRATIVE EXAMPLES INDICATE 10 LEVELS OF SPECIFICITY IN THE PROPOSED TAXONOMY. MAJOR STEPS IN CURRICULUM DEVELOPMENT, UTILIZING THE TAXONOMY AS A CONTEXT RESERVOIR, ARE TO ESTABLISH THE TAXONOMY, THE BASIC CONCEPTS AND PRINCIPLES, UNITS OF CONTENT INSTRUCTION BASED ON ANALYSES OF CONCEPTS AND PRINCIPLES, AND COURSES OF STUDY BY GROUPING LOGICAL COMBINATIONS OF INSTRUCTIONAL UNITS. SOME ADVANTAGES OF THIS APPROACH ARE THAT (1) CONTENT SELECTION CRITERIA ARE PROVIDED, (2) FLEXIBILITY, ADATABILITY, AND INTERNAL CONSISTENCY ARE INTRINSIC, (3) PROGRAMS RATHER THAN ISOLATED COURSES ARE POSSIBLE, (4) TEACHER COMPETENCY CAN BE INCREASED THROUGH SPECIALIZATION, AND (5) A BASE IS PROVIDED FOR LIFETIME STUDY AND PROFESSIONAL CONTRIBUTION BY TEACHERS. IT IS RECOMMENDED THAT THE PROFESSION, THROUGH THE AMERICAN INDUSTRIAL ARTS ASSOCIATION, ESTABLISH A PERMANENT COMMITTEE FOR DERIVING A TAXONOMETRIC STRUCTURE FOR THE INDUSTRIAL ARTS. THIS DOCUMENT IS AVAILABLE FOR 90 CENTS FROM AMERICAN INDUSTRIAL ARTS ASSOCIATION, NATIONAL EDUCATION ASSOCIATION, 1201 SIXTEENTH STREET, N.W., WASHINGTON, D.C. 20036. (EM)

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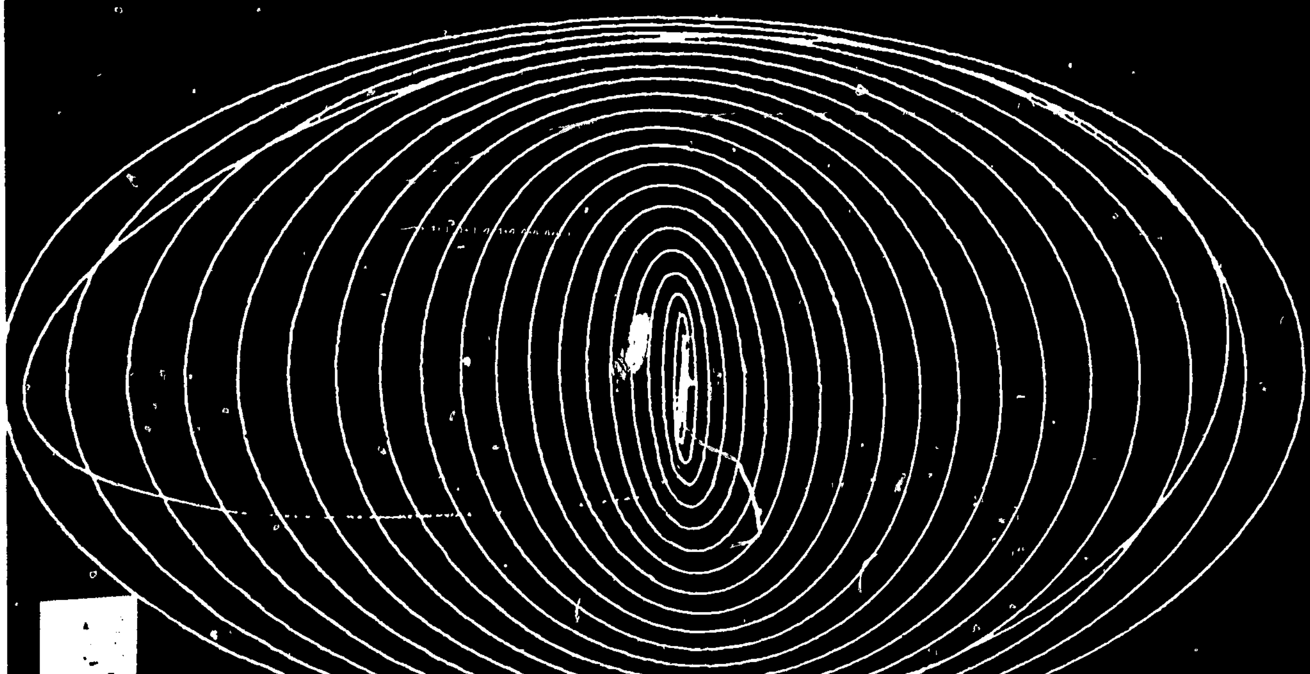
Structure and content foundations for curriculum development



STRUCTURE AND CONTENT FOUNDATIONS FOR CURRICULUM DEVELOPMENT

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One of the most fundamental tasks continually facing all facets of formal educational endeavor is that of curriculum development. This is so because the curriculum is the medium through which the aims, purposes and objectives of education are implemented and realized. It is especially true in an area of study which evidences one of man's highest levels of intellectual attainment; his accomplishments in the technologies.

The task of curriculum development is not the creation of knowledge but rather the structuring and disseminating of knowledge in the technologies for efficient learning and intelligent use.

Curriculum development has always been the concern of educators. And yet, it is one of the most difficult and elusive areas in which to attain results. One generally held assumption is that curriculum development must be a constant on-going activity. But the truth of this assumption should be questioned. Are there no constants or universals upon which to build a curriculum which can provide a structure with external stability and internal flexibility and adaptability to change as man's knowledge increases or changes? At what level is this constant on-going curriculum activity required? Is it necessary constantly to revise the total, or can a structure be established whereby various content levels can be adjusted to meet changing knowledge requirements?

A review of the fundamentals of curriculum development, together with an analysis of structural concepts, indicates the latter is attainable. In fact, our profession has been moving in this direction for some time.

The task then is to analyze the approach and ascertain whether a structure can be determined from which a curriculum and its content can be derived. It should be noted that other disciplines and professional fields of endeavor have approached the solution to their problems through structural analysis, with profitable results.

THE STUDY OF TECHNOLOGY: AN APPROACH

In today's world, when there is a greater need than ever before for technological literacy, we discover the contemporary status of the industrial arts to be one of confusion and perhaps indecision, with a few notable exceptions. Teachers in the profession, however, are becoming increasingly aware that the confusion is the result of our heritage, and indecision the result of inadequate perspective.

Contemporary scholars of the heritage have provided new insights which have changed our perspective. Because of these efforts our history is less perplexing and our perspective more adequate. Three rather distinct philosophies have emerged and are supported in various degrees by members of the profession. These philosophies range on a continuum from courses based on a craft or trade approach devoted to vocational or occupational goals with emphasis on skill development, through programs concentrating on the study of the production elements of industry indigenous to the United States, to programs evolved from the concept of man as the creator of technology, incorporating the fundamental technical and cultural elements of the several areas of technology.

It is proposed that an industrial arts curriculum based upon the study of Man and technology is the most valid of the three content approaches, for the following reasons. A study of Man and technology

1. provides a better base from which to implement the purposes and objectives of general education;
2. is not limited or isolated by geographical boundaries, thereby evidencing the true nature of disciplined inquiry;
3. is concerned with man as the creator of technology regardless of national origin;
4. provides a meaningful relation between technology and man's culture. Historical, anthropological, social and economic elements of the culture are important to the understanding of man's technology, and a knowledge of man's technology is vital to the understanding of any culture; and
5. identifies a knowledge area meeting the criterion of a discipline in the truest sense of the term.

THE STUDY OF TECHNOLOGY

The Technological Base, Cultural Universals and General Education

Technology has been described as man's special power, and Arnold Toynbee (20, p. 650), the great historian, considers it one of the major areas of human endeavor on a plane equal to economics, politics, art and religion. Therefore, if we accept as valid the assumption that education is integrally related to the culture of each period, we must assume that a society whose base is technological and scientific will reflect, in some measure, the technology in the curriculum of its schools. When one examines the areas of human endeavor, he is amazed at their variety and realizes that all activities cannot become a part of the school curriculum nor can any one activity serve as a master activity. However, many of the major activities are so interrelated that to omit the study of certain key activities is to limit perspective and deprive the student of true understanding. Certainly this is true of the study of technology, an area of endeavor common to all mankind. One would assume, then, that technology will be afforded increasing importance in determining the goals and content of general education.

Today, there is a growing realization of the vast complexities of technology. Man has discovered the value of theory and knowledge in the technologies and the fact that technology can serve his social progress. No longer does he question whether a problem can be solved. His experience limits his question to this: "How long will it take?"

In our society we cannot discuss economics intelligently without a knowledge of technical innovation, invention and the functions of these elements in producing goods and services. The body of knowledge created by technology is vast, and interrelated to all fields of knowledge.

The question remains as to whether man comprehends his technology sufficiently to utilize it intelligently to solve his problems.

The social and cultural relationships involved create a discipline area far more complex than that of science in terms of the spread and adaptation of the knowledge of technology. Whereas only a few in a society are directly involved in the pure sciences, all are involved, to some degree, in the creation and utilization of technology. Thus, it is of vital importance that all men be conversant with the technologies so the knowledge may be used for the good of man and his society.

Schrier points out the complexity of the area with which we are concerned:

> Creation of an environment conducive to technological development is not a simple matter. The transfer of technology involves more knowledge and capability than are available through the physical sciences and engineering and more factors than are under the control of any one segment of society. Before significant progress can be made we have to become fully aware of the broad, complex, multi-discipline, multi-function inputs of technology transfer. (16, p. 346)

Only recently has man become aware of the force exerted by technology in the development of civilization. The understanding and comprehension of technology are important in fulfilling a fundamental objective of education, namely, understanding the culture. This is clearly indicated by Kranzberg:

Anyone who is at all interested in understanding the past, in learning how the present got to be the way it is, or in speculating about the future—and this would include every thinking man —must be concerned with the development of technology and its relation to society and culture. (8, p. 56)

THE DISCIPLINE AND KNOWLEDGE BASE

Technology as a Discipline

One of the reasons for the confusion and lack of consistent direction in industrial arts has been the failure to establish the area or to think of it as a discipline. Why is the concept of a discipline a necessary consideration? For one thing, the term has distinct meanings, and, as in all concepts, it is a convenient way of conveying, by the use of one term, a broad and complex idea.

Discipline, as a term, can be used to define a minute segment of knowledge which meets certain criteria, or it can be used to describe a body of knowledge which meets certain criteria. The use of the term depends on the hierarchical level at which one is discussing the knowledge concept. In this discussion the latter is assumed, together with the elements which make up the discipline.

When we use the term discipline we are actually indicating that a body of established knowledge exists, a body of knowledge which has been determined and agreed upon by specialists in the identified field.

To understand the term more fully we should realize that a discipline is:

1. **Dynamic.** Disciplines and the knowledge fields comprising them are not static. They are constantly evolving. New disciplines are established and old disciplines eliminated or changed. (13, p. 10 and 17, p. 86).
2. **Cumulative.** The body of knowledge comprising a discipline is cumulative and has been established by its own unique pattern of investigation utilizing proven techniques, methods and procedures. Validation of new knowledge by others is possible. (17, p. 84–85).
3. **Theoretical.** The body of knowledge of a discipline consists of key ideas, principles and concepts unique to the field and evidencing the essence of the discipline. The basic concepts range in difficulty from elemental to complex. Understanding the basic concepts provides a means to comprehend a vast knowledge field and serves as a foundation from which to increase knowledge and simplify learning. (See Brady, **Organization, Automation and Society**) (13, p. 11–12 and 17, p. 84).
4. **Structural.** A discipline evidences a system or structure, and the body of knowledge composed of ideas, principles and

concepts is patterned in a hierarchical order. (11, p. 47 and 13, p. 324).

5. **Integrative.** Disciplines, although unique and separate in their own right, are interrelated and utilize findings from allied fields. Some are more separate or isolated. Some are more dependent on other areas. (13, p. 320; 4, p. 18 and 24, p. 50).

A discipline, therefore, is essentially a body of knowledge which meets certain criteria. Whether the subject matter of a course meets these criteria depends upon how the course is taught. The methods of inquiry, the concepts, basic ideas and the application of principles must all be consistent with the discipline. This according to Ten Hoor (19, p. 424) determines its claim to being a contribution to the discipline. And this internal consistency is extremely significant when one is concerned with curriculum development and the structure of a knowledge area. (4, p. 14)

What justification is there for concern about the development of knowledge and suggestions that the structure of knowledge and the methods of the discipline be utilized in deriving curriculum content?

For one thing, general education is concerned with common learning based upon cultural universals. This is distinct from concern with specialities which consist pricipally of vocational callings. (18, p. 230) According to Phenix, disciplined understanding is the foundation of general education. The content of general education is not "knowledge in general", which everyone has, but authentic disciplined knowledge. It is general in that it is based upon cultural universals and relevant to all students and not to members of special groups. (13, p. 314)

Knowledge is both basic to and a means of implementing the objectives of education. For instance, development of problem-solving abilities, interests, attitudes or appreciations depends on the student's obtaining new knowledge and new information as opposed to mere opinion. This is true if we desire certain specific attitudes, abilities or interests to be developed. A curriculum based on organized knowledge fields is better learned and retained than knowledge which is specific and isolated. The discipline structure provides meaningful relations required for efficient learning. In addition, knowledge in a discipline is cumulative, utilizing a hierarchy of concepts applicable to numerous situations in an individual's learning experience, thereby providing a greater efficiency and permanence of learning through continual reinforcement of the basic ideas, principles and concepts. (4, p. 19 & 42) Fundamental to this point of view is the need to stress that the student learn the methods whereby new knowledge is added to the field and present knowledge is altered or eliminated.

> He also observes that when problems are solved, they are solved through the utilization of similar methodologies and techniques. The techniques of postulation, deductive reasoning, empirical verification, inference, proof, trial and error and discovery are recognizable elements. Each of these techniques for solving problems is shared by all engaged in technology in essentially the same manner in each development. (5, p. 8)

Determination of the fields of knowledge which can be classed as cultural universals is not an easy task. Many systems have been devised for different purposes. Our purpose is formal education, and for this Ten Hoor provides a logical answer based upon three questions:

> Formal education, it can be said, is concerned with three different though interrelated kinds of knowledge, each of which is man's answer to questions he has been asking himself since the beginning of civilization. (1) What is there to be known about the external world and about those who live in it? (2) What use can we make of this knowledge? (3) What use ought we make of this knowledge? (19, p. 423)

The three questions identify respectively the distinct but interrelated knowledge fields of the sciences, the technologies and the humanities. (19, p. 423) Utilizing a basic criterion of a structure, namely, simplicity, these three knowledge areas are accepted as the foundation upon which to base further analysis and to derive a structure and content for the industrial arts. (15, p. 3) These fields of knowledge contain discipline areas which meet the criteria set forth by Phenix as being an identifiable organized tradition of men of knowledge and evidence fields of inquiry in which learning has been achieved in an unusually productive way. (13, p. 316–17) The present analysis is a macro-technology analysis identifying a universe of content and is in keeping with the principles of structure and general education. Other examples, of more definitive classification, are of the micro-technology analysis and are concerned with areas or divisions of the content universe which can be subsumed under one of the three knowledge areas described. Both efforts must be pursued.

CRITERIA FOR JUDGMENT

Curriculum Principles:

The three fields of knowledge comprising the framework for general education have patterns or structures, and interrelationships, essential to teaching and learning, exist between the elements.

The task then is one of selecting principles and procedures to serve as criteria for determining a pattern of curriculum organization.

The tremendous volume of knowledge available to be learned forces the search for criteria which can be justifiably utilized to reduce the mass to suitable and manageable proportions.

Essential to the determination of any curriculum structure is a basic philosophy. The present analysis is based on a sociological concept of defining curriculum structure in terms of the universal institutions created by man or the universal endeavors engaged in by man. These universal institutions and endeavors make up the fabric of all progressive societies.

An historical and social analysis of man's endeavors in various cultures, for instance, establishes a number of man's universal technological endeavors. We discover in our analysis that man in all stages of his technical development has been a builder, a communicator, a producer, a developer, a transporter, a craftsman and an organizer.

All progressive societies evidence these areas of technology, namely construction, communication, production, research and development, transportation, craft industries and an hierarchical division of labor. These are universal technological endeavors that have developed and progressed, establishing bodies of knowledge which have survived.

The importance of approaching curriculum development for the industrial arts and general education from this point of view is supported by Smith:

> . . . . Finally, the civilized person is one who has mastered the art of living with others in harmony and cooperation. But since the universal institutions are, in every progressive society, the means of cooperative life, the civilized person is on 'who is in possession of the universal institutions of his time' (18, p. 229)

***Taxonometric Principles:**

Much effort has been directed by the profession to defining the industrial arts with little attention to the identification of the body of knowledge, determination of a valid philosophical base or selection of curriculum principles or guides. Even these are inadequate if a classification of knowledge in the technologies does not exist. Machlup (10, p. 15) believes that attempts to classify and order knowledge (in the sense of what is known) are often more enlightening than attempts to define it. He states that an exhausive classification may

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*Taxonomy from the Greek *taxis*, arrangement, + *nomis*, law.

suggest a definition. This would indicate one reason for our failure to implement a fruitful and productive educational program in the industrial arts: preoccupation with definitions and the almost total lack of concern with knowledge classifications and content.

Attempts at curriculum analysis and development are less than rewarding without a taxonomy of the body of knowledge identifying the structure and its elements. Technology can be verbally defined, but to understand the elements and their functional relationships requires a knowledge of the total structure.

> The questing mind is naturally given to analysis; and whatever else it may also mean, analysis always seems to imply a search for component 'parts'. Without relations between the parts they would remain isolated, meaningless and unintelligible. If we can speak of analysis, we can also speak of the structure which we hope will emerge as a result of our analysis. (21, p. 28)

There is a number of reasons to engage in efforts in taxonomy or classification of knowledge areas, not the least of which is to obtain an accurate perspective of the content reservoir. Without a full perspective of the content reservoir, a valid curriculum cannot be developed.

A taxonomy of the area of technology would:

1. eliminate confusion and simplify the task of curriculum planning by providing a perspective of the relationships between the elements and the structure, and by ordering the knowledge area into specific categories, thereby assuring a balanced allocation of content. (13, p. 250)
2. facilitate communication among the membership of the field of knowledge, together with others, such as administrators, curriculum specialists and scholars in related fields. (4, p. 10)
3. simplify understanding and economize intellectual effort by treating large numbers of different things as though they were identical with respect to the aspects by which the categories are defined. (11, p. 47) (4, p. 36 and 42) (13, p. 45)
4. provide a base for long term research and inquiry into the nature of the discipline area by ordering the area of knowledge in such a way as to reveal significant relationships and properties as well as the interrelationships between the elements of the structure. (4, p. 17)
5. provide a base for developing valid evaluation instruments by identifying elements of content to be evaluated.
6. aid in identifying difficulty levels of content areas for establishing instructional sequences at different learning levels.

A review of taxonomies established by other knowledge areas reveals certain guiding principles which have been developed to serve as selection criteria.

1. Mutually exclusive groups. Categories or clusters are established wherein each larger unit is a combination of subgroups. The groups or categories are established in an hierarchical order. (23, p. iii,
2. Each category is identified by a word or phrase which delimits the category but is non-transient and permits additions to the structure as discoveries of new knowledge warrant.

Example:

The remaining categories form the basic taxonometric hierarchy of animals, any given species belonging thus to seven obligatory categories as follows: (11, p. 47)

FIGURE 1 (Wolf)

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Carnivora
Family	Canidae
Genus	Canis
Species	Lupus

3. There is a relatively small number of mutually exclusive groups or categories. (15, p. 3)
4. The distinction between groups or categories is established by a universal concept inherent in the knowledge area itself.
5. Taxonomies are logically developed and internally consistent. There is evidence of external stability with internal flexibility and adaptability to evolving new knowledge within the discipline. (4, p. 14)
6. Taxonomies are not limited to local or national knowledge areas but are international in scope. The mutually exclusive categories are of the external world and not simply categories of the contents of first-person experience. (24, p. 120)
7. Taxonomies have structure because there are internal relations existing between the elements. The structure is dependent upon this interrelationship. (21, p. 12)
8. The structure of taxonomies varies from extremely logical and homogeneous classifications of the elements to vague, ambiguous, heterogeneous and difficult-to-define relationships of the elements. (21, p. 20–24)

FIGURE 2

Math	Esthetics
Logic Homogeneous Structure	Heterogeneous Structure

Many knowledge structures exist and for various purposes. The Dewey Decimal System, Department of Commerce, Bureau of the Census classification system, Society for the History of Technology Bibliography Committee Outline, Domestic and Foreign Government Economic Report Classifications and the US and International Patent Classification System are several examples. Each of the systems contains both macro- and micro-analysis. The US Patent Office Classification System is divided into 5 major groups, 300 classes and 57,000 subclasses. All of the above classification systems deal with technology in one way or another.

An analysis of the several systems, however, discloses support for Tranoy's conclusion:

> There are also certain important cases where the same whole can be analyzed in different ways giving totally different structures that do not bear any simple relation to each other although they give equivalent explanations for the whole. A case in point are the two different 'models' that can be given for any atomic phenomenon, the particle model and the wave model. (21, p. 21–22)

Continual evaluation is in progress pertaining to classification systems in the technologies. There is evidence that more and more of what was once separated into separate categories, with separate functions and purposes, is now being incorporated into a total system such as communication systems, transportation systems or production systems. Concern is with the "whole" and not only the component parts. For instance, the function of the knowledge area of communication concerns information dissemination, storage and retrieval and use. The methods of accomplishing this, whether in a man-to-man, man-to-machine or machine-to-machine system, vary with the task. Elements of radiant energy, printing, photography or graphic representation, by man or machine, are utilized to attain the most valid solution to a given communications problem.

One test of an adequate taxonometric structure for the study of man and technology, in addition to the principles of taxonomy listed previously, is universalism. The structure must be applicable to technology in general and not indigenous to any one country or civilization. This is true, since no one country or civilization can claim credit as the sole creator or utilizer of technology.

The purpose of a taxonomy is not to limit a field of knowledge arbitrarily but to ascertain its totality, together with the component elements and their interrelationships. Curriculum development thus follows the determination of the structure and its elements.

. . . . . The nature and function of the 'elements' is determined by the position which the 'elements' occupy in the 'structure', while the 'structure' is what it is because of the 'elements' which constitute it. That is to say, 'structure' and 'element' occur only in indissoluble fusion. There exists no 'structure' without constituent 'elements' and there exist no 'elements' without functional relations of some sort of a 'structure.' (24, p. 120)

IMPLEMENTATION OF THE CONCEPT

The Total Structure

Using the information provided in the analysis of disciplines, knowledge areas and taxonometric principles, an approach can be determined which **possibly** provides a base for establishing a definitive curriculum structure for the study of the industrial arts and technology.

It should be recognized and made very clear that **a structure is not a curriculum.** Nor is it something to be "**given**" or taught to a student. A structure is a tool to be used in curriculum development and is "arrived at" by the student through the learning process. A discipline structure does not classify instructional methods, materials or behavior changes expected in students. Each of these areas requires separate analysis and structure. (4, p. 12) It does classify elements of knowledge and indicate relationships. Also the previous discussion implies that the nature of the content in large measure determines the method of instruction required. (see Ten Hoor)

It has been premised that all of man's knowledge can be subsumed under three broad headings. The major knowledge areas created by man are: The sciences, the technologies and the humanities.

Each knowledge area seeks to answer a basic question:

1. What is there to be known about man and his physical universe?
2. What use can be made of the information furnished by the sciences for the benefit of man?
3. What use ought to be made of the information furnished by the sciences for the benefit of man?

The knowledge area of technology furnishes the base for the derivation of the content reservoir for the industrial arts. Following this approach, the function of industrial arts in a formal educational program is delimited to:

> the study of man and technology (including the technical and cultural-social elements) as a creative endeavor in meeting the needs of individuals and cultures, in the areas of products, transportation and communication, through the utilization of the properties of matter and energy.

The industrial arts are closely related to man's endeavors in meeting his biological-physiological needs. The main responsibility for meeting these needs rests with the agricultural and medical technologies and is not a part of the present consideration. However, in terms of products, communication and transportation, definite interrelationships exist.

Man's development of his technology in the area of the industrial arts is directly related to his culture and is social in nature. Drucker notes this in his discussion of the production area:

> The mass-production principle is not a mechanical principle. If it were, it could never have been applied beyond manufacturing, and independently of assembly line, conveyor belt and interchangeable parts. It is a **social** principle—a principle of **human** organization. (6, p. 6)

Therefore, throughout the development of the following example of a taxonomy, a social orientation is implied if not specifically indicated. A taxonomy of technology incorporates both cultural-social and technical elements. The present example is limited to **one** series of hierarchical elements. (See Figure 12 for example of total series.)

FIGURE 3

DISCIPLINE: **Technology**

Technical Elements — Cultural-Social Elements

A taxonometric structure for the study of man and technology, based on the foregoing definition and delimitation and from an historical and social analysis, identifies three major areas of technological endeavor. These areas represent the essence of the discipline, are consistent with major components in other technological classifications and provide for internal adaptability to change through the use of non-transient terms.

The technical areas are:

1. Production—providing goods and services of economic value for man's needs and wants.
2. Communication—providing information dissemination, storage, retrieval and use.
3. Transportation—providing movement of man, materials, products and services.

The technological areas of production, communication and transportation are found in all cultures regardless of their stage of development. Hence they meet the criterion of universalism.

A study of each of these physical areas indicates that they vary in their primary function, being unique discipline areas in their own right, and, as with other discipline areas such as zoology and botany, require their own taxonometric classification scheme. However, a close interrelationship exists between the areas of production, communication and transportation and their elements, thereby meeting a requirement of structure. Analyzing one technical area, production, we can provide an example of the procedures in taxonomy.

The area title is Production. Production is composed of two divisions. namely, manufacturing and construction. Manufacturing, to take one division in the structure, is composed of two categories, fabrication ([1]) and processing ([2]).

FIGURE 4

Discipline: **Technology**

Technical Elements — Cultural-Social Elements

Areas: Production — Communication — Transportation

FIGURE 5

Discipline: **Technology**

Areas: **Production** — Transportation — Communication

Division: **Manufacturing** — **Construction**

Category: Fabrication — Processing

The next level in the structural hierarchy provides for the **departments** in the **fabrication** category. The **departmental level** also exists in the processing category. However, for purposes of this discussion only one line of development is illustrated.*

[1]Fabrication is the making of a product from pieces such as parts, components or assemblies. It also includes the making of the individual products or parts. Items of a discrete nature such as tires, nails, spoons, screws, refrigerators or hinges are fabricated. (1, p.32)

[2]Processing consists of manufacture by continuous means, or by a continuous series of operations, for a specific purpose. Items of a continuous nature such as strip steel, beverages, breakfast foods, tubing, chemicals and petroleum are processed. (1, p. 32)

*Note: Anatomy of Automation by Amber and Amber was used as a resource for classification terms.

FIGURE 6

Category: **Fabrication**

Departments:
- Research and Development
- Purchasing
- Design and Engineering
- Sales and Distribution
- Product Processing
- Plant Engineering
- Personnel
- Finance
- Planning and Control

Various functions are assigned to each department. Focussing on one department product processing, the following functions are evident:

FIGURE 7

Department: **Product Processing**

Function:
- Materials Handling
- Testing
- Materials Working
- Packaging
- Inspecting
- Assembling

Each function, such as materials working, is composed of operational levels. The operational levels relating to materials working are identified in Figure 8.

FIGURE 8

Function: **Materials Working**

Operation:
- Tools and Tooling
- Chip Generating
- Bending
- Mold Forming
- Fabrication Treatment
- Electro and Chemical
- Assembly
- Force

Each operation is composed of basic structural elements which can be subdivided and classified as to type. Selecting one element from the operation classification, tools and tooling, an illustration of type level in the hierarchy is shown in Figure 9.

FIGURE 9

Operation: **Tools and Tooling**

Type:
- Jigs
- Fixtures
- Machines
- Patterns
- Molds
- Templates
- Gages
- Dies and Punches

The next to last classification heading denotes to some degree the evolutionary stages of the operational type. The element "machines", as an example, is composed of classes as shown in Figure 10.

FIGURE 10

Operation: **Tools and Tooling**

Type: **Machines**

Class: Stone and Wood Hand Tools | Metal Hand Tools | Power Machine Tools | Semi-Automatic Machine Tools | Fully-Automatic Machine Tools

The final hierarchical level further delimits the evolutionary aspects by denoting the order of complexity. See Figure 11.

FIGURE 11

Class: **Fully Automatic Machine Tools**

Order: Repeat Cycle | Self Correcting | Equation Solving | Limited Self-Programming | Relating Cause and Effect | Creation and Originality | Command

An example of a classification for one series of elements is shown in Figure 12.

FIGURE 12
A Taxonomy of Technology

Discipline: **Technology**

Technical Elements — Cultural-Social Elements

Areas: Transportation — **Production** — Communication

Division: **Manufacturing** — Construction

Category: **Fabrication** — Processing

Department: **Product Processing**

Function: **Materials Working**

Operation: **Tools and Tooling**

Type: **Machines**

Class: **Fully Automatic Machine Tools**

Order: **Repeat Cycle**

IMPLEMENTATION OF THE CONCEPT

The Public School Program

The basic premise of the foregoing discussion rests on the assumption that the development of general education programs for the public schools involves three bodies of knowledge created by man, namely, the sciences, the technologies and the humanities. As defined previously, the body of knowledge called technology contains the content reservoir from which public school programs in the industrial arts derive instructional content.

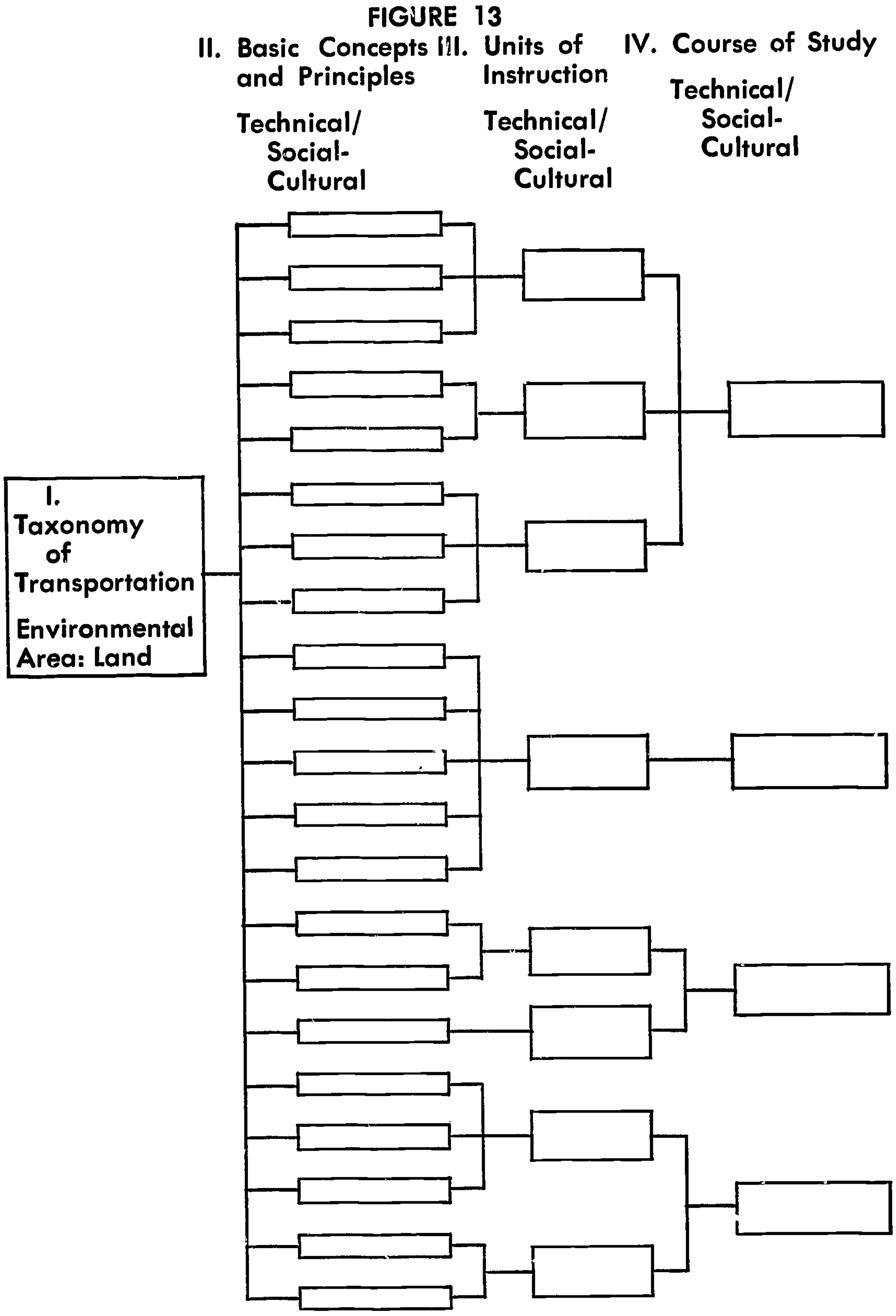
Derivation of the content is attained through the establishment of a taxonomy. With properly developed stuctures from which to derive content, it is possible to proceed with curriculum development for the public schools. Here, too, some form of structure is required. Basing the program on the sudy of man and his technology and his three foundational technical endeavors, namely, production, communication and transportation, it is possible to provide flexible solutions and a logical program of general education courses for schools of various student population levels. Programming for various ability levels, interests, intelligence levels and time requirements can be designed. Integration of discipline areas and opportunity for concentration in a knowledge area accrue in this approach.

The taxonomy and resulting structure does not rule out **ipso facto** certain already-established subject areas or courses. It does provide a basis for valid content selection. In many instances present content is retained and given new meaning through the establishment of interrelations between areas as they exist in actuality in the technological environment.

A diagrammatic example of the utilization of a taxonomy in curriculum development is shown in Figure13. The knowledge area is transportation, which deals essentially with different environments as the problems of providing movement of man, materials, products and services. There are essentially four major steps to curriculum development, utilizing the taxonomy as the content reservoir.

I. Establishment of the content reservoir—taxonomy.
II. Establishment of the basic concepts and principles of the content area from the content reservoir.
III. Establishment of units of content instruction based upon an analysis of the basic concepts and principles.
IV. Establishment of courses of study through the grouping of logical combinations of units of instruction.

FIGURE 13



An intermediate step can be taken by curriculum developers based upon present knowledge of content areas. For example, an evolutionary step can be pursued as shown in the skeletal program outline for the secondary level. Content areas already available have been utilized. The example relates to the knowledge area of communications and is primarily concerned with the technical means man has created to solve his problems in information dissemination, storage, retrieval and use. Each subject area, noted in the diagram, relates to some aspect of the information dissemination, storage, retrieval and use problem and contributes, through the concepts taught, to the total.

FIGURE 14
Communications Program*
Secondary School

12	Electronics Communications	Elective
	Photography	Communications Research and Development
11	Graphic Arts	Graphic Arts
	Advanced Electronics	Drawing and Design
10	Intro. to Communications	Drawing and Design
	Intro. to Communications	Basic Electronics
9	Manufacturing	Manufacturing
	Manufacturing	Manufacturing
8	Manufacturing	Manufacturing
	Manufacturing	Manufacturing
7	Introduction to Technology	Introduction to Technology

*Note: Taxonometric classifications may be developed for the communication area based upon three types of communication: man to man, man to machine or machine to man, and machine to machine. Systems include sensing, encoding, transmission, signaling, receiving, decoding, storage, retrieval and use. Sub-elements may be considered in the areas of: (1) Information dissemination, including radiant energy, mechanical-chemical, and electro-mechanical methods. (Sub-elements are derived from applications such as: radio (including radar, sonar, loran and radio-photo), television graphic arts (including printing, stenciling and drawing) and photography); (2) Information storage and retrieval, including dynamic and static systems utilizing mechanical, magnetic, photographic, thermoplastic, chemical, stylus and composition record, electrostatic, magnetic cores, superconductors, capacitors and relays, to name a few.

The components (elements) of the structure vary according to man's selection of elements meeting the criteria of adequacy, efficiency and economy in solving communications problems.

Several levels of content for each course can be developed, thereby establishing a program meeting the ability levels of all students.

Attention is called to the junior high school program based upon the knowledge area of production with the manufacturing division as the content field. This follows current proposals in present operation. The senior high school program would consist of the knowledge areas of construction, communication and transportation.

Senior high school programs should be flexible so a student not concentrating in one of the divisions or areas would be able to elect one or more courses in keeping with his avocational or vocational interests. Other patterns of curricular organization, courses of study, units and methods of instruction are possible, once the taxonomy of the knowledge area has been structured and the content defined.

CONCLUSION

An attempt has been made to present an approach to curriculum development for the industrial arts which is logical, consistent and attainable.

The function of the industrial arts as a part of formal education has been reviewed. A technological base for the study of the industrial arts was discussed together with the philosophy of cultural universals and general education. The purpose of a discipline and knowledge base was established and the principles of taxonomy outlined. An example of structure was shown and an outline of a curricular program for both junior and senior high school diagrammed.

It should be noted that the structuring of knowledge is not the complete basis for the organization of the curriculum. Instructional methods, psychological principles and cultural and social factors are essential considerations. The structure and system of knowledge serves only as the foundation upon which to build. But it is a most essential foundation, for without it we have nothing.

In evaluating the concept presented, there are several advantages which accrue from such an approach.

1. Criteria for content selection are established and curriculum development ordered and simplified. Optimum learning sequences can be planned by identifying complexity levels of content.
2. Flexibility and adaptability to change and internal consistency are intrinsic through the use of technological universals as a base. The overall structure is stable.
3. Programs of studies are inherent rather than isolated and repetitive courses.

4. Teacher competency is increased through the medium of a specialization in a field of knowledge such as communication, transportation or production.
5. Teacher education programs at both the undergraduate and graduate levels would be improved, from the point of view both of the student and of the faculty.
6. Utilizing the discipline and knowledge base would permit and require theoretical and laboratory study of technical programs through both the master's and doctoral levels. Advanced study programs, based on the content area in which one is expected to perform and not on peripheral or available content areas, would become meaningful. The structure provides a base for a lifetime of learning and professional contributions through legitimate, recognizable specialization.
7. Communication would be improved in the profession.
8. New and more profitable research problems would become evident.
9. Both program and student evaluation would be enhanced and improved.

From a structure based on cultural universals, the curriculum problem can be delimited and a specific content reservoir identified.

From the content reservoir the several objectives of the industrial arts and general education can be determined and implemented.

Through a knowledge and understanding of the nature of the content, together with the stated and agreed-upon objectives, the basic concepts, units of instruction, programs of study and methods of implementation can be determined.

Without a definitive content base, however, the goals of general education to which we should contribute cannot be attained. For this reason, it is recommended that the profession, through the American Industrial Arts Association, establish a permanent committee to serve as the legal body in establishing a taxonometric structure for the industrial arts.

BIBLIOGRAPHY

1. Amber, George H. and Amber, Paul S. **Anatomy of Automation.** Englewood Cliffs, NJ: Prentice-Hall, Inc., 1962.
2. Association of Consulting Management Engineers, Inc., **Common Body of Knowledge Required By Professional Management Consultants.** New York: Association of Consulting Management Engineers, Inc., 1957.
3. Beer, John J. "Historical Relations of Science and Technology." **Technology and Culture.** Vol. VI. No. 4 (Fall, 1965), 547–52.
4. Bloom, Benjamin S (Ed.). **Taxonomy of Educational Objectives.** New York: Longmans, Green and Co., 1956.
5. DeVore, Paul W. "Technology: A Structure for Industrial Arts Content." American Industrial Arts Association. 1964.
6. Drucker, Peter F. **The New Society.** New York: Harper and Brothers, 1950.
7. Foshay, Arthur W. "Education and the Nature of a Discipline." **New Dimensions in Learning: A Multidisciplinary Approach.** Washington, DC: Association for Supervision and Curriculum Development, NEA, 1962.
8. Kranzberg, Melvin. "At the Beginning." **Technology and Culture.** Vol. I, No. 1. (Fall 1959).
9. Library of Congress. **Classification: Class Technology 4th** ed. Washington, DC: US Government Printing Office, 1953.
10. Machlup, Fritz. **The Production and Distribution of Knowledge in the United States.** Princeton, NJ: Princeton University Press., 1962.
11. Mayr, Ernst, Linsley, E. Gorton and Usinger, Robert L., **Methods and Principles of Systematic Zoology.** New York: McGraw-Hill Book Co., Inc., 1953.
12. Miller, Robert B. **Some Working Concepts of System Analysis.** Pittsburgh. American Institute for Research, 1954.
13. Phenix, Philip Henry. **Realms of Meaning: A Philosophy of the Curriculum for General Education.** New York: McGraw-Hill Book Co., Inc., 1964.
14. Price, Derek J. De Solla. "Is Technology Historically Independent of Science? A Study in Statistical Historiography." **Technology and Culture.** Vol. VI. No. 4 (Fall 1965), 553–568.
15. Schenk, Edward Theodore and McMasters, John H. **Procedure in Taxonomy.** Stanford: Stanford University Press, 1948.
16. Schrier, Elliot. "Toward Technology Transfer." **Technology and Culture.** Vol. V., No. 3 (Summer 1964), 344–57.
17. Shermis, Sherwin S. "On Becoming an Intellectual Discipline." **Phi Delta Kappan,** Vol XLIV., No. 2 (November 1962), 24–26.
18. Smith, Bunnie Othanel, Stanley, William O. and Shores, J. Harlan. **Fundamentals of Curriculum Development.** New York: World Book Company, 1950.
19. Ten Hoor, Marten. "Why the Humanities?" **Journal of Higher Education.** Vol. XXXIV, No. 8. (November 1963).
20. Toynbee, Arnold J., **A Study of History Vol. XII.** New York: Oxford University Press, 1961.
21. Tranoy, Kurt Erik. (Ed.) **Wholes and Structures.** Copenhagen: Munksgaard, 1959.
22. United States Department of Commerce. **Patent Office Manual of Classification.** Washington DC: US Government Printing Office, 1965.
23. Ward, Joe H. Jr. **Hierarchical Grouping to Maximize Payoff.** Lackland: United States Air Force, 1961.
24. Werkmeister, William Henry. **The Basis and Structure of Knowledge. New York:** Harper and Brothers Publishers, 1948.